Susitna-Watana Hydroelectric Project Document
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Notes:
Distributed as a posting of FERC eSubscription to Docket 14241.

Enclosures accompanying letter:
- General comments framework.
- Susitna-Watana ISR resource studies reviewed. *[The table of Contents to next enclosure]*
- Summary of proposed modifications and new studies. *[One summary for each study]*
- New study request for Susitna-Watana integrated modeling and decision-support system.
- Conserving salmon habitat in the Mat-Su basin, executive summary, the strategic action plan of the Mat-Su Basin Salmon Habitat Partnership. 2013 update.

United States Department of the Interior

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IN REPLY REFER TO:
FWS/AFES/AFWCO

JUN 21 2016

Ms. Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street
Washington, D.C. 20426

Subject: Susitna-Watana Hydropower Project, FERC Project No. 14241-000; Review of Initial Study Reports

Dear Ms. Bose:

The U.S. Fish and Wildlife Service (USFWS) has reviewed the Initial Study Reports (ISR) on the Susitna-Watana Project (Project) that were submitted by the hydro-power license applicant, Alaska Energy Authority (AEA), in June 2014 (Parts A-C) and the supplemental (Part D) that was submitted in November 2015. We also reviewed the Project's Post-ISR reports, including various technical memoranda, Study Completion Reports and Study Implementation Reports that were submitted by AEA in subsequent filings. In this letter, we collectively refer to these materials as the June 2014 ISR and the November 2015 ISR filings.

Our comments and requests are in accordance with provisions of the National Environmental Policy Act, Endangered Species Act, Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, Clean Water Act, Fish and Wildlife Coordination Act, and authorities under the Federal Power Act (FPA). As a result of our resource review and pursuant to 18 CFR § 5.15 we are proposing several study modifications and one new study request for Model Integration and a Decision-Support System.

The USFWS is submitting five enclosures, as follows:

1. General comments.
2. List of resource studies reviewed.
3. The USFWS's requests for study modifications and one new study. These detailed comments are organized by individual study number as assigned by AEA. For each study modification request we provide supporting documentation and justification of good cause. We present those as either (1) approved studies were not conducted as provided for in the approved study plan, or (2) the study was conducted under anomalous environmental conditions or that environmental conditions have changed since the study plan approval.
4. The USFWS's request for a new individual study: Model Integration and Decision-Support System.

5. The Strategic Action Plan of the Mat-Su Salmon Habitat Partnership: *Conserving Salmon Habitat in the Mat-Su Basin*, 2013 Update. We offer this comprehensive plan under Section 10(a)(2)(A) of the FPA, for the Federal Energy Regulatory Commission's (FERC) use in considering the extent to which a project is consistent with Federal or state comprehensive plans for improving, developing, or conserving a waterway or waterways affected by the Project. This plan is a comprehensive study of the beneficial uses of the Matanuska-Susitna waterways. It was cooperatively developed by local governments, State and Federal fisheries managers, Native Alaskan organizations, and non-governmental partners. The plan examines how the different uses of waterways will promote the overall public interest.

For reference, we mention here that AEA considered the March 2016 ISR meeting to be a cumulative ISR meeting; however, while all of AEA's studies appeared on the meeting agenda, only some of the cumulative ISR materials were covered. Much of the June 2014 ISR (Parts A-C) materials were last discussed during the October 2014 ISR meeting and the March 2016 ISR agenda did not allow for additional discussion of Parts A-C within the context of Part D. In response to discussions prompted by AEA at both the October 2014 and March 2016 ISR meetings, the USFWS provided verbal comments and recommendations for study modifications and new studies. These recommendations are on record in the FERC docket for this Project in the meeting transcripts.[1]

Our intent in filing the following ISR recommendations and request for study modifications and a new study is to make clear our concerns regarding pre-Project resource characterization, reporting, and post-Project predictive capabilities necessary to meet requirements of the USFWS' mandate under the FPA.

We hope our filing will be helpful to support FERC's October 21, 2016, Director Determination. If you have any questions, please contact project biologist Betsy McCracken at (907) 271-2783 or via email at betsy_mccracken@fws.gov and include Project No. P-14241-000.

Sincerely,

Socheata Lor, Ph.D.
Field Office Supervisor

Enclosure 1: General comments
Enclosure 2: List of Susitna-Watana resource studies reviewed
Enclosure 3: Individual study requests for modification and new study
Enclosure 4: New study request for Model Integration and Decision-Support System
Enclosure 5: The Strategic Action Plan of the Mat-Su Salmon Habitat Partnership: *Conserving Salmon Habitat in the Mat-Su Basin*, 2013 Update.

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[1] Transcripts from the October 2014 and the March 2016 ISR meetings are inaudible because of the quality of the teleconferencing and in-room acoustic conditions.

Enclosure 1
General Comments

Authority under FPA

Under Section 10(j) of the FPA, the National Marine Fisheries Service and the USFWS (together referred to as the "Services") are authorized to recommend license conditions necessary to adequately and equitably protect, mitigate damages to, and enhance fish and wildlife (including related spawning grounds and habitat) affected by the development, operation, and management of hydropower projects. Under Section 18 of the FPA, the Services have authority to issue mandatory fishway prescriptions for safe, timely, and effective fish passage for anadromous fish. This includes prescribing that passage be provided by the applicant/licensee (AEA) for 1) adult salmon migrating upstream above the proposed Susitna River Watana dam location to spawning sites in tributaries above the proposed reservoir and 2) downstream passage for juveniles migrating from upstream spawning and/or rearing sites to downstream lateral habitats to the mouth at Upper Cook Inlet. Additionally, Section 10(a)(1) of the same act requires FERC to condition hydropower licenses to best improve or develop a waterway or waterways for the adequate protection, mitigation, and enhancement of fish and wildlife (including related spawning grounds and habitat) based on Services' recommendations and plans for affected waterways.

ILP Abeyance and Review Schedule

To provide context for our comments and concerns, here we present developments in the Project's Integrated Licensing Process (ILP) review schedule relevant to our ability to fully participate in the process.

On December 31, 2014, AEA requested a 60-day ILP abeyance for the Project. A 60-day project status update from AEA on March 4, 2015, requested a continued hold on the abeyance. On May 4, 2015, AEA followed up with a 60-day status report requesting an additional hold on the abeyance. AEA filed a status report on July 2, 2015, indicating that the Project would provide a specific plan to FERC within 60-days. The initial requested 60-day ILP abeyance resulted in an 8-month gap in process.

On August 26, 2015, AEA requested that FERC lift the licensing process abeyance. Between the 8-month abeyance and the issuance of the revised licensing schedule, AEA continued to collect field data, conduct analyses and develop reporting to supplement the June 2014 ISR record. These data were collected without a normal study design process that would have included stakeholder participation (including the USFWS). AEA acknowledged the associated risk in foregoing stakeholder participation to address concerns previously raised (USFWS letter to AEA, dated September 22, 2014 and filed with FERC) related to data collection and reporting.

The decision to assume the associated risk of continuing with the studies eliminated opportunities for collaboration prior to AEA's 2014 field work. This resulted in the magnification of the concerns the USFWS had with the 2013 studies because AEA proceeded with the 2014 field work without addressing those concerns. As a result, the 2014 field work resulted in ineffective, incomplete, and unsuccessful data collection for several studies during 2014 (e.g., 8.5 Instream Flow HSC, 9.5 and 9.6 FDA, 9.8 River Productivity, 9.9 Characterization and Mapping of Aquatic Habitats, 7.5 Groundwater). We believe that the effect of the abeyance and AEA's efforts to "advance" the Project without the benefit of agency and stakeholder review have magnified the inadequacies and concerns expressed in our September 2014 letter.

AEA moved forward with Project efforts (e.g., fish and wildlife resource data collection) without resolving our agency's concerns for studies intended to characterize resources. The Project's ILP process did not provide opportunity following the "first-year studies" (2013) field effort for our agency to meet statutory responsibilities to 1) identify study gaps; 2) provide recommendations for the second year of studies (and beyond); 3) assess the project's ability to quantify baseline and proposed Project operational effects to fish and wildlife resources; 4) develop and support our recommendations for the protection, mitigation and enhancement measures associated with the project, and 5) make informed decisions pursuant to our Section 18 Fishway Prescription authority under the FPA.

We believe this lack of study planning and coordination with stakeholders, including the USFWS, resulted in a continuation of problems identified in the data collected in 2013 and further inconsistencies in data collected during 2014. We also believe this has contributed to a lack of scientific rigor in the analyses.

Statistical Methods for pre- and post-Project Resource Comparison

To allow the USFWS to meet our FPA responsibilities, the applicant (AEA) must provide relevant resource information that will enable us to make appropriate recommendations based on characterization and comparison of pre- and post-Project effects to fish and wildlife resources. The purposes of the Fish and Aquatics Final Study Plan (AEA, 2013) were to 1) provide baseline characterization of existing resources, and 2) collect information that will support the evaluation of potential resource impacts of the proposed project. We do not believe this information has been provided in adequate detail to allow us to meet our FPA responsibilities.

For the USFWS to characterize and quantify comparisons of pre- and post-Project conditions, we need collective estimates of fish abundance, by species and lifestage, and valid and reliable models to forecast effects of the proposed hydropower dam under various operational scenarios. While such data were collected, they were not presented in a manner that facilitates rigorous evaluation and analysis. For instance, scientific estimates for this purpose are accompanied by estimates of sampling error, expressed as confidence intervals or standard errors. However, the sampling error for AEA's fish and aquatic studies has generally been absent in reports to date, making pre- and post-Project comparisons impossible. The USFWS considers providing estimates of sampling error to be an important and standard practice in scientific research studies; this is supported by Bernard et al. (1993) as well as in the State's (Alaska Department of Fish and Game) fisheries research Operational Planning guidance document (Regnart and Swanton 2012). We reference studies 8.5, 9.5, 9.6, and 9.7 as examples of FERC-approved studies where the specific estimates are named or described yet are absent in AEA's reporting. The USFWS requests that statistical methods for comparison be provided by AEA that would allow us to understand the rigor of studies conducted and provide appropriate recommendations based on our Federal standards for scientific integrity.

Specifically, to complete our evaluation we require more detail on 1) how specific sampling efforts related to an important estimate, 2) how the estimates interrelated, 3) how the estimates were intended to be constructed, 4) how AEA intended to use some of the estimates, and 5) how or if important sampling considerations had been communicated to field crews. It is important that all study reports contain accessible, detailed, clear, and specific descriptions of statistical methods.

The Project material released to date is insufficient for the USFWS to evaluate and forecast the effects of the proposed hydropower dam and allow us to recommend license conditions to protect resources under our responsibilities. Much of the effort for sampling fish abundance, for example, has only produced a large amount of un-summarized data. We do not have meaningful estimates of abundance that can be used for statistically valid comparisons. Furthermore, much of these data cannot be combined into valid estimates because they were not collected consistently or in a way that allows statistical comparisons. Additionally, we believe that some data should not be used due to missing or erroneous data (e.g., fish species misclassification, lifestages were not recorded, or species were combined in analyses).

The descriptions of the modeling methods do not meet scientific standards. Project review materials have not been provided to demonstrate that the preliminary models to forecast the effects of the hydropower dam are adequately constructed, statistically valid, or are otherwise capable of reasonable forecasts. We are concerned that the material we have received does not allow us to interpret, analyze, and replicate the modeling effort and the data collection. We address these concerns in greater detail in the individual study reviews in Enclosure 3.

Based on our review of the June 2014 and November 2015 ISRs, we conclude that the current study results are inadequate to accurately characterize baseline conditions and the data are insufficient to predict Project effects. Furthermore, we are concerned about the level of accuracy and precision for the studies. Several of the studies (e.g., 5.5, 8.5, 9.5, 9.6, 9.7, 9.8, 9.9, 9.12) either have been conducted under ineffective, incomplete, or unsuccessful field sampling and/or do not meet the scientific standard for analyses and reporting (Council of Science Editors 2006). As an example of the concerns expressed above, we reference the Instream Flow study (8.5), which has been proposed to model the effects of the Project on fish and fish habitat. The effects of dam operation on fish will be predicted, at least in part, through habitat suitability curves. However, the habitat suitability component of the study has no ability to use the current habitat suitability data or presented analyses (e.g., habitat suitability curves) to characterize baseline conditions or predict Project-effects. The large number of suitability curves generated are not useful for this intended purpose. Important material that is necessary to judge the statistical significance of the overall models, including statistical significance of the model parameters, the overall quality of the model fit, and information on model validation (Zuur et al. 2009) was not reported.

To help address our concerns surrounding the statistical methods and reporting, the USFWS respectfully requests that FERC require a study modification for AEA's Fish and Aquatic Study Plans to follow the State's own fisheries research protocols (Regnart and Swanton 2012; Bernard et. al. 1993) and develop State fisheries research operational plans for fieldwork. The operational plans should contain: 1) a clear statement of the overall goals of the sampling or field effort and a statement of what the effort is intended to produce, 2) a list of each statistical estimate that the sampling is intended to produce, 3) a statement of the intended statistical precision for each estimate and how that precision will be sufficient to meet the overall project goals, and 4) a clear statement of all methods in sufficient detail for an independent scientist to be able to repeat all aspects of the study. For these reasons, we recommend that FERC closely evaluate the 2013 data. We also recommend that the 2014 data not be considered as year-two Project data until FERC determines if information collected in 2013 meets the intent of the approved study plan determination and allows for rigorous comparisons of pre- and post-Project effects.

Anomalous Weather Conditions

Another important limitation of the studies conducted to date is that the data were collected under anomalous or unusual environmental conditions in the study years. The watershed experienced unusually high levels of flooding in 2012 and 2013. The top three discharges ever recorded in the Susitna River watershed at the Chulitna and Talkeetna Rivers and Montana Creek were recorded at the USGS station gauges during the September 2012 floods. The 2012 September Susitna River peak discharge was 72,900 cubic feet/second (cfs), which at the time was the 6th highest discharge in a 59 year record (Curran, et.al. 2016). The 2012 flood was anomalous, affecting fish spawning distribution and incubation success. The 2013 flood surpassed the 2012 flood with a discharge of 90,700 cfs (USGS, Jeff Conway, personal communication). The September 2013 flood reached the equivalent of a 50-year flood, also affecting fish spawning distribution and success. The winters of 2014-2015 and 2015-2016 were unusually characterized by warm temperatures in mid-winter, causing anomalous open-water and ice jamming patterns. The latest spring break-up on record occurred in late May 2013. We are concerned that Project studies conducted under the recent anomalous weather conditions do not accurately represent Susitna River baseline resource characterization. We request that FERC consider these anomalous conditions in their determination on the "first-year" studies, and whether additional years of study may be necessary.

New Study Request: Model Integration and Decision Support System

We propose a new study request for Model Integration and Decision Support System to help address our concerns regarding appropriate characterization and evaluation of Project effects. A new model integration study proposal is requested for the purposes of determining how or if the data produced by the interrelated studies will or can be integrated, and that this study be conducted by an independent group. Furthermore, we are requesting that the model integration effort be used to develop the Decision Support System to help stakeholders and decision makers evaluate the effects of the Project on fish and wildlife resources and their habitats. The USFWS requests that our concerns on these topics be supported by FERC's requirement of the request for the new study (Enclosure 4).

References

Alaska Energy Authority. 2013. Susitna-Watana Hydroelectric Project (FERC No. 14241) Fish and Aquatics Resources Study Plan, Section 9, Introduction, Final Study Plan.

Bernard, D.R., W.D. Arvey, R. A. Holmes. 1993. Operational Planning: the Dall River and rescue of its sport fishery. Fisheries Volume 18, Issue 2

Council of Science Editors. 2006. Scientific Style and Format, 7th ed. Rockefeller University Press. Reston, VA.

Curran, J.H., Barth, N.A., Veilleux, A.G., and Ourso, R.T. 2016. Estimating flood magnitude and frequency at gaged and ungaged sites on streams in Alaska and conterminous basins in Canada, based on data through water year 2012: U.S. Geological Survey Scientific Investigations Report 2016–5024, 47 p., http://dx.doi.org/10.3133/sir20165024.

Regnart, J. and C.O. Swanton. 2012. Operational planning–policies and procedures for ADF&G fisheries research and data collection projects. Alaska Department of Fish and Game, Special Publication No. 12-13, Anchorage.

The Mat-Su Salmon Habitat Partnership. 2013. The Strategic Action Plan of the Mat-Su Basin Salmon Habitat Partnership: *Conserving Salmon Habitat in the Mat-Su Basin*, 2013, Update.

Zuur, A., E.N. Leno, N. Walker, A.A. Saveliev, G.M. Smith. 2009. Mixed Effects Models and Extensions in Ecology with R. *Statistics for Biology and Health.*

Enclosure 2

Susitna-Watana ISR Resource Studies Reviewed

5.5 Baseline Water Quality
5.6 Water Quality Modeling
5.7 Mercury Assessment and Potential for Bioaccumulation
6.5 Geomorphology
6.6 Fluvial Geomorphology
7.5 Groundwater
7.6 Ice Processes
8.5 Instream Flow and Habitat Suitability Criteria
8.6 Riparian Instream Flow
9.5 Fish Distribution and Abundance in the Upper Susitna River
9.6 Fish Distribution and Abundance in the Middle and Lower River
9.7 Salmon Escapement
9.8 River Productivity
9.9 Characterization and Mapping of Aquatic Habitats
9.11 Fish Passage Feasibility at the Susitna-Watana Dam
9.12 Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries
9.14 Genetic Baseline Study for Selected Fish Species
9.16 Eulachon run timing, distribution and spawning in the Susitna River
10.14 Surveys of Eagles and other Raptors
10.15 Waterbird migration, breeding and habitat use
10.16 Landbird and shorebird migration breeding and habitat use

5.5 Baseline Water Quality

Summary of Proposed Modifications and New Studies

USFWS PROPOSED MODIFICATIONS:

Based on the March 2016 ISR meeting the USFWS recommends the following modifications to address study objectives:

- **Modification 1:** Collect another year of water chemistry, water quality, and groundwater data. The majority of water chemistry data collected in 2013 was disqualified due to quality control problems. It is therefore recommended that data collection be extended for another year to compensate for the inadequacy of 2013 data.

- **Modification 2:** Describe data quality issues in a report. The approach used to resolve data quality issues with suspended solids, holding times and temperatures was not sufficiently described.

- **Modification 3:** Make the study completion report into a stand-alone document that provides information about quality control and describes analytical methods and how data will be used in modeling.

- **Modification 4:** Collect data to eliminate spatial and temporal discontinuities. There are no continuous data in the river collected downstream of PRM 90, and there are several 30+ mile reaches in the river where no data have been collected due to access issues. Collection of these data will help in development of more accurate hydrodynamic and water quality models. Sediment should be sampled in slack water areas to determine baseline metals concentrations and assist with the understanding of mercury methylation potential.

Additional recommendations and modifications are found within.

AEA PROPOSED MODIFICATIONS:

- **Modification 1:** AEA proposes to apply a correction factor to the 2013 data.
    - Application of the total phosphorus (TP) correction factor is questionable. The issues associated with the 2013 data are multiple and diverse. The application of this factor will not correct all of them.

- **Modification 2:** AEA discontinued Thermal Infrared Remote Sensing (TIR).
  - TIR sensing is an important component of the study and should not have been discontinued. It was successful in 2012, and only partially completed in 2013 due to persistent poor weather. AEA planned to complete the TIR data collection in 2014 in the Lower River; however that objective was not completed.

REVIEW BY STUDY OBJECTIVE:

In this section, we present the documents we reviewed and review by study objective.

Documents Reviewed

The following represent current and outstanding comments that have not been addressed by the Alaska Energy Authority (AEA), or the Federal Energy Regulatory Commission (FERC) and remain as outstanding comments, concerns or recommendations. We reviewed the body of comments, meeting summaries, and meeting comments related to Topic 5 since AEA released the Final Initial Study Report (ISR) on June 3, 2014. These comments focus on the review of the Susitna-Watana Hydroelectric Project, Water Quality Baseline Study, Study Plan Section 5.5, Final ISR (AEA, June 2014). Since the June 2014 ISR was issued, AEA has released or presented additional study plan information and errata including:

2014 Study Season Technical Memoranda, September 30, 2014

ISR Meeting Presentation Materials, October 16, 2014

Errata Release & Additional 2013 Sampling Data, November 14, 2014

Part D - Supplemental Information to June 2014 ISR Report, November 2015

Baseline Water Quality Study Completion Report, November 2015

Attachment 2 – Initial Study Report Meetings, Agenda, Meeting Summary, and Presentation, March 23, 2016

Study Objectives

The objectives of the Baseline Water Quality Study, as specified in Section 5.5.1 in the July 2013 Final Study Plan (FSP) are summarized below.

- **Objective 1:** Document historical water quality data and combine this information with data generated from this study. The combined data set will be used in the water quality modeling study to predict Project impacts under various operational scenarios.
- **Objective 1:** Add three years of current stream temperature and meteorological data to the existing data set. An effort will be made to collect continuous water temperature data year-round with the understanding that records may be interrupted by equipment damage during river floods, ice formation around the monitoring devices, ice break-up and physical damage to the anchoring devices, or removal by unauthorized visitors to the site.
- **Objective 3:** Develop a monitoring program to adequately characterize surface water physical, chemical, and bacterial conditions in the Susitna River within and downstream of the Project area.
- **Objective 4:** Measure baseline metal concentrations in sediment and fish for comparison to state criteria.
- **Objective 5:** Perform a pilot thermal imaging assessment of a portion (between Talkeetna and Devils Canyon) of the Susitna River. The thermal assessment results would be used to map groundwater discharge and the possible extent of thermal refugia, as specified in the Executive Summary of the ISR.

Following their review, FERC approved the above stated objectives but also recommended changes to the Standard Operating Procedures (SOP) and Quality Assurance Project Plan (QAPP), specifically:

- **Objective 6:** Implementation of Environmental Protection Agency (EPA) 1631E method for laboratory analysis of total mercury in water, sediments, and fish tissue, and EPA Method 1630 for laboratory analysis of methylmercury in water and fish tissue, and application of Method 1669 (Clean Hands/Dirty Hands) for all mercury field sampling.
- **Objective 7:** Utilization of Toxicity Reference Values (TRVs) as an additional benchmark when evaluating the need for additional baseline water quality data collection.

General Comments

The ISR states the methods for the Baseline Water Quality Study were developed to satisfy the calibration needs of the water quality models, establish consistency with historical data collection on the river, and meet the requirements of the 401 Water Quality Certification Process. One of the purposes of collecting baseline water quality data is to calibrate the Water Quality

Model study (5.6). Three issues deserve further consideration in the application of baseline water quality data in this calibration effort, specifically:

The draft ISR revealed that two types of modeling analyses are currently being conducted (page 16, paragraph 2) including (a) pathway model analysis to evaluate potential for transfer of contaminants between different media (sediment – pore water, pore water – surface water, surface water – fish tissue; and (b) numerical modeling. While some details are provided on the numerical model in ISR Study 5.6, it is essential to obtain more details on the pathway model analysis and its relationship to the numerical model to be able to evaluate the use of these approaches in evaluating project impacts.

AEA should elaborate further on the interdependencies between the water quality data and its use in the other studies, i.e. the groundwater study (7.5), river productivity study (9.8), and the mercury pathways analysis (5.7). The water quality data should not only complement development of the riverine water quality model, but also better define the surface water – groundwater interaction.

AEA should also explain whether data are sufficient to accurately model the focus areas. There is a need to increase the resolution of the water quality modeling grid in these Focus Areas. The accuracy of model predictions (e.g. contaminant concentration per cell) and the uncertainty around these estimates increases with smaller grid size (i.e., increased grid refinement); however, smaller grid sizes require more data. Determination of the level of resolution needed to detect differences in water quality parameters between groundwater and surface water in side channels and sloughs (particularly temperature and dissolved oxygen) under different operating scenarios will be critical to evaluate project effects.

As such, the collection of tributary data for use in model calibration requires further description in the reports, as the level of detail currently provided does not allow for an evaluation of how these data will be used.

AEA should sample zooplankton based on known chemical transport mechanisms (see literature review in comments on study 5.7 for a discussion of the potential role of zooplankton in the downstream transport of mercury from newly formed reservoirs). Currently, additional environmental media will only be sampled for metals should exceedances be observed in water, sediment, and fish tissue. Establishment of baseline concentrations in these organisms will be important to the calibration and evaluation of bioaccumulation modeling results, and should be incorporated into the upcoming field sampling program rather than being sampled only if metal concentrations are elevated in fish tissue.

Additional comments regarding how the water quality baseline sampling may impact the modeling program can be found in our comments on studies 5.6 and 5.7.

Review by Objective

Objective 1: Document historical water quality data and combine this information with data generated from this study.

Historical data from the 1980s Susitna project study and monitoring locations were evaluated to determine which historic locations to use in this effort (particularly temperature and water quality). For example, 37 sites were selected at or close to the original 1980s monitoring sites. However, four of the historical sites were not accessible due to geomorphic changes in the river channel.

The Study Completion Report (SCR) included a comprehensive map (Figure 4.1-1) showing the project river miles and sampling/monitoring gauges specifying the monitoring period at each station. While it appears there is a relatively good spacing of monitoring stations that overlap, there is (1) a lack of closely spaced continuous monitoring stations downstream of PRM 90; and (2) there is an almost 30-mile gap (no stations) in the Lower Talkeetna River (between PRM 90 and PRM 60).

An attempt was made to provide more comprehensive discussion of how the data collected in the 1970s/1980s compares with more recent data acquisitions (Section 6, Table 6.0-1). However, it would be useful to have some understanding of how such issues as prevailing weather (temperature, snow/ice cover), flow and geomorphic conditions compare between the times of the original sampling to the present. For example, were summer conditions particularly wet/dry, hot/cold when the samples were obtained in the 1980s? How might this affect the results in comparison with more recent data? This information would be useful when calibrating water quality modelling. There is a danger that the model would be calibrated only to replicate the specific conditions that occur where acceptable data quality is available. This may become skewed in favor of more recent monitoring. More specifically, there are significant and unexplained differences in the concentrations of dissolved calcium and magnesium (increased 1,000 times during existing summer conditions compared with the 1980 summer).

The SCR report confirms that all surface water sample collection avoided pools or slack water. However, sediment samples were taken from slack water areas. Any comparative water quality analysis will need to address this discontinuity. For example, if an appraisal of leaching of metals from sediments into water is carried out, then this will need to recognize that the impact would be directly to water in pools/slack water areas and not necessarily to the main river flow. No supporting discussion or revisions to sediment sampling to address this issue have been provided.

Objective 2: Add three years of current stream temperature and meteorological data to the existing data set.

The success of monitoring during winter 2013/2014 (all 19 thermistor's data were recovered), and monitoring during summer 2014 (all 36 thermistor data were recovered) provided one continuous period of data set in the Upper Susitna River, with an exception of recognized data gaps (page 4 – variances, SCR).

Continuous Water Temperature Monitoring

The number and locations of water temperature monitoring sites were reduced from 37 to 36 sites, however the missing data was supplemented by collecting data upstream and downstream of that site. This variance is minor, and USFWS does not have concerns about it due to potential loss in data accuracy.

Continuous water temperature loggers between PRM 145.6 and the Oshetna River confluence (PRM 235.2) had different periods of record due to late start of deployment in 2012, loss of logging equipment due to ice break-up (winters 2012/13 and 2013-14), and site access issues in 2013. There could be some loss of data accuracy.

The project QAPP called for redundant data loggers at each site (the second instrument to be installed as a bank-mounted pipe system). AEA found it impractical and/or unsafe to implement this protocol at many locations. USFWS does not have concerns about this variance, especially since overwinter anchor and buoy systems were shown to be resilient and had better survival rates than the bank mounted thermistor systems.

Objective 3: Develop a monitoring program to adequately characterize surface water physical, chemical, and bacterial conditions in the Susitna River within and downstream of the Project area.

Since publication of the ISR, AEA has attempted to address the three major issues identified in our previously expressed concerns, specifically: 1) Lack of data from the 50 mile river reach area; 2) Serious problems with the collection, chain of custody, and analysis of representative 2013 baseline samples; and 3) the stated intention to use a "correction factor" to adjust 2013 data concentrations.

Concern 1: The 50-mile reach of Susitna River (including Tsusena Creek), previously inaccessible due to land ownership issues, was successfully sampled in summer of 2014. Winter monitoring was not conducted in that reach and should be included.

Concern 2: AEA provided a consistent summary of all data collected during the 2013 and 2014 sampling seasons, laboratory data reports, and quality control sheets; explained on how this data was contaminated, rejected, and consequently resampled (SCR, pp 15-16). While USFWS looked through this information, we did not have time to conduct quality control of these results. However, we noticed a significant discrepancy in the percentage of the rejected samples (9% - 30%, according to Table 5.1-1), compared to 90% of rejected samples according to our analysis of the 2013 metadata. Thus, AEA should explain why the 2013 data previously rejected, have now been accepted in the analysis. Non-conformance with this objective, if confirmed, is significant.

Concern 3: AEA has provided an explanation of the total phosphorus (TP) conformance factor; however, some of the values in Tables 4.5-3 and 4.5-4 are dubious: corrected TP was calculated as -0.065 (Table 4.5-3); estimate % of TP that is due to TSS was calculated as 128.8%, raising questions on the methodology applied. If there were only one consistent and explainable quality control issue associated with the 2013 data results, the application of a correction factor might be appropriate, after careful review of the procedure to be used. However, the issues associated with the 2013 data are multiple, and diverse, so the application of the TP Correction Factor may be inappropriate.

Water Quality

Two types of water quality data were collected: in-situ data and field samples sent for analysis by an accredited laboratory. The in-situ data included dissolved oxygen (DO), acidity (pH), specific conductance, color, redox potential, and chlorophyll a. A large portion of the laboratory processed samples were labeled as “qualified” in several data validation reports.

- One of the monitoring stations was moved from PRM 225.5 to PRM 235.2 due to limited site access by helicopter. USFWS agrees that this relocation will not jeopardize construction and calibration of the water quality model.
- During winter of 2013/14 baseline monitoring, samples were collected in January instead of December, and because of the limited access to PRM 187.2 samples were collected at PRM 185. USFWS agrees that both variances have minimal effect on study results.
- Additional water quality sampling occurred in 2014 at selected locations and for parameters for which 2013 samples were qualified as either “rejected” or “estimated”. However, all the 2014 samples were “single grab sample-types” based on the conclusion that there was no horizontal or vertical variability at sample locations (from 2013 samples). USFWS questions the validity of that conclusion, as it could have been based on the 2013 samples that were previously rejected.
- The TP detection limit of 3.1 micrograms per liter (used in 2013 samples) was lowered to 2.0 micrograms per liter in processing 2014 samples. USFWS agrees that this lower detection limit will improve accuracy.

Another decision made based on the 2013 data was to conduct sampling in 2014 using a single grab sampling method. All the 2014 samples were "single grab sample-types" based on the conclusion that there was no horizontal or vertical variability at sample locations. The problems with the data collection in 2013 may have led AEA to an erroneous conclusion because it is difficult to assess variation using questionable data. Additional water quality sampling occurred in 2014 at selected locations and for parameters for which 2013 samples were qualified as either "rejected" or "estimated". We question the validity of the lack of variation in the data, as it was based on 2013 samples that were rejected.

Focus Area Water Quality Monitoring

Seven instead of ten Focus Areas were sampled due to site access limitations. AEA corrected this sampling gap in the 2014 field season.

More sampling points (up to six) along each transect were included within each Focus Area than originally identified in the FSP. We agree that this variance will improve resolution in modeling of the focus area.

Groundwater

Groundwater samples were collected from wells in four Focus Areas. However, the Final ISR included only samples processed and analyzed before August of 2013. No anomalies were detected in the results presented through August 2013 period.

Shallow groundwater was not identified in the Focus Areas closest to the proposed dam site. The proposed reservoir area will experience alternating groundwater levels and increased surface water-groundwater connectivity in previously unsaturated strata under operational scenarios. The TIR data may help distinguish areas of the Susitna River subject to complex hyporheic zone processes and those that are not but does not preclude necessary analyses of ground and geological conditions in the vicinity of the dam.

Wells for groundwater sampling had to be moved from the end of each main transect to area where they could be successfully installed, and more aligned with the groundwater wells from the groundwater study. This change would improve likelihood of measuring groundwater interaction with surface water.

A planned groundwater well installed at the downstream end of Focus Area 138 did not have sufficient recharge rate, indicating little surface water – groundwater interaction at this location.

Additional groundwater samples were not collected in 2014, although the data collected in 2013 were suspect and required additional sample collection to further support 2013 efforts.

Objective 4: Measure baseline metal concentrations in sediment and fish for comparison to state criteria.

Measuring baseline metal concentrations in sediment and fish for comparison to state criteria is the main objective. Methods to assess the baseline metals in fish tissue are provided in the Study 5.7 ISR (see Section 5.7, pages 17-19, Study Plan Section 5.7-Part A, ISR.

While the RSP targeted the collection of seven to ten fish of each target species, additional fish were collected for Arctic grayling (16) and round whitefish (12), including the incidental collection of some juvenile fish (also in variance with the FSP stated intent of only collecting adult fish). Due to the scarcity and difficulties in differentiating between humpback and round whitefish, only two known individual humpback whitefish were collected for analysis in 2014. No rainbow trout or sticklebacks were captured in 2014, and there was no evidence that these species were present in the proposed inundation zone. In contrast, slimy sculpin, a non-target species, were observed in large numbers in the study area, and were collected for analysis of whole body samples (due to their small size) to expand the amount of data available for mercury bioaccumulation. Otoliths could not be extracted for all fish. Only 21 fish have had otoliths extracted and analyzed for age as part of this study to date. The determination of sex and sexual maturity of fish proved to be problematic in the field, and the sex of only 12 fish was determined. In contrast with the FSP, fish samples were collected past the originally identified August to September sampling period, extending into early October to obtain sufficient sample size for targeted species. A final variance was the substitution of polyethylene sheets for the originally identified Teflon sheets in sample bags. Samples were analyzed for total mercury and methylmercury by EPA Methods 1631 and 1630, respectively. Liver samples were also collected from burbot and analyzed for total mercury and methylmercury. Species identification, measurement of total length (mm), and weight (g), sex and sexual maturity were recorded when possible.

While the FSP specified collecting seven to ten adult fish per species, additional Arctic grayling and round whitefish samples were collected in 2013, with some of the species being juveniles. In contrast, only one humpback whitefish was captured, and two whitefish individuals could not be identified as to species. No rainbow trout or sticklebacks were captured during the field effort, and no evidence was found that these species are present in the proposed inundation zone. While slimy sculpin were not originally targeted for collection in the FSP, this species was found to be common in 2013 and was collected for whole body analysis for methylmercury concentrations. Aging all collected fish through the collection of otoliths has not been possible. Only 21 fish have had otoliths extracted and analyzed for age to date. Similarly, not all fish could be sexed during collection and the sex of only 12 fish has been determined. The period during which fish were collected was extended from September to October in 2013. The project QAPP stated that

Teflon sheets would be used for the fish when placed in the sample bag. The study team had difficulty sourcing this material, and switched to polyethylene sheets. Given that muscle samples are taken from inside the fish, this material should not have introduced any contamination to the sample and have no effect on achievement of the study objectives. The study plan will be modified to allow use of polyethylene sheets for sampling.

Sediment Sampling

Four instead of ten sites were sampled in 2013 due to land access restrictions.

Sediment was sampled using hand auger or stainless steel spoons. This change was necessitated by restrictions on sampling equipment weight imposed by helicopter use (instead of boats) to access sampling locations. We agree that this change in sampling technique should not affect quality of the collected sediment data.

There is no analysis or explanation why sampling avoided slack and pool channel areas. The SCR confirms that all surface water sample collection avoided pools or slack water while sediment samples were taken from slack water areas. There is no comparative water quality analysis to address this discontinuity. Given that fine sediment with higher organic carbon content is often localized in these areas, this avoidance has large implications for baseline metal concentrations and especially for mercury methylation modeling, which depends in part on organic carbon and sulfate concentrations in sediment. If an appraisal of leaching of metals from sediments into water is carried out, then this will need to recognize that the impact would be directly to water in pools/slack water areas and not necessarily to the main river flow. No supporting discussion or revision to sediment sampling to address this issue has been provided. This is a problem and should be corrected in a subsequent year of sampling.

Objective 5: Perform a pilot thermal imaging assessment of a portion (between Talkeetna and Devils Canyon) of the Susitna River.

The main objective of Thermal Infrared Remote (TIR) in 2013 was to collect thermal data for the Focus Areas and for the Lower River. This is important for understanding groundwater/surface water interactions. The TIR sensing methodology was successful in 2012, collecting TIR data for Lower and Middle rivers. In contrast, the TIR sensing effort was only partially successful in 2013 in collecting data for the Focus Areas and portion of the Lower River. AEA had planned to complete the TIR sensing effort in 2014 for the remaining portions of the Lower River.

Data Acquisition for this technique requires that the air temperature be cold, with no wind, no ice on the river, and no precipitation during the sampling flights. In 2013 six weeks of effort during October through November of 2013, resulted in only five days of usable data, including all the

Focus Areas, and 73% of the Lower River. AEA collected the remaining data for the Lower River and Middle River in the 2014 field season.

This technique, although not complete, identified numerous groundwater contributions in eight (of ten) Focus Areas. The remaining two Focus Areas showed only minimal groundwater activity. Temperature data derived from the TIR analysis showed relatively good correspondence with temperature data from the in-stream sensors, where these sensors were located close to the identified source of groundwater upwelling.

The methodology for data interpretation is not well described. For example, what criteria were used by the analyst to determine whether "increased groundwater activity" had been detected? It is not clear from the images reproduced in Appendix J.

Water temperature, water quality, hydraulic head depth at between 0.15 m and 0.3 m below the river or stream bed can supplement TIR to clarify the relationship between hyporheic conditions and incubation periods for indicator species. There is evidence based on salmon-spawning rivers (although not in Alaska) that dissolved oxygen in particular can vary considerably at 0.3 m depth and is strongly linked to river discharge (Malcolm et al, 2006; Environment Agency 2009).

TIR is relatively constrained by weather conditions and the fact that temperature differentials between surface water and groundwater are lower in Alaska than in other areas of the United States. Caution must be applied when using TIR data to interpret hyporheic mechanisms and their implications for year-round water quality and habitat characteristics. Prevailing weather can alter surface water – groundwater interactions. For example, a cool, dry summer may lead to lower river flows due to reduced snow melt and a greater influence from groundwater base flows.

AEA planned to complete the TIR data collection in 2014 in the Lower River; however that objective was not completed, and no plausible explanation was provided (page 14, SCR, Section 4.8 states: "The data was reviewed further and it was determined that no additional TIR data would be collected.")

Caution should be exercised in interpretation of results from remote sensing applications, especially where there is potential for anomalous results. A clear distinction should be drawn between the use of TIR for identifying areas where there is strong potential for surface water – groundwater interaction at certain times of the year and in-situ field data for baseline water quality monitoring.

There is no information in the ISR about other potential means of determining groundwater-surface water interactions such as hydrochemical tracers.

Objective 6: Implementation of Environmental Protection Agency (EPA) 1631E method for laboratory analysis of total mercury in water, sediments, and fish tissue, and EPA Method 1630 for laboratory analysis of methylmercury in water and fish tissue, and application of Method 1669 (Clean Hands/Dirty Hands) for all mercury field sampling.

Implementation of the EPA methods for laboratory analyses of mercury and methylmercury has been included in the Final ISR (revised QAPP document) (Table 12b, Section 5.5, Part B, and Attachment 1). A more detailed discussion can be found in the Objective 3 section above.

Objective 7: Utilization of Toxicity Reference Values (TRVs) as an additional benchmark when evaluating the need for additional baseline water quality data collection.

The Final ISR confirmed that AEA has accepted FERC's recommendation for the use of TRVs "as an additional benchmark when evaluating the need for additional baseline water quality data collection"; yet no discussion has been provided as to the specific TRVs to be incorporated, or how they would be applied in determining additional sampling needs for the upcoming field season. Although it has been noted that TRVs will be used in the evaluation of the baseline data (Final ISR, Section 5.5, Part B, Attachment 1 – QAPP), the TRV values have not been explicitly identified. A table of actual TRV values should be provided.

Comments on the ISR and QAPP

The following are comments were developed from review of the Final ISR Section 5.5 Part C - Executive Summary and Section 7:

Section 7.1.2, page 2

The Final ISR should explain measures proposed to correct data quality issues in 2013 for water samples (i.e., sample preservative affecting detection of the target analyte, bottles of reagent water were contaminated with the target analyte(s). AEA has performed split sample analysis with multiple laboratories, although other steps (pre-analysis of reagent water and sample preservative) may be useful.

Section 7.1.2, page 2

AEA notes that "the strategy for additional sampling was based on comparison of 2013 results with applicable criteria or thresholds (RSP Section 5.5.4.4)." The comparison of 2013 results to thresholds should be provided.

Section 7.1.2, page 2

AEA should provide the data analysis that indicates a lack of horizontal or vertical variability in the water quality results for 2013.

Section 7.2, page 4 – water temperature data collection, second bullet:

It is stated that "continuous temperature data collection…will be partitioned". More details should be provided on how that will be done.

Section 5.5B – Attachment 1, QAPP

Nowhere in the documentation issued to date has there been an appropriate discussion of the overall ecological health of the river and tributaries. There is significant discussion of water quality parameters and some of this relates to species present in the project area. The overall documentation would therefore benefit from, at least, a qualitative statement on species present, relative abundance and habitat health.

Vegetation monitoring and meteorological monitoring are to be carried out. There is no information within the QAPP about quality assurance and control for the monitoring carried out under these studies.

QAPP, Section B.1.1, page 42

AEA has noted that "TRVs for surface water ecological receptors and TRVs calculated for community measurement receptors in sediment will be determined as outlined in EPA (1999)". EPA (1999) TRVs were not explicitly listed by AEA in Section 5.5, and it is difficult to discern which TRVs would be selected for decision-making, and which of the project species would be assessed. For example, while EPA (1999) provides a TRV for mercury chloride and methylmercury for mammals and birds, and it is unclear whether AEA will assess both mercury and methylmercury separately.

QAPP, Section B.1.2, page 54

The paired soil and vegetation samples appear clustered in the middle section of the reservoir. AEA should provide information on how plants and soils in this area will be representative of the other (unsampled) areas.

QAPP, Section B.2.1, page 65

AEA should specify which fish tissues were collected. A footnote on page 37 suggests fillet samples will be analyzed from all fish. Although samples of fillet are appropriate to evaluate human health risks, concentrations of mercury in whole body samples are generally used for evaluated ecological risks to piscivorous wildlife. Wildlife generally consumes the entire fish, and concentrations of mercury in fillet do not equal concentrations of mercury in whole body, since mercury can preferentially accumulate in organ tissue.

QAPP, Section 2, Table 12a

The maximum holding time for Total Phosphorus (TP) was specified as 48 hours (if not field preserved) and at 28 days if preserved. AEA should provide additional information on the TP holding time for the TP sent to the AR and SGS laboratories that conducted split sample analysis for the data collected in August 2013 and for which preliminary results were presented at the December 2, 2013 TWG meeting. If the holding time was adequate for August 2013 samples, was an appropriate preservation method used according to this table? Explanation of this discrepancy in laboratory results has been noted during TWG meetings, but never explained.

QAPP, Section B.2.3, page 72

The Final ISR should include the depth of probe insertion for porewater extraction. In addition, describe procedures and additional measurements to confirm that the probe did not short-circuit (i.e., confirm it sampled sediment porewater and did not pull in surface water). Additional description of how the sample containers were filled (i.e. no headspace) is required. Headspace in sediment porewater sampling containers can alter mercury/methylmercury speciation.

QAPP, Section B.2.3, page 72

For the porewater method, it is possible to have a “short circuit” in which surface water (rather than sediment porewater) is extracted by the device. AEA should comment on and provide more detail on the procedures that are being followed to ensure no short circuiting is taking place during sampling, and how chemistry results are being evaluated to ensure that short circuiting did not occur.

QAPP, Section B.2.3, page 73

AEA should confirm that sediment sample containers were filled entirely (without headspace). The presence of headspace can result in changes to mercury speciation and alter methylmercury levels.

QAPP, Section B.2.3, page 73

AEA should provide additional details about which plant tissues will be collected. Root tissue should be collected in addition to shoots/leaves, as roots can exhibit higher concentrations of mercury compared to other plant tissues (Boening, 2000). Additionally, below-ground plant tissue will be subject to anoxic conditions in sediment following inundation, encouraging the formation of methylmercury.

QAPP, Appendix D-4, page 1

AEA should identify the method(s) of fish collection. We could not find anything in the documents on how AEA is capturing fish from the river. All we could find was "Clean nylon nets and polyethylene gloves will be used during fish tissue collection" (D-4, page 1)

QAPP, table on pages 28-37 and again in Appendix A

Focusing on the column for "most stringent water quality standards, sediment thresholds and designated uses", we are concerned the values listed for the following factors are inappropriate:

Barium: Should be 3.9 µg/L, based on chronic aquatic life criteria. Source is NOAA SQuiRT, http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf

Beryllium: Should be 0.66 µg/L based on chronic aquatic life criteria. Source is NOAA SQuiRT, http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf

Cobalt: Should be 3.0 µg/L based on chronic aquatic life criteria. Source is NOAA SQuiRT, http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf

Vanadium: Should be 19 µg/L based on chronic aquatic life criteria. Source is NOAA SQuiRT, http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf

QAPP page 12, paragraph 2: This section states that mercury data collection is also to include fur and feathers from piscivorous wildlife, per FERC-approved study plan, however to date the Project has not accomplished this objective and according to the Project Implementation Schedule (Part B, Attachment 1 – Page 23) AEA is not planning to implement the Fur and Feather Sampling survey until Summer 2015 and only if pathways analysis indicates transfer of mercury/methylmercury from the aquatic to terrestrial environment. This second statement is not in accordance with the FERC-approved study plan and conflicts with the QAPP.

QAPP page 16 – The statement "The ADEC limit for mercury in fish tissue that protects human health consumption is 0.3 mg/kg." is incorrect. ADEC does not establish the health-protective value for mercury in fish; the Alaska Division of Public Health does.

QAPP page 17 – objective A.5.3, paragraph 2: The goal of the Water Quality and Mercury Assessment is also to protect aquatic biota and piscivorous wildlife. NOAA SQuiRT chronic screening levels for protection of health of aquatic biota should be used, per the FERC-approved study plan.

QAPP Table 5 page 23 – The issue of whether to sample fur and feathers for mercury in piscivorous wildlife should not depend on the pathways analysis. Per the FERC-approved study plan, AEA is committed to sampling fur and feathers. It is not consistent with the FERC approved study plan to delay the fur and feather sampling, nor to substitute a "mercury pathways analysis" for actual biota samples collected within the Project area. Performing the survey only if the results from pathways analysis indicate transfer of mercury/methylmercury from the aquatic to the terrestrial environment is not an option due to the lack of representative data collected to date (2013 rejection of all water quality mercury sampling) and the fact that models can be inaccurate. Given the lack of data it may not be possible to generate an adequate pathway analysis. Furthermore, fur sampling should not be conducted in the summer; it should be conducted in the winter (see QAPP appendix D-5). The QAPP is internally inconsistent in body vs. appendices.

QAPP page 55 – second paragraph – this approach is not in accordance with the FERC-approved study plan, which includes the collection of fur and feathers for mercury analysis. AEA has committed to doing that analysis, the modeling alternative is not a substitute for collection of representative baseline data.

QAPP Appendices D-5 and D-6 does not acknowledge the method that was agreed to in a technical conference call on July 3, 2013. Verbrugge (USFWS) presented evidence for the superiority of EPA method 7473 (Direct Mercury Analyzer) when sample size is very small (as with a hair snag). The consultants and AEA agreed to consult with Verbrugge and strongly consider using EPA 7473 when only small hair or feather samples are obtained (less than 0.5 g). This would lead to usable data rather than a "non-detect" from EPA method 1631, which has a higher detection limit.

QAPP Appendix D-6 does not reflect the strategy to collect blood from bald eagle nestlings rather than attempting to collect feathers from the ground below nests.

ISR – Part D - Specific comments

No explanation was provided on why the Thermal Infrared Remote (TIR) sensing study was terminated and not continued in 2014, although it was identified as one of the main project objectives (pages 2-3). The TIR was also identified in the study plan modifications (page 9), but was never conducted on the remaining portion of the Lower Susitna River in 2014.

Page 8, last paragraph – our analysis of the 2013 metadata identified significant quality control issues with the 2013 data (February 25, 2014 Technical Memorandum from Ramboll Environ) affecting most (97%) of the water quality results for mercury analysis. The paragraph on page 8 identified a sample preservative as a culprit that contaminated majority of the results. Nothing was stated about contamination of samples by glacial flour, although it was discussed during the latest post-ISR meeting.

Page 8, last paragraph, the hyper-link identifying the summary table of the lab results could not be accessed at the time of the review (week of February 15, 2016).

Page 8, last paragraph, "*as modification was implemented*"... It is not clear which modification AEA is referring to.

Page 8, last paragraph, last sentence: …*given the lack of horizontal and vertical variability in the results for 2013…, only a single grab sample was collected at each site transect in 2014,*….While the RSP allows change in the sampling protocol under these conditions, we are questioning the interpretation of the 2013 results. If it is known that the majority of 2013 samples were either contaminated or rejected, how was that conclusion (about spatial non-variability) reached? If that conclusion was based on the analysis of the rejected samples, the conclusion is not valid, and no deviation from sampling methodology should have been allowed.

Study Completion Report - Specific comments

Page 2, Section 4.1 (last paragraph) – "baseline temperature data were spaced at approximately 5-mile intervals…" According to Table 4.1.-1 (page 36), there are several 30-mile gaps on the river with no temperature data (for example no stations between PRM 59.9 and 87.3). AEA should explain how the lack of the data in this section may have affected calibration of the hydrodynamic model.

Page 5, Section 4.2.1, 2nd paragraph – additional collection of data at some meteorological stations is appreciated, but the hydrodynamic model should utilize simultaneous meteorological data (from different stations) for best calibration and spatial representation.

Page 7, Section 4.3 – Does the rationale for reducing number of samples collected in 2014 seem adequate based on the data provided in Figures 6.1-4, 6.4-2 and 6.4-5?

Page 7, Section 4.3 – What criteria were used to establish acceptable limits for precision between the two analytical laboratories, SGS and ARI. How was the subset of sites selected for re-sampling in 2014? What specifically was the method used to estimate concentration by eliminating interfering elements?

Page 8, Section 4.3.1, last paragraph – Analysis of the 2013 data showed no spatial variation….We question this inference, as the majority of the 2013 data was compromised. If the data from 2013 cannot be used to make conclusions regarding overall water quality, then the reduced sampling effort in 2014 may not be sufficient to provide a baseline of water quality conditions.

Page 9, Section 4.3.2 – How can the assumption that there is little difference in physical and chemical conditions between PRM 235.2 and PRM187.2 be verified? What were the limits established to suggest samples values are similar or different? Also in 2014 the Watana Dam site was not sampled due to limited accessibility. Monitoring occurred several miles downstream. Since this is the proposed siting of the dam, additional data should be collected from this location.

Page 9, Section 4.3.2 – Sample results from 2013 showed little horizontal and vertical variability however because the data was flagged for interferences how can the data be used with any reasonable assurance to reduce sample collection efforts in 2014?

Page 10, Section 4.4 – Why were additional groundwater samples not collected in 2014 if the data collected in 2013 was suspect and required additional sample collection to further support 2013 data collection efforts?

Page 10, Section 4.4.1- It is not clear that the rationale for reducing sample collection efforts in 2014 is sound given the quality issues associated with the 2013 data sets. How can variability or lack thereof be assessed using low quality data?

Pages 11-13, Section 4.5 – TP Correction Factor – Some of the calculated values in Tables 4.5-3 and 4.5-4 are dubious: corrected TP was calculated as -0.065 (Table 4.5-3); estimate % of TP that is due to TSS was calculated as 128.8%, raising questions on the methodology applied. If there were only one consistent and explainable quality control issue associated with the 2013 data results, the application factor might be appropriate after careful review of the procedure to be used. However, the issues associated with the 2013 data are multiple, and diverse, so the application of the TP Correction Factor is inappropriate.

Page 14, Section 4.6.1 – Change in sample collection from Ekman Dredge and van Veen to hand auger and or stainless steel spoon. AEA should describe comparability of sample collection methods, particularly for capturing fine grained sediments.

Page 14, Section 4.8 – Decision not to collect any more TIR data in 2014 was sudden. AEA should provide an explanation for this variance.

Page 15, Section 5.1.1 – Data quality issues with TSS, holding time and temperature exceedances - the approach has not been sufficiently described, questioning the interpretation of the data. USFWS did not have time to review data reports (field data reports, laboratory data reports) summarizing field data collected during 2013 and 2014 monitoring seasons, and/or conduct any quality control. Thus, we cannot assure data quality provided in the data reports.

Page 23, Section 5.4.7 – We recommend showing graphs of the dissolved metals accepted for analysis – only one example is shown in Figure 5.4-8.

Page 24, Section 5.4.8 – The TDS concentrations were shown in graphs, but TSS concentrations were not.

Page 30, Section 6.1 – It is stated that "*water quality conditions have not changed over the past approximately 30 years and is typical of water quality*….".While this statement is true for the majority of the data, there is significant difference in the concentration of dissolved calcium and magnesium (increased 1,000 times during summer). Please explain.

SUMMARY COMMENTS

The USFWS has concerns about the quality of the water chemistry and water quality data collected in 2013, as well as decisions made using these data as inputs. These data quality issues should be described in a data quality report, which will allow stakeholders to better understand usability of the data. We do not support the use of a total phosphorus correction factor because the application of a correction factor to poor quality data is likely to result in more poor quality data. Further justification for this method must be provided. We maintain that the thermal infrared sensing should have been completed in 2014, as originally planned. In addition the spatial and temporal discontinuities in the data set should be addressed. The design for this repeat sampling should account for data quality as well as data quantity in 2013.

References

Boening, D.W. 2000. Ecological effects, transport, and fate of mercury: a general review. Chemosphere 40:1335-1351.

Environment Agency. 2009. The Hyporheic Handbook: A handbook on the groundwater–surface water interface and hyporheic zone for environment managers. Integrated catchment science programme Science report: SC050070.

[EPA] Environmental Protection Agency. 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities (Volume 1): Appendix E Toxicity Reference Values. EPA 530-D-99-001A. U.S. EPA Region 6, Office of Solid Waste, Multimedia Planning and Permitting Division. Dallas, TX.

Malcolm, I.A., C. Soulsby, and A. Youngson. 2006. High frequency logging technologies reveal state dependent hyporheic process dynamics: implications for hydro-ecological studies. Hydrological Processes 20:615–622.

5.6 Water Quality Modeling

Summary of Proposed Study Modifications and New Studies

USFWS Proposed Study Modifications
Based on the March 2016 ISR meeting and to meet the overall study goals, the USFWS recommends the following modifications:

Modification 1: Complete the Water Quality Modeling Study. The items completed since the June 2014 ISR report were actually completed ahead of the April 2014 Proof of Concept (POC) meeting.

Modification 2: Provide a Model Integration Study Plan to document modeling methods and show how the water quality model integrates with other models.

Modification 3: Extend the modeling studies below project river mile 29.9.

Modification 4: Validate and calibrate the riverine model for the focus areas, and provide summary statistics that quantify model fit.

Modification 5: Describe the effects of missing or inadequate water quality data on model performance (also see comments on 2013 data in section 5.5).

Modification 6: Provide "preliminary calibration" results of the water quality model incorporating hydrodynamics, water quality results, model parameterization, and goodness of fit statistics for selected locations, dates, and times.

Modification 7: Provide evidence that the use of the 20-layer model (not a 40-layer model) with the bottom layer thickness of 25 meters retains accuracy in predicting thermal stratification in the future reservoir.

Additional recommendations and modifications are included within.

AEA's PROPOSED MODIFICATIONS:
AEA has not proposed modifications to this study.

REVIEW BY STUDY OBJECTIVE:
The goal of the Water Quality Modeling Study was to use data from the Baseline Water Quality Study (Section 5.5.) to develop models to evaluate the impacts of the proposed Project on physical parameters within the Susitna River watershed. The objectives of the Water Quality

Modeling Study, as specified in Section 5.6.1 in the July 2013 Final Study Plan (FSP), are as follows:

Objective 1: To implement an appropriate reservoir and river water temperature model for use with the past and 2012–2014 monitoring data.

Objective 2: To use the data from Study 5.5 to simulate water quality conditions in the future reservoir, including temperature, DO, fine suspended sediment and turbidity, chlorophyll-a, nutrients, ice, and metals, and

Objective 3: To use the data from Study 5.5 to simulate water quality conditions in Susitna River downstream from the future reservoir, including temperature, DO, fine suspended sediment and turbidity, chlorophyll-a, nutrients, ice, and metals.

Objective 4: To account for ice process effects using output from the River 1D Ice Processes Model (in coordination with the Ice Processes Study).

General Comments

The water quality model (EFDC) has been developed from the Susitna reservoir upstream to the Susitna River PRM 29.9 downstream. The extension of the EFDC model in the Susitna River downstream of PRM 29.9 would significantly increase complexity (because of a multiple braided river), and would require collection of detailed bathymetry to establish a solid hydraulic, geomorphologic, and water quality database. Simplified studies were conducted in off-channel areas in downstream reaches below PRM 29.9. The approach could be simplified by using the EFDC model, open water model, and the PHABSIM model during the ice-free period as needed to assess project-related impacts in this downstream reach. Relationships to the other suite of project models (groundwater and geomorphology) could be utilized only if the data are available.

A significant focus of recent project activities has been devoted to model integration (Model Integration Meeting, Proof of Concept Meeting). However, the Final ISR does not provide any details on integration between the Water Quality Model and the Ice and Groundwater models.

While some modeling results have been provided in the Final ISR, no sensitivity analysis of different operating scenarios has been conducted.

It would be useful if AEA would provide tables identifying grid sizes used in (a) the main Susitna River, b) target focus areas – main channels, and c) the target focus areas – lateral side channels and sloughs.

The Final ISR states that the reservoir water quality model and the mercury recycling model will be configured and tested in 2015 and that the downstream water quality model will be configured for Pre-and Post- project conditions and calibrated for Pre-project conditions. Additional calibration is planned for the Focus areas. At the time of this submission, this calibration and validation has not occurred.

The plan for conducting the mercury cycling model is not clear. The Final ISR does not provide details regarding the mercury modeling and, to date, details on this modeling effort have not been released. The Final ISR does not provide a schedule for completing the mercury cycling model.

The Final ISR states that the results of the pre- and post-project EFDC modeling runs will be used to determine whether to extend the Water Quality Modeling study below PRM 29.9. Prior to finalizing this decision, an assessment of how the EFDC model will be used to represent a multiple braided river is required.

Objective 1: Implement an appropriate reservoir and river water temperature model for use with past and current monitoring data.

This section is well presented, including the relationship between the Water Quality Model and the Geomorphology Model, and the relationship between the Water Quality Model and the River Ice Process Model. However, relationships between these models and the Groundwater Model and Open Water and Ice Cover Model have not been described. A description of how the model results will be integrated with these other studies should be provided to the Services.

The Water Quality Modeling Section of the ISR states that the hydrodynamic/water quality model Environmental Fluid Dynamics Code (EFDC) was selected with three different Resolutions including: 3-D Reservoir Water Quality Model, a general 2-D River Water Quality Model, and 2-D River Water Quality Model with Enhanced Resolution Areas. Selection of the EFDC model with its variations fully satisfies Objective a. for the Final Study Report (Study Implementation Report) Water Quality Modeling Study, if implemented correctly. The EFDC model is suited for modeling reservoir and riverine environments, and a suite of water quality parameters. Nonetheless, the model does not provide a detailed simulation of ice dynamics and/or groundwater processes. Close coordination with the Ice Modeling and Groundwater Study teams will be required.

AEA has not released summary table of selected EFDC model parameters used in different parts of the model and state model variables and outputs have been only partially summarized in the ISR, Parts A and B, although they were presented in one of the previous technical meetings.

In addition, is a standard practice to provide comparison statistics while evaluating how "good" a model is. Although scatter plots of the predicted versus observed temperature were provided for the April 2014 Proof of Concept analysis (Appendix A, Figures A-4 and A-6), similar graphs are needed for the updated analysis. Please provide a table of calibration statistics (residual average, residual standard deviation, R2, etc.) for selected locations and selected times/dates. It is important to provide this information as early as possible in the process (i.e., not at the end of the study), to provide sufficient time for mitigation measures if the model needs to be corrected.

It is unclear how the spatial and temporal discontinuities in the data—specifically large gaps between water quality transects—affect the hydrodynamic part of the water quality model (see also comments on Section 5.5). We suggest a longitudinal profile of the model be displayed graphically to evaluate how well the model predicts conditions at locations on the river where there is a greater distance between data collection sites. The specific reach in question is: Reach PRM 143.6 – PRM 209.2 (no water temperature data were collected during summer 2013 and winter 2013–2014);

Objective 2: Integrate data from the Baseline Water Quality Study to predict water quality conditions in the proposed Watana Reservoir, including (but not necessarily limited to) temperature, dissolved oxygen, fine suspended sediment and turbidity, chlorophyll-a, nutrients, ice, and metals.

The plan of the proposed model grid covering the reservoir appears adequate. The model grid in a vertical direction was not illustrated. The proposed thickness of the bottom layer (in the 20-layer vertical grid) is too high (82 feet) to accurately capture the reservoir temperature stratification. Results supporting "adequate simulations under ice-free conditions" using the 20-layer and 40-layer configurations should be presented to allow for an appropriate review of the modeling results.

The 3-dimensional model is being developed to simulate the future conditions in the proposed reservoir. The model has been set to simulate temperature, dissolved oxygen (DO), suspended sediment (less than 125 microns), turbidity, chlorophyll-a, nutrients, metals, and ice dynamics. Dissolved oxygen and some nutrients (nitrite plus nitrate, ammonia nitrogen, dissolved and particulate organic phosphorus, dissolved and particulate inorganic phosphorus) are being included as the model state variables. Suspended sediment transport is included in the model through the sediment diagenesis module and through the solids and fate transport module.

An explanation of how chlorophyll-a will be included in the EFDC model has not been provided. The horizontally variable ice cover and thickness will be simulated by the reservoir temperature model. Although the model was calibrated, no results demonstrating success of the calibration have been presented in the report. This validation and calibration information is critical. Although reservoir simulations showing changes in water temperature have been described, simulations for the other variables are missing.

Objective 3: Model water quality conditions in the Susitna River from the proposed site of the Watana Dam downstream.

The riverine model has not been validated and the model has not been calibrated in the focus areas. The simulation results provided show that the model performs satisfactorily for selected times and locations; however, no model summary statistics were provided to show how these results are spatially representative of the overall model performance. Furthermore, no backup information was provided to complement the riverine model calibration, the model has not been validated, and no model calibration has been conducted for any of the selected focus areas.

The proposed configuration grid for the main river stem and tributaries appears reasonable. The results and the material illustrating the preliminary model calibration were not available at the time of this review.

The Susitna River water quality model downstream of the proposed reservoir has been developed. The model is designed to simulate temperature, suspended sediment (less than 125 microns), turbidity and ice processes. It is understood that the ice cover and thickness will not be directly simulated in the river, but will instead be provided by the River Ice Process model.

Some modeling results are presented in the Final ISR. The integration of the Water Quality Model with the Groundwater Model assessments is not reported. However, some discussion about integration with the Ice Processes Model was provided.

The ISR report should provide a detailed discussion regarding the integration of the Water Quality Model with the Groundwater Model, Ice Processes Model, Geomorphology Model, and other models and their connection (i.e. which model parameters and results are being transferred from the Water Quality Model). Access to this information is vital to determining how and if the scale and resolution of this information transfer may affect results and conclusions of the overall study.

The model should be undergoing calibration using data collected during the June through August 2012 period, however little progress was made on the modeling study in 2015 due to loss of staff on the project. The hydrodynamic module was being calibrated first (to velocities and water levels), followed by the water quality module. The ISR did not disclose details regarding the ongoing calibration efforts. Some riverine model simulation results were provided during the 2014 Proof of Concept Meeting and are described in the ISR report. However, no calibration details have been provided. In addition, only the flow and temperature simulation results were presented. Suspended sediment, turbidity, and metals should also be simulated.

AEA has not clarified why the hydrodynamic model has not been calibrated and validated. AEA is required to complete model calibration and validation according to the Final Study Plan (FSP). AEA committed to release the hydrodynamic calibration report in early 2015. It is unclear whether AEA will be able to split data set in two parts (one part for calibration, and one part for validation) as required in the FSP. AEA acknowledged that the model sensitivity analysis will be provided to the Stakeholders. Until a satisfactory calibration report has been provided, it is difficult to place confidence in the water quality model results.

Further details are needed regarding incorporation of the mercury model into the EFDC. This model will be incorporated as a new EFDC module "to simulate mercury cycling and possibly other metal and organic contaminants, if analysis of observational data suggests a need to address this toxicity" (ISR Section 5.6, page 7).

Hydrodynamic and temperature modeling results were included in the Final ISR showing robust modeling can be conducted in Focus area 128. It is unclear whether the EFDC modeling grid provides adequate accuracy to model lateral habitats.

The report states that "anticipated spatial resolution in the focus areas is "…100 meters (m) longitudinally and 30 m laterally". The corresponding grid shown in Figure 5.4-1 appears adequate; however the grid resolution should be scaled to the level of resolution needed to represent groundwater upwelling and ice dynamics in each area. It will be necessary to show how the selection of this particular grid resolution improves the accuracy of capturing groundwater upwelling and the thermal stratification reflected in the thermal image assessment maps.

Variances from the study plan were not identified, however the water quality model is still under development and we anticipate there will be revisions and improvements. Variances in the water quality study 5.5 will affect the completion of study 5.6 however; those are discussed in our comments on study 5.5, rather than in this section.

SUMMARY COMMENTS

Based on our review, the AEA did not provide sufficient information to reliably assess the proposed modeling approach. We recommend that AEA do the following:

Provide a Model Integration Study Plan and coordinate the different modeling groups. This would include quality control of the model input data, modeling assumptions, consistency in the use of parameters between different models and modeling integration.

Provide better integration between the Groundwater and Water Quality Models, making sure that accuracy and resolution is preserved when defining groundwater upwelling areas. Specifically, the potential lateral transport of groundwater as affected by changes in river stage associated with various load following scenarios needs to incorporate into modeling efforts for lateral side channels and sloughs. A revised plan for incorporating and addressing this phenomenon should be incorporated into the Study Plan.

State the specific operating scenarios and associated time steps to be evaluated by each of the models.

Provide evidence of empirical data used in each modeling assumption.

Complete the mercury modeling and incorporate it into the EFDC water quality model.

Request for New Study

Model Integration Study Plan

It is recommended that FERC require AEA to prepare a Model Integration Study Plan. At present, AEA does not have a transparent process to integrate the individual models. Accordingly, it is difficult for the Services to comment on the process. A Model Integration Study Plan would provide better coordination among the individual modeling groups, including opportunities for quality control of model input data, clarified modeling assumptions, and consistency in the use of parameters. Although information on model dependencies was provided by AEA during the Model Integration Meeting in Seattle November 13–15, 2013, questions about model integration, calibration, and validation remain. Consequently, we anticipate difficulties in model integration and information transfer. AEA made an admirable effort in 2013 to provide stakeholders with workshop meetings, however current study plans are not sufficient to meet the stated information needs. The cost of proceeding without a clear methodology could be high if AEA determines later that appropriate parameters were not considered during the field sampling window. The following justification for a new study includes references to the Study Request Criteria as outlined in FERC's guidance document entitled "A Guide to Understanding and Applying the Integrated Licensing Process Study Criteria", dated March 2012.

The Need for Greater Clarity:

It appears that AEA does not have a clear and transparent plan to integrate the individual study models. Accordingly, it is difficult for the Services to effectively comment on the process without a comprehensive integrated modeling plan. AEA did not release the "Proof of Concept" Report that was supposed to address this issue (18 CFR ξ 5.9(b) (2)).

Goal and Objectives:

The Model Integration Study Plan would provide better coordination between the individual modeling groups. This would include quality control of the model input data, modeling assumptions, consistency in the use of parameters between different models and seamless modeling integration. The Model Integration Study Plan would allow the stakeholders to understand the methods and methodologies of the Plan and allow informed participation (18 CFR ξ 5.9(b) (1)).

Existing Information and Need for Additional Information:

Significant information regarding different model dependencies was provided by AEA during the Model Integration Meeting in Seattle November 13-15, 2013. However additional information is clearly needed since major questions regarding model integration, calibration, and validation remain (18 CFR ξ 5.9(b) (4)).

Project Nexus:
The Model Integration Meeting held in Seattle November 13-15, 2013 revealed serious deficiencies in integration and information transfer between different study models, and especially information from the groundwater model feeding into the Water Quality Model (18 CFR ξ 5.9(b) (5)).

Proposed Methodology:
Currently AEA does not appear to have a documented study methodology for stakeholders to review. AEA made an admirable effort in 2013 to provide stakeholders with workshop meetings to allow participation by the Services and the Services' contractors. However, these efforts are significantly challenged by the lack of a Model Integration Study Plan (18 CFR ξ 5.9(b) (6)).

Level of Effort and Cost:
The current Study Plans are not sufficient to meet the stated information needs. The cost of proceeding without a clear methodology could be significantly greater if AEA were to determine that the required input and output parameters were not considered and this could ultimately delay the licensing process (18 CFR ξ 5.9(b)(7)).

References

Ji, Z., J.H. Hammrick, and J. Pagenkopf. 2002. Sediment and Metals Modeling in Shallow River. Journal of Environmental Engineering, DOI: 10.1061/(ASCE)0733-9372(2002)128:2-105.

US Army Corps of Engineers, Savannah District, Environmental Impact Statement. 2012. Appendix : Cumulative Impact Analysis, Savannah Harbor Expansion Project, Chatham County, Georgia and Jasper County, South Carolina, January 2012

5.7 Mercury Assessment and Potential for Bioaccumulation

Summary of Proposed Modifications and New Studies

USFWS Proposed Modifications

Based on the March 2016 ISR meeting and to meet the overall mercury assessment study goals, the USFWS recommends the following modifications:

- **Modification 1:** We recommend AEA complete all elements set forth in the study implementation report (SIR) including the mercury pathways assessment that was presented in Section 5.7.4 of the RSP 5.7. Other incomplete elements include the phosphorus release modeling and the measurement of mercury in biota, fur and feathers pre-project, and modeling of mercury concentrations in fish and piscivorous wildlife over time post-impoundment.

- **Modification 2:** We recommend that AEA conduct the Mercury Assessment Pathways Analysis. It should be noted that the pathway analysis should not preclude collection of baseline data and in particular fur and feather sampling must be conducted to meet the FERC-approved study plan objectives.

- **Modification 3:** We have indicated in previous memoranda that the 2013 mercury data were of inadequate quality and are inappropriate for use in characterizing pre-project baseline. We have suggested that a full comprehensive summary of the analytical issues encountered and how these issues were addressed needs to be provided to stakeholders. Without agreement on the validity of the 2013 analytical data set, we recommend that a replacement year of field sampling be conducted.

- **Modification 4:** AEA should describe how the 2013 data were reviewed for quality. We maintain that mercury sampling has not yet been completed in accordance with the study plan. See also our comments on Section 5.5.

- **Modification 5:** Wildlife samples are an important component of understanding mercury transport and bioaccumulation. We recommend that AEA collect samples of tissues from piscivorous birds and mammals to document baseline mercury concentrations in wildlife. These samples were not collected in 2014 or thereafter; therefore they are an important data gap for the project.

- **Modification 6:** Use the water quality model to predict where in the reservoir conditions (pH, dissolved oxygen, turnover) are likely to be conducive to methylmercury formation. To our knowledge this task has not been completed.

Additional modifications and recommendations are included within.

AEA Proposed Modifications

The following modifications proposed by the AEA represent significant areas of disagreement.

- **Modification 1:** AEA has requested that the limited sampling of fish and piscivorous birds and mammals performed to date be considered adequate. AEA indicated that initial evaluation of bioaccumulation potential will be focused on the aquatic environment only, and analysis of wildlife tissues should not be required until after model predictions of mercury exposure are available.
    - We maintain that AEA should collect wildlife tissue (fur and feather) samples from piscivorous wildlife, regardless of model results. Especially when model input is based on data that has been flagged during quality assurance review, additional effort should be expended to collect baseline data especially for birds and mammals.
- **Modification 2:** Mercury samples in 2013 were either rejected by the laboratory or had significant quality control issues. AEA proposes to apply a total phosphorous (TP) correction factor to these data, suggesting that will make them usable for the water quality modeling and the pathways analysis.
    - We maintain that use of the correction factor is not appropriate in this case. Sampling for mercury should ultimately provide at least *two* years of representative data to document baseline. The use of a data correction factor is not appropriate given the additional issues associated with the 2013 data. There were numerous other problems in the QA/QC control (field or method blank data contamination, bottle, or suspect bottle contamination, and/or preservative contamination, failure to meet specified holding times), so the TP correction factor should not have been used.

OBJECTIVES

The objectives of the Mercury Assessment and Potential for Bioaccumulation Study, as specified in Section 5.7.1 in the July 2013 Final Study Plan (FSP), are to:

- **Objective 1:** Summarize available and historic water quality information for the Susitna River basin, including data collection from the 1980s Alaska Power Authority (APA) Susitna Hydroelectric Project.
- **Objective 2:** Characterize the baseline mercury concentrations of the Susitna River and tributaries. This will include collection and analyses of vegetation, soil, water, sediment pore water, sediment, piscivorous birds and mammals, and fish tissue samples for mercury.
- **Objective 3:** Utilize available geologic information to determine if a mineralogical source of mercury exists within the inundation area.
- **Objective 4:** Map mercury concentrations of soils and vegetation within the proposed inundation area. This information will be used to develop maps of where mercury methylation may occur.
- **Objective 5:** Use the water quality model to predict where in the reservoir conditions (pH, dissolved oxygen, turnover) are likely to be conducive to methylmercury formation.
- **Objective 6:** Use modeling to estimate methylmercury concentrations in fish post-project over time.
- **Objective 7:** Assess potential pathways for methylmercury to migrate to the surrounding environment.
- **Objective 8:** Coordinate study results with other study areas, including fish, instream flow, and other piscivorous bird and mammal studies.

The Federal Energy Regulatory Commission (FERC) approved the above objectives, but also recommended changes to the FSP, specifically:

- **Objective 9:** Use of the Harris and Hutchinson and Environmental Fluid Dynamics Code (EFDC) Models for Mercury Estimation: FERC recommended that AEA use the more sophisticated Phosphorus Release Model to predict peak methylmercury levels in fish tissue, regardless of the outcome of the other two models.
- **Objective 10:** Mercury Effects on Riverine Receptors: FERC recommended that AEA include likely riverine receptors (i.e., biota living downstream of the reservoir that may be exposed to elevated methyl mercury concentrations produced in the reservoir and discharged to the river) as part of the predictive risk analysis. The

additional study element would have a low cost (section 5.9(b)(7)) because AEA would simply add consideration of additional receptors to the existing analysis. This information is necessary to evaluate potential project effects downstream of the reservoir (section 5.9 (b)(5)).

Note that AEA stated in the Final Study Plan (FSP) that FERC modifications to the FSP will be provided in the Quality Assurance Plan and Protocol (QAPP) and that "the information in the QAPP will supersede relevant details in the FSP" (page 5.5-1). AEA has provided an updated QAPP for the water quality and mercury assessment as Attachment 1 to Section 5.5, Part B, provided in June 2014. Updates to the QAPP have been considered in the review of Section 5.7, Parts B and C, where relevant.

Review by Objective

Documents Reviewed

The USFWS is submitting comments addressing Topic 5, Water Quality Studies for the Susitna-Watana Hydroelectric Project (Project). The following comments represent current and outstanding comments that have not been addressed by the Alaska Energy Authority (AEA), or the Federal Energy Regulatory Commission (FERC) and remain as outstanding comments, concerns or recommendations. This section focuses on the review of the Susitna-Watana Hydroelectric Project, Mercury Assessment and Potential for Bioaccumulation Study, Study Plan Section 5.7, Final Initial Study Report (ISR) (AEA, June 2014). This review focuses on Section 5.7, Part B (Supplemental Information and Errata) and C (Executive Summary and Section 7) of the Final Initial Study Report (ISR), submitted in June 2014 by the AEA. The Section 5.7, Part B and C documents follow what is now referred to as "Part A", the Draft ISR, Mercury Assessment and Potential for Bioaccumulation Study, Section 5.7. Our comments provides an update of information following review of new information provided in Parts B and C. Specific review of the Parts B and C is included in Section 2.6 of this memo. We reviewed the body of comments, meeting summaries, and meeting comments related to Topic 5 since AEA released the Final Initial Study Report (ISR) on June 3, 2014 (10 documents). Since the ISR was issued, AEA has released or presented additional study plan information and errata including:

2014 Study Season Technical Memoranda, September 30, 2014

ISR Meeting Presentation Materials, October 16, 2014

Errata Release & Additional 2013 Sampling Data, November 14, 2014

Part D: Supplemental Information to June 2014 Initial Study Report, November 2015

Study Plan Section 5.7 2014 Study Implementation Report (SIR), November 2015

Study Plan Section 5.7 Appendix A: Mercury Assessment Pathways Analysis Technical Memorandum, October 2015

The USFWS has not had the opportunity to review most of the documents and data associated with the 2014 field season, although AEA has released information regarding 2014 study results. The following comments are therefore focused on 2013 study plan reports and metadata results. We did not have sufficient time or resources to review most of the documents from 2014, including the field sampling data for water chemistry or quality control documents for these data.

Objective 1: Summarize available and historic water quality information for the Susitna River basin, including data collection from the 1980s Alaska Power Authority (APA) Susitna Hydroelectric Project.
Both historic and literature data were reviewed to summarize the current understanding on the occurrence of mercury in the environment. These were included in the FSP and repeated in the ISR, and summarized in the SIR. Sources included information developed by the APA Susitna Hydroelectric Project, state and federal agencies and the published scientific literature.

Objective 2: Characterize the baseline mercury concentrations of the Susitna River and tributaries.

General Comments

Data Quality
AEA should provide a data quality report to stakeholders describing the results of the analytical quality review from 2013 and 2014

Significant progress was made on mercury assessment pathways analysis where conceptual pathways were developed for three conditions: the riverine model, mature reservoir model, and new reservoir model. However, neither the SIR report nor Technical Memorandum provided sufficient details to document or assess quality control.

New mercury data were collected during the 2012–14 monitoring programs. However, some of the data were rejected during the quality assurance review. The rejected 2013 dataset was then corrected using a TP correction factor method. For reasons already described above, we disagree with the use of a correction factor for the mercury data based on suspended solids loads. There were multiple issues associated with the 2013 data set and the use of a correction factor does not address all of the data quality issues (blank contamination, preservative contamination, cooler temperature, filter breakthrough, and shipment breakage). Further mercury sampling is needed for water, sediment and biota based on the water quality issues associated with the 2013 sample reports. In addition, an insufficient mercury sampling program was conducted for piscivorous birds and mammals. No fur or feather samples were collected for methylmercury analysis in 2013. AEA was unable to collect any bird/feather samples in 2014 and only a limited number of fur samples were collected which included one river otter pelt and two mink pelts from a trapper in the Chulitna River/Indian River area (exact location unknown). Hair snare results were also limited to four hairs from a single river otter at one site. Further sampling should be conducted for these biota groups.

Mercury Pathways Analysis

AEA needs to define the procedure to be used in their development of the Mercury Pathway Analysis and what the ultimate purpose of the analysis is. AEA has indicated that the mercury pathway analysis will drive decisions, including whether to continue mercury data collection and whether to complete or conduct the fur and feather sampling as described in the FERC-approved Study Plan. Additional supporting information is needed to show the validity of the Mercury Assessment Pathways Analysis. For example, (a) Consideration of suspended solids to promote mercury bioavailability in surface water and (b) More complete description on the subset of metals selected for pathway analysis should include description of the concentration of metals found in the baseline sampling effort.

SIR Report

The SIR Report tables are not specific. AEA should state whether concentrations in the SIR Report tables are total or methyl mercury. All data should be properly labeled and any use of the data into models should be clearly defined.

AEA should provide sources of the data in the bullet items that summarize total mercury concentrations. For example, were data generated from the means provided in Tables 5.3-1 through Table 5.7-8. Are all the data in Table 5.3-1 used to generate a mean total mercury value in soils and which EPA method was used to generate data? More detail on how sediment/porewater values were obtained is needed. In addition, details on which fish species were placed into non-piscivorous and piscivorous categories is not provided.

The maximum predicted concentration for non-piscivorous fish would be 289 if burbot is included in this category.

AEA should provide a table in the SIR report showing the model inputs and outputs so the results can be reviewed and verified. For example, the Harris and Hutchinson model (2008) should be showed in its entirety so readers can conduct and verify the analysis.

The discussion of mercury methylation downstream should be made less speculative. The discussion is based on general parameters such as relatively shallow and highly oxygenated water. Further consideration and analysis of downstream export should be considered, including review of literature.

Other Models

The water quality model (5.6) has not yet been updated to include the mercury pathway analysis.

There are inadequate modeling descriptions in the SIR report. A table should be provided showing the inputs to the model and the model outputs so the results can be reviewed and verified. For example, the Harris and Hutchinson model (2008) should be shown in its entirety so readers can conduct and verify the analysis.

Prediction of projected potential mercury concentrations in fish (using the phosphorus release model) has not yet been completed. The applicant has provided additional information related to the inputs to the Harris and Hutchinson model. These data have not been reviewed, and additional comments may be provided.

Water Sampling

In 2014, both baseline and focus area water quality sampling were conducted. For the baseline effort, water quality samples were collected on an average of five mile intervals, with a total of 18 locations in 2013 (one more than originally indicated in the FSP). Samples were collected at each baseline sampling location near the right and left banks and mid-stream locations from a depth of 0.5 meters below the surface and 0.5 meters above the bottom.

For Study 5.7, grab samples were analyzed for total and dissolved mercury. Laboratory quality control samples included duplicate samples between laboratories. Spiked and blank samples were prepared and processed by the laboratory. The Focus Area Sampling Protocols differed from the baseline sample locations in that they have a greater density of locations, with transects spaced every 100 m to 500 m and water quality samples collected at three or more locations along each transect.

Water samples were analyzed for mercury (total and dissolved) and methylmercury utilizing EPA Methods 1631E and 1630. The laboratory attained method detection limits specified in the QAPP that were at the applicable regulatory criteria and provided all laboratory QA/QC documentation. Additional details of the sampling methods were provided in the updated QAPP for the water quality and mercury assessment in June 2014 as Attachment 1 to Section 5.5, Part B.

In a variance from the FSP, water samples intended to be collected from PRM 225.5 were instead collected at PRM 235.2 due to limited access to the original site by helicopter. Similarly, water samples from PRM 235.2 (Susitna River adjacent to Oshetna Creek) and 187.2 (Susitna at Watana Dam) were collected from just one position in the river due to limited access when wading. The ISR stated that there are no known influences to water quality between the proposed monitoring sites and those that were sampled.

Vegetation

Vegetation samples were collected from ten different sites within the proposed inundation area in 2013. This included twelve plant species common to many study sites (four species total), or plants present at only a few sites, but with large mass at the sites where they were present (eight species total). Plants with low vegetation mass at all sites and rare plants were not collected. No results for mercury levels were reported in the ISR, although some raw data is available for review in laboratory reports attached to the data validation reports posted to the http://gis.suhydro.org/reports/isr website. It was not feasible to fully evaluate the data at this time due to the lack of metadata (e.g., sample geospatial information, sample details). It is important that USFWS be provided the time and resources to review the vegetation metadata. These data are an important part of the post-Project (i.e., with Project) mercury modeling effort.

The sampling was biased toward vegetative mass, that is to say species that were present in the inundation area at low frequency and size were not sampled, because even if these plants contain mercury, their contributions to mercury methylation will be low. This sampling approach is consistent with the study goals of collecting representative data on concentrations of mercury in the dominant vegetation in the inundated area.

No variances were reported for the collection of vegetation, with a total of 50 vegetation samples collected from plants at five sites in each of ten locations within the proposed inundation zone in August 2013. The sampling was biased toward plants with the largest vegetative mass at most sites. Plant samples were analyzed for total and methyl mercury per EPA Methods 1631 and 1630, respectively.

Soil

All planned soil samples were collected in 2013, consisting of a combination of surface moss, peat, and mineral soils. A general observation was provided that a significant fraction of organic matter (moss and peat) overlays the mineral soil at each sample location, with this material likely being the primary potential source of mercury methylation in the future reservoir. No results for soil sample mercury levels were reported in the ISR, although some raw data is available for review in laboratory reports attached to the data validation reports posted to the http://gis.suhydro.org/reports/isr website. It was not feasible to fully evaluate the data at this time due to the lack of metadata (i.e., sample geospatial information, sample details, etc.). However, both mercury and methylmercury were detected in soil samples.

Each soil sample was split and digested using two methods in the laboratory analysis to ensure that the presence of high organic matter (peat) did not underrepresent the amount of mercury in each sample. In Part B of 5.7, AEA notes that EPA recommends digestion with HNO_3/H_2SO_4 before using BrCl with organic soils. It is not possible at this time to evaluate the differences in results obtained from the two extraction methods because a data summary is not provided.

In a variance from the FSP, two digestion methods were used in the preparation of soil samples for mercury analysis due to the large proportion of peat present in the soil samples. A total of 50 soil samples were collected at each of the vegetation sampling sites in the inundation zone during

August 2013. Samples were analyzed for total mercury and methylmercury using EPA Methods 1631 and 1630, respectively, and the results reported as both wet (ww) and dry (dw) weight.

Sediment and Sediment Porewater

Sediment and sediment porewater samples were collected in the mainstem Susitna River near the mouths of the following tributaries: Jay, Kosina, and Goose Creeks, and the Oshetna River, downstream of islands, and in similar riverine locations. Sediment porewater was collected from the sites listed above and separated from sediments in the field laboratory using a pump apparatus, and filtered with a 0.45-µm pore size filter in both the lab apparatus and field apparatus. Samples were analyzed for total mercury by EPA Method 1631E. In addition, sediment size and total organic carbon (TOC) were analyzed to evaluate whether these parameters are predictors for elevated mercury concentrations.

Sediment samples were collected at four of the ten proposed sample locations at mouths of Jay, Kosina, and Goose creeks, and the Oshetna River, and the remaining samples were collected in the following year. These samples were analyzed for metals, sediment grain size, total solids, and with the additional parameters of pH, temperature, hardness, alkalinity, TOC and DOC for sediment porewater.

Additionally, sediment samples were collected using hand augers or stainless steel spoons in a variance (the FSP stated use of an Ekman dredge or a modified Van Veen grab sampler), and followed the Clean Hands/Dirty Hands sampling method identified in Objective f of Section 5.5. All 2014 sediment samples were collected using these methods.

Piscivorous Birds and Mammals

A very limited number of fur samples were collected and no feather samples have been collected to date. Wildlife samples are an important component of understanding mercury baseline within the study area. The SIR Report indicates mercury samples could not be collected from wildlife tissues and the mercury pathway analysis has proceeded using only fish tissue samples.

This approach neglects an important component of the pathways analysis. Although there were some opportunities for data collection in 2013, there should have been an effort to collect samples in 2014. Wildlife samples will be necessary to accurately understand bioaccumulation of mercury in local wildlife populations. Baseline levels of mercury in local piscivorous wildlife pre-project are needed to determine how much assimilative capacity may exist for additional mercury exposure (i.e., whether mercury levels in local biota are close to effects thresholds). This information will be invaluable for determination of ecological risk, and potential environmental effects of the project. This information, in turn, will be used by the USFWS to develop potential mitigation measures to minimize harmful effects of the project.

While the FSP identified the collection of feathers from raptor nests, no feather samples were collected for methylmercury analysis in 2013. Reasons for this variance ranged from the lack of required permits (e.g., bald eagle feathers) and the absence of nests for other targeted bird species within the proposed inundation area (e.g., belted kingfishers, loons, grebes, terns). The

ISR stated that alternate methods for collecting samples from other piscivorous birds will need to be considered for the 2014 field season. In Part C of Section 5.7, AEA stated that alternative approaches for tissue sampling of piscivorous birds will be pursued in 2015, pending further data analysis and identification of data needs to complete the mercury pathways analysis. Revised sampling approaches and target species were developed with input from USFWS, ADF&G, and other licensing participants in wildlife technical meetings on March 7, 2014 and April 9, 2014. The minutes of these meetings are available online and linked in the 5.7 Part C document. These documents detailed informal plans to coordinate feather collection with the efforts of other researchers operating in the study area, plus plans to evaluate the possible collection of avian blood samples (leveraging the work and permits of other researchers). Additionally, the group decided to narrow the focus of the avian monitoring to 4 species: bald eagle common loon, red-breasted merganser, and common merganser. These species were selected based on their high consumption of fish (40% of diet) and likely ease of obtaining samples for analysis in the area. Despite these conversations, no subsequent collection of avian samples has occurred.

Similarly, no fur samples were collected for methylmercury analysis in 2013, also due to the absence of targeted species in the proposed inundation area. The ISR stated that alternate methods for collecting fur samples from piscivorous mammals were needed. These may include targeted trapping or expansion of the proposed study area. The USFWS prefers non-lethal sampling methods for wildlife for this project, and these should be feasible if project contractors who know how to sample blood from birds and perform the correct mercury analysis (the Direct Mercury Analyzer (DMA-80) method) on fur samples collected from snags.

Only a few fur samples were collected for methylmercury analysis in 2014, consisting of a limited data set (one river otter and two mink pelts and four hair snares from one river otter). The ISR stated that alternate methods for collecting fur samples from piscivorous mammals would need to be considered, which may include using targeted trapping or expansion of the proposed study area. In prior meetings with AEA the USFWS discussed the use of a more sensitive analytical method if only a few hairs were available from a snag (using a Direct Mercury Analyzer). Despite our agreement that the contractor would consult with the USFWS and consider using that method if a small sample from a snag was collected, the contractor did not communicate with the USFWS when they collected such a sample, nor did they use the sensitive method.

AEA indicated that initial evaluation of potential bioaccumulation will focus on the aquatic environment only, and that mercury analysis of wildlife tissues will not be required until after initial model predictions of mercury exposure to piscivorous wildlife are available in the first quarter of 2015. Collection of fur samples using snag sampling techniques failed to provide samples of fur from target species. Location of feather samples for target species was also unsuccessful for all targeted species except for bald eagle; however, proper permits were not obtained by the sampling team to allow collection of bald eagle feathers at the time samples were located. Collection of fur samples may be modified to include lethal trapping methods to collect target species. For piscivorous birds, the USFWS recommends that FERC require AEA to engage specialty contractors with extensive experience in capturing live birds to obtain blood and feather samples for mercury analysis.

For piscivorous birds, AEA plans to engage specialty contractors with extensive experience in capturing live birds to obtain blood and feather samples for mercury analysis. If lethal trapping is employed to collect piscivorous mammals, additional analysis can be performed to enable a more thorough interpretation of baseline results. For example, age of the animals collected should be recorded (e.g., via cementum annuli analysis) because mercury concentrations in piscivorous mammals are correlated with age (Yates et al., 2005). These age data would be useful in understanding baseline results and aiding in comparisons to data from other areas, tissue levels associated with effects, or data collected from the project area in potential future studies. Also, since the samples could be easily obtained from carcasses, AEA should analyze soft tissue samples (e.g., liver and/or muscle) for mercury and methylmercury, or at least collect and archive samples for future analysis.

Fish Sampling

Not all targeted fish species were collected in the study area during 2013, and none in 2014. Overall numbers of each species and whether otoliths could be collected for use in aging samples are presented in the following table.

Target Species	Number collected in 2013	Otoliths Collected?
Lake Trout	7	Yes
Longnose Sucker	7	Yes
Dolly Varden	7	Yes
Arctic Grayling	16	No
Burbot	8	Yes
Slimy Sculpin	7	No
Whitefish	1 – Humpback 2 – unidentified	Yes

No mercury or methylmercury tissue concentrations were reported in the ISR, although some raw data is available for review in laboratory reports attached to the data validation reports posted to the http://gis.suhydro.org/reports/isr website. It was not feasible to fully evaluate the data at this time due to the lack of metadata (i.e., sample geospatial information, sample details, etc.). However, both mercury and methylmercury were detected in fish tissue samples. Due to lack of metadata, it was not possible to discern which results were for liver and which results were for filets.

While the RSP targeted the collection of seven to ten fish of each target species, additional fish were collected for Arctic Grayling (16) and Round Whitefish (12), including the incidental collection of some juvenile fish (also in variance with the FSP stated intent of only collecting adult fish).

Due to the scarcity and difficulties in differentiating between humpback and Round whitefish, only two known individual Humpback Whitefish were collected for analysis in 2014.

No Rainbow Trout or Sticklebacks were captured in 2014, and there was no evidence that these species were present in the proposed inundation zone.

In contrast, Slimy Sculpin, a non-target species, were observed in large numbers in the study area, and were collected for analysis of whole body samples (due to their small size) to expand the amount of data available for mercury bioaccumulation. Slimy sculpin were chosen as an alternative species. Because Humpback Whitefish were rare and Rainbow Trout were not found in the inundation area, this alternative species was chosen. AEA should describe the difference in feeding behavior between target species and Slimy Sculpin and the overall implications for pathway analysis.

Otoliths could not be extracted for all fish. Only 21 fish have had otoliths extracted and analyzed for age as part of this study to date. The determination of sex and sexual maturity of fish proved to be problematic in the field, and the sex of only 12 fish was determined. In contrast with the FSP, fish samples were collected past the originally identified August to September sampling period, extending into early October to obtain sufficient sample size for targeted species.

A final variance was the substitution of polyethylene sheets for the originally identified Teflon sheets in sample bags. However since phthalates are not of concern for this Project, this change in sheet material is not of concern. Samples were analyzed for total mercury and methylmercury by EPA Methods 1631 and 1630, respectively. Liver samples were also collected from Burbot and analyzed for total mercury and methylmercury. Species identification, measurement of total length (mm), and weight (g), sex and sexual maturity were recorded when possible.

The project QAPP stated that Teflon sheets would be used for the fish when placed in the sample bag. The study team had difficulty sourcing this material, and switched to polyethylene sheets.

Given that muscle samples are taken from inside the fish, this material should not have introduced any contamination to the sample and have no effect on achievement of the study objectives. The study plan will be modified to allow use of polyethylene sheets for sampling.

Objective 3: Utilize available geologic information to determine if a mineralogical source of mercury exists within the inundation area.

Co-occurrence of elevated mercury concentrations in multiple samples may indicate a mercury hotspot or area of concern. Such hotspots would need to be evaluated explicitly in future modeling or risk estimation exercises, as they may result in localized post-project mercury risks. The presentation of the data is insufficient for a full understanding of mercury conditions in the project area, because simple averages obscure the spatial patterns. This is a situation where the variance is more important than the mean. Mercury concentrations range over two orders of magnitude, with maximum values for fish, sediment, and water that exceed the screening criteria. Because of the exceedances and wide variability in the data, it may not be appropriate to treat the project area as a simple homogenous unit. The raw data should be mapped as well as shared in tables and figures that describe the range in concentrations, as well as measures of central tendency. Percentiles are often used to describe non-normally distributed environmental data. No variances were identified in the methodology section of the ISR concerning the methods used to determine if a mineralogical source of mercury exists within the inundation area.

Objectives that were not addressed in the ISR

Objective 4 - mapping mercury concentrations in soils and vegetation within the proposed inundation area,

Objectives 5–8 - using the water quality model to predict reservoir conditions conducive to mercury methylation to estimate methylmercury concentrations in fish, assess migration pathways for methylmercury to move to the surrounding environment, and incorporate the Phosphorus Release Model into the water quality model for the estimation of methylmercury concentrations.

Objective 9 – coordination of the mercury bioaccumulation study results with other study areas, including fish, instream flow, and other piscivorous bird and mammal studies

Objective 10 – addressing mercury effects on riverine receptors in the predictive risk analysis

Literature Review

To assist AEA with these objectives, we have performed the following literature review to assess the validity of some AEA statements of concern to the USFWS.

Additional literature references are needed for general statements. References are required for mercury accumulation on soils, sediments and biota, particularly in section 4.2.3 of the riverine model of the SIR Appendix A. For example, we address several poorly supported statements below.

"The largest proportion of methyl-mercury (MeHg) is produced and resides in flooded soils and not mobilized into the water column (Hall et al., 2009)".

Few studies have examined the total mass of MeHg in different compartments of reservoir ecosystems. It is much more common to examine MeHg concentrations without extrapolating to total mass, and even mass balance studies tend to focus on MeHg inflows and outflows from reservoirs rather than the mass distribution of MeHg within the reservoir. Because there are few studies on the subject, it would be appropriate for AEA to qualify their statements about the pools of MeHg in reservoirs, to state that the findings of Hall et al. (2005, 2009) are based on studies from the experimental creation of reservoirs in three basins with different levels of pre-impoundment organic carbon stores.

Although we did not locate other directly comparable data sets, other studies provide information that is generally consistent with the findings of Hall et al. (2005, 2009). For example, Gandhi et al. (2007) constructed a model of mercury transport, speciation, and bioaccumulation for application to Lahontan Reservoir, in the mercury-contaminated Carson River system (Nevada). An early version of the model that did not account for MeHg adsorption to iron and manganese oxides in sediment overestimated the measured MeHg flux from sediment by two orders of magnitude. Despite significant net production of MeHg in sediment, the authors "hypothesize[d] that geochemical process at the sediment-water interface limit[ed] MeHg diffusion, thereby controlling the loading of MeHg from the sediment to water" (Gandhi et al. 2007). Also, Lucotte et al. (1999) stated: "the amounts of Hg released to the water column by diffusion are exceedingly small as compared to the total Hg burden found in the humic layer of podzolic soils or organic layer of peatlands, and consequently, no significant departure of Hg can be evidenced in the soil even after a decade flooding."

Given the lack of comparable studies, it is not possible to determine whether it is typical for 1% to 10% of the MeHg produced in reservoirs to reside in the food web. However, it is reasonable to expect substantial variation among sites, because aqueous MeHg is generally correlated with biota MeHg concentrations, and partitioning of MeHg between sediment and water is affected by a number of factors, such as pH, iron and manganese oxides and oxyhydroxides, formation of soluble sulfide complexes, changes in biotic particulate matter, temperature, and nutrient status (Ullrich et al. 2001).

"The mechanisms for bioaccumulation of MeHg in higher aquatic vertebrates including fishes, is through direct adsorption from the water column through respiratory tissue like gill filaments (Friedl and Wuest, 2002)."

It is well known that MeHg concentrations in biota, including fish, increase with increasing trophic level. This phenomenon is a function of MeHg trophic transfer, not direct uptake from the water column. The quoted statement is a reference to Friedl and Wüest (2002), who actually state that mercury "enters the food chain and accumulates in higher organisms and fishes or it is directly adsorbed from water in the gills of fish." A few additional citations follow:

"Although bio concentration is the main route of uptake at the base of an aquatic food web, primary through tertiary consumers are exposed to Hg^{2+} and CH_3Hg^+ from both the water and their diet, with the relative importance of dietary exposure increasing with an organism's trophic level" (Kidd et al. 2012).

"Despite considerable accumulation of [inorganic Hg] from both aqueous and dietary exposure routes, the high assimilation efficiencies and slow loss of MeHg from dietary sources are the principal determinants of predicted Hg burdens in both fish species" (Pickhardt et al. 2006).

"…while dietary exposure is the dominant Hg accumulation pathway … uptake of water-borne Hg is also an important route of exposure" (Power et al. 2002).

Although the reference to Friedl and Wüest (2002) is somewhat inaccurate, the related contention that water hardness affects Hg bioaccumulation through its influence on the direct uptake pathway is supported by the literature (see Power et al. 2002 and references cited by Tetra Tech).

"Bioaccumulation of MeHg appeared to be sequestered in the existing vegetation and soils and not in the aquatic food web of the newly formed reservoir".

The last two sentences in this paragraph, including the sentence quoted above, are a misinterpretation of the results of Hall et al. (2005, 2009). Indeed, Hall et al. (2009) concluded that "our study confirmed the results of previous studies that flooding of terrestrial catchments invariably results in large increases in MeHg concentrations in zooplankton." From a risk perspective, it is the concentrations of MeHg in biota that are critical, not the distribution of MeHg mass among compartments of the system.

In addition, the statement that "DOC concentration is directly related to change in MeHg concentration" is true, but "positively correlated" would be clearer than "directly related." One example of this relationship can be found in a study of Maryland reservoirs (Sveinsdottir and Mason 2005). Hall et al. (2009) found that MeHg concentrations in water were positively correlated with DOC concentrations, while bioaccumulation factors (ratio of biota to water concentrations) were negatively correlated with DOC concentrations. The authors did not report the net effect of these relationships on the correlation between DOC and biota MeHg concentrations. However, considering that MeHg concentrations in biota were closely correlated with MeHg concentrations in water (Hall et al. 2009), and DOC and water MeHg concentrations were positively correlated, it seems likely that DOC and biota MeHg concentrations would have been positively correlated in this study as well. Thus, it is not clear from the studies cited that the net relationship between DOC and biota MeHg concentrations is "equivocal."

The paragraph on pH could also note that pH strongly affects partitioning of Hg between sediment and water. Ullrich et al. (2001) hypothesize that this effect may contribute to the widely recognized phenomenon of increased Hg concentrations in fish from low-pH lakes.

Summary Comments

Mercury Modeling

At the time of this review, the AEA modeling team did not provide enough information to allow an assessment of methylmercury modeling results. AEA needs to define the procedure to be used in their development of the Mercury Pathway Analysis and what the ultimate purpose of the analysis is. AEA has indicated that the mercury pathway analysis will drive decisions, including whether to continue mercury data collection and whether to complete or conduct the fur and feather sampling as described in the FERC-approved Study Plan. The following details are necessary for further assessment.

Provide maps of mercury concentrations in soils and vegetation within the proposed inundation area, to identify areas where mercury methylation may occur.

Describe the models (Harris and Hutchinson, EFDC, and Phosphorus Release Models) and calibration results to be used to predict reservoir conditions conducive to methylmercury formation and the uptake and accumulation of mercury in fish.

Provide details in the potential pathways for methylmercury to migrate to the surrounding environment, and provide an expanded literature survey on these pathways to ensure applicability to the conditions expected in the future impoundment.

Identify the alternative methods to be used to sample fur and feathers and any considerations and implications of expanding the study area to support the collection of these samples. Although alternate collection methods have been informally discussed in wildlife technical meetings held in March and April, 2014 and noted in Part C, the final detailed procedures should be provided fully in the QAPP.

Identify the additional riverine receptors to be evaluated in the risk analysis as well as the receptor specific TRVs to be used in analyzing model results.

Identify the pathway analysis/modeling methods and decision criteria to be applied to the 2013 and 2014 aquatic sample data in order to decide the need for the possible additional sampling of piscivorous wildlife. Part C indicates that wildlife will be sampled "if there is a potential for mercury transfer from aquatic to the terrestrial environment via piscivory by birds and mammals". Considering the ubiquity of mercury and methylmercury in fish, plus the recently-posted project sample data confirming detection of mercury and methylmercury in 2013 samples of fish obtained from the study areas (http://gis.suhydro.org/reports/isr), it appears that currently there is a potential for mercury transfer to piscivorous wildlife. Considering the hypothetical increase in mercury mobility in newly-created reservoirs, this potential transfer to piscivorous wildlife will be present or possibly exacerbated following inundation.

AEA should take advantage of the additional analyses than can be performed on small sample sizes (e.g., fur) to enable a more-thorough interpretation of baseline results. For example, age of the animals collected should be recorded (e.g., via cementum annuli analysis) because mercury concentrations in piscivorous mammals are correlated with age (Yates et al., 2005). This age data would be useful in understanding baseline results and aiding in comparisons to data from other areas, tissue levels associated with effects, or data collected from the project area in potential future studies. Also, since the samples could be easily obtained from carcasses, AEA should analyze soft tissue samples (e.g., liver and/or muscle) for mercury and methylmercury.

Additional Study

An expedited sampling plan should be provided to discuss the findings of the 2013 sampling season, how these data are informing the 2014 field season, and the additional method and collection details associated with the potential 2015 wildlife sampling efforts.

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6.5 Geomorphology

ISR Review and Study Modifications

The USFWS review of Geomorphology (study 6.5) is a compilation of previous document reviews that were prepared by AEA. The reports, technical memoranda (TM) and meeting presentations include (partial list):

- Revised Study Plan (RSP), December 2012;
- Final Initial Study Report (ISR), June 2014 & ISR Meeting, October 2014;
- Mapping of Geomorphic Features and Turnover within the Middle and Lower Susitna River Segments form 1950s, 1980s and Current Aerials Tech Memo (TM), Sept. 2014;
- 2014 Update of Sediment Transport Relationships and a Revised Sediment Balance for the Middle and Lower Susitna River Segments TM, September 2014;
- Historical Cross Section Comparison (1980s to Current) TM, September 2014;
- Assessment of the Potential for Changes in Sediment Delivery due to Glacier Surges TM, November 2014;
- Winter Sampling Technical Memorandum (WSTM)
- Literature Review- Dam Effects on Downstream Channel and Floodplain Geomorphology and Riparian Plant Communities and Ecosystems, November 2014; and
- Team meeting, Presentation of "Assessment of the Potential for Changes in Sediment Delivery due to Glacier Surges", December 5, 2014.

The geomorphology investigation includes two studies (Study 6.5 and Study 6.6). Based on USFWS' understanding of the Revised Study Plan (RSP), the Geomorphology Study Section 6.5 investigates the historical and current geomorphology and geomorphic/geologic controls of the Susitna River and is expected to identify historic changes in morphology over time along the Susitna River and key physical processes governing the behavior of the river. The data collection varied from exceptional (main channel pebble counts) to not complete (sediment supply from tributaries). Some modifications to data collection efforts are listed below.

The 6.5 study did not yet use the past data to identify trends or qualitatively predict the project effects. USFWS was hoping these qualitative, common-sense projections in 6.5 could be used as a check of the geomorphic modeling results presented in 6.6.

The Fluvial Geomorphology Modeling Study 6.6 (reviewed separately) will apply 1-D and 2-D bed evolution models to further quantify geomorphic processes in the existing river, the equilibrium status of identified reaches, and potential project effects on river geomorphology.

Study Objectives

The Geomorphology Study (6.5) objectives as stated in FERC Study Plan Determination (4/1/2013) were:

1. Geomorphically characterize project-affected river channels and floodplains by delineating reaches and mapping geologic and geomorphic features from the proposed

dam site downstream to Cook Inlet and from the dam site upstream to the Maclaren River confluence (including the reservoir inundation zone).

2. Collect flow, suspended sediment, and bedload data to support characterization of sediment supply and transport in the Susitna River from RM 84 (Sunshine Station) upstream to RM 182 (Tsusena Gage) and the Chulitna and Talkeetna Rivers near their confluences with the Susitna River.
3. Determine sediment supply, bed mobilization, sediment transport, and mass balance in the Middle River and Lower River segments between the proposed dam site and downstream to the Susitna Station gage, including the mainstem Susitna River and its tributaries.
4. Assess geomorphic stability and change in the Middle River and Lower River segments by comparing existing geomorphic mapping with geomorphic feature data from historical aerial photography.
5. Characterize surface area versus flow relationships for riverine macrohabitat types over a range of flows in the Middle River segment from the three rivers confluence area upstream to the dam site using information mapped and digitized from aerial photography.
6. Conduct a reconnaissance-level geomorphic assessment of potential project effects on the Lower River segment and Middle River segment considering stream flow, sediment supply and transport, and conceptual frameworks for geomorphic reach response (Grant et al., 2003; Germanoski, 1989).
7. Characterize surface area versus flow relationships for riverine macrohabitat types in the Lower River segment between the Yentna River confluence (RM 28.5) and Talkeetna (RM 98.5). The task includes conducting analyses contingent on a determination that (1) a comparison of riverine habitat in the Lower River segment under pre- and post-project flows is warranted for additional flow conditions and (2) aquatic resource studies need to be continued downstream in the Lower River segment.
8. Characterize geomorphology within the proposed reservoir area and assess reservoir trap efficiency, sediment accumulation rates, delta formation, and erosion and mass wasting potential within the reservoir fluctuation zone and shoreline up to 100 vertical feet above the proposed full-pool elevation.
9. Assess large woody debris transport, recruitment, and influence on geomorphic forms in the Susitna River between the mouth and the Maclaren River using recent and historic aerial photography and field studies.
10. Characterize geomorphic conditions (i.e., channel morphology and sediment dynamics, channel migration zone, large woody debris transport, and erosion and sediment delivery) at stream crossings along access roads and transmission line alignments using data obtained from existing sources and field assessment.
11. Integrate the study with Study 6.6 (Fluvial Geomorphology Modeling).

USFWS Study Modifications

To fulfill the goals of the Geomorphology Study (6.5) and be able to differentiate between natural change and project induced change, USFWS poses the following question which is essential to evaluating the project's effects on geomorphology and is germane to both 6.5 and 6.6.

- Does AEA intend to use existing conditions to represent the future without project effects?
- If AEA does not intend to use existing conditions to represent the future without the project, USFWS requests:
  - A detailed explanation of predicted changes in channel morphology over the next 100 years.
  - An evaluation of the uncertainty of the predictions of change.

In order to meet the 6.5 study objectives and as a result of the March 2016 ISR meeting, USFWS recommends the following modifications:

1-1 Characterize the geomorphology of the watershed as a whole and its Middle River tributaries in relation to the present and expected future sediment yield.

2-1 Provide an assessment of uncertainty in the suspended load and bed load estimates for both reported daily values as well as annual load estimates. This may require conducting additional suspended load and bed load measurements to help define the variability of sediment transport rates at a station over time.

3-1 Clarify which size classes of sediments are considered to be supply-limited in the context of this river system and what is meant by sediment transport equilibrium.

3-2 Assess the feasibility of using a morphological approach to estimate long-term bed load transport rates along the Middle and Lower Reaches to provide an independent check on the short-term measurements from samplers.

3-3 Use information from the 7.7 Glacier and Runoff Study to help predict changes in sediment supply. Substantial modifications to study 7.7 have been requested.

5-1 Take aerial photos to document the rivers lateral extent in the middle river at the range of flows that AEA intends discharge from the dam. To date the photos are at a single flow, 12,500 cfs.

6-1 Conduct the literature review in the manner of Kellerhals and Gill (1973) to provide case histories and experience related to downstream effects of dams in northern climates. This information should assist in defining potential effects on the Susitna River.

6-2 Use a range of methods gleaned from the literature review, case histories from past projects, and site specific analysis to provide reconnaissance level assessment of project impacts.

7-1 Take aerial photos from the Yenta Confluence to Talkeetna to document the rivers lateral extent at the range of flows that are likely post project. To date the photos are at a single flow, 12,500 cfs.

11-1 Utilize information from study 6.5 to test and validate the accuracy of long-term (decadal) predictions from the numerical models and utilize geomorphic methods to make predictions of channel response to changes in sediment supply and discharge so as to provide independent checks on the model predictions.

11-2 Provide details about how the lateral channel changes along the Middle River will be predicted if the effective discharge calculation is abandoned.

Review by Objective

Objective 1: *Geomorphically characterize project-affected river channels and floodplains by delineating reaches and mapping geologic and geomorphic features from the proposed dam site downstream to Cook Inlet and from the dam site upstream to the Maclaren River confluence (including the reservoir inundation zone).*

Modification 1-1: USFWS recommends characterizing the geomorphology of the watershed as a whole beyond the river valley bottom and evaluating the Middle River tributaries in relation to the present and expected future sediment yield.

A description of the basin and its major tributaries in terms of physiography, geology, climate, hydrology, land use, mass wasting processes and sediment sources are basic to understanding the factors that govern the morphology and sediment transport characteristics of a river.

The work to date provides a description of the geomorphology of the Susitna River and describes geologic features on the valley floor that affect local channel morphology. The assessment does not include any characterization of watershed-scale processes in the basin or the major tributaries, particularly information on variations in watershed sediment sources and sediment supply. This omission makes it difficult to interpret morphological changes along the mainstem of the river.

The studies were not conducted as provided for in the approved study plan because the characterization of the geomorphology of the tributaries was not completed.

Objective 2: *Collect flow, suspended sediment, and bedload data to support characterization of sediment supply and transport in the Susitna River from RM 84 (Sunshine Station) upstream to RM 182 (Tsusena Gage) and the Chulitna and Talkeetna Rivers near their confluences with the Susitna River.*

The final study plan indicated that bed load measurements would be collected at the gage "Susitna River above Tsusena Creek" (Study Plan RSP Section 6.5.4.2.2). The ISR indicated measurements were conducted on only five dates in 2012 and the program was subsequently terminated. The ISR stated that alternate means would be used to determine the bed load passing the dam site. In particular, it was proposed to utilize data from the Gold Creek gage, since there is only a 20% difference in drainage area between the two gages. However, Table 4-2.3 of the ISR indicated no bed load data were collected in 2012-2013 at the Gold Creek gage. Therefore, information on bed load transport rates at the dam site will be limited to data from previous studies in the 1980s. If data from the 1980s and 2012-2013 are combined, the consistency of the rating curves needs to be confirmed. Since this location represents a key boundary condition for establishing the sediment balance and sediment transport modeling, this could represent a significant limitation to the study.

Modification 2-1: USFWS recommends an assessment of uncertainty in the suspended load and bed load estimates for both reported daily values as well as annual load estimates. This may require conducting additional suspended load and bed load measurements to help define the variability of sediment transport rates at a station over time.

Information on the amount of sediment moving past the proposed dam site is required in order to assess potential downstream effects from the dam and rates of infilling in the reservoir. The sediment load has been estimated by AEA using Helley-Smith bed load samples and P61 suspended sediment samples. Only very limited sampling was carried out in this study; most of the data were collected during previous studies in the 1980s (Knott et al. 1987). Based on the methods described, the sampling program is expected to be subject to at least two biases.

A P61 suspended sediment sampler was used at the centroid of the flow, rather than a depth integrated sampler, or a P61 at multiple depths and verticals. We expect the majority of the sand load will move in the lower portion of the profile, possibly resulting in under-estimation of the very coarse sand, coarse sand and most of the medium sand. On account of the changes in channel hydraulics and bed texture down river, it is not possible to simply assume the bias introduced is the same at all stations. The shear velocity is anticipated to decrease downriver and as a result, the suspended sediment profile will also change down river.

Helley-Smith samples are known to have variable sampling efficiencies. At no point in the current work, or the 1980's reports, is the efficiency of the sampler mentioned. Based on the bed material grain size data, stones on the bed larger than the opening of the Helley-Smith are present, and are presumably mobile during some portion of the year. No discussion of this problem and potential solutions are provided. It cannot simply be assumed that the bias will be consistent at all of the sites, as the sites have different bed material grain size and the bed load grain size becomes finer farther down river. The issue of temporal variability of bed load transport rates is also not discussed. It is necessary to collect a significant number of samples under steady conditions in order to define accurate mean bed load rates for different flow strengths, and to assess the error around the load estimates due to the bed load temporal variability (Vericat et al, 2006).

AEA referred to the Middle Susitna River as 'sand-dominated', although the bed is made of gravel/cobble with a median size of 100 mm. They showed measurements indicating that 99% of sediment transported is sand. However, USFWS mentioned that some bedload measurement equipment, such as a Helley-Smith sampler which has a 75 mm opening, will not capture (and measure) large sediment sizes. Also, that although gravel transport may be relatively low, gravel can transfer between bars. Since gravel is the fraction that makes up the bed, it is the most important from both geomorphology and fish habitat standpoints.

To model the sediment transport behavior, a relatively detailed description of observed transport dynamics is critical. For example:

- Does the grain size of the bed load change on the rising and falling limb?
- At what flow does equal mobility start to occur?
- In the gravel bed reaches, are there areas of pure sand, strips of sand, or only extensive gravel deposits? If strips of sand, or pure sand, does this change seasonally?
- Across the channel does the bed load grain size change? Does it correspond with the local bed material?

To better assess the implications of the observed variability, one approach would be to fit upper and lower envelopes by eye to the rating curves. These relations could then be used in the sediment balance assessment to illustrate the precision of the differences between stations. In particular, the lower bound from the middle reach should be used along with the upper bounds from the lower reach sites to assess the minimum contribution from the area upstream of the proposed dam. Likewise, the upper bound from the middle reach should be used along with the lower bounds from the lower reach sites to assess the maximum contribution from the area upstream of the proposed dam. The sediment budget results need to be presented along with an assessment of the uncertainty of the approach, and this provides one potential mechanism.

More consideration should be given to the underlying uncertainties in predictions and how uncertainty can be accounted for in the studies, since this affects the robustness of the results and confidence in the decisions that are based on the results. This issue is increasingly a significant concern in many earth science studies (Caers, 2011) and among modelers (Cunge, 2008).

The studies were not conducted as provided for in the approved study plan because no measures of uncertainty were presented for the sediment load.

Objective 3: *Determine sediment supply, bed mobilization, sediment transport, and mass balance in the Middle River and Lower River segments between the proposed dam site and downstream to the Susitna Station gage, including the mainstem Susitna River and its tributaries.*

Modification 3-1: USFWS recommends clarifying which size classes of sediments are considered to be supply-limited in the context of this river system and what is meant by sediment transport equilibrium.

Various sediment size classes stop moving down a river either because there is no source (supply), or the flows are not powerful enough to transport them. If the dam is not built, which sizes of sediment will not be present because they are not being supplied by the upstream river, the tributaries, or landslides? Conceptually, without models, what size classes would we expect to be supply limited with the dam (see further discussion under modification 3-2)? The presentation to date implies there is plenty of every size class in the Middle River. Whether that size class moves is a function of only hydraulics or more specifically channel form and discharge.

The approved study was not conducted as provided for in the approved study plan as sediment supply was not fully investigated.

Modification 3-2: USFWS recommends an assessment of the feasibility of using a morphological approach to estimate long-term bed load transport rates along the Middle and Lower Reaches to provide an independent check on the short-term measurements from samplers.

The ISR states, in Section 4.3.2.1, the reach is in sediment transport equilibrium for coarse load (gravel and cobble). Transport equilibrium is not defined in the ISR but we assume this means the coarse fraction of the sediment load is governed by hydraulic conditions, not sediment supply. However, on many gravel-bed rivers, bed load is often governed by both hydraulic conditions and supply: At intermediate flows, transport rates may be governed by the state of the bed (imbrication/paving, armoring) and local influx of loose, unsorted materials introduced by bank collapse and local erosion processes. At higher flows, the surface may become fully mobilized so that transport rates are governed more by hydraulic conditions.

Knott et al. (1987, page 13) reports that the bed load transport follows a cyclical pattern with much more occurring on the rising limb than falling limb. Knott et al. (1987) emphasize the seasonal pattern of transport, and how at high discharge sand and gravel bed load appears to be supply limited. This observation should be the focus of the current studies as more information about the hysteresis is needed to adequately characterize the total load.

Sediment transport that is supply limited is usually associated with wash load, while sediment that is governed by hydraulic conditions is associated with bed material load. The report doesn’t explicitly define wash load/bed material load in this relatively coarse sedimentary system. The tabulated results generally report suspended sediment coarser than 0.063 mm as bed material load, which is a common assumption on sand-bed rivers but is not necessarily valid on steep gravel/cobble rivers where much of the suspended sand load is basically wash load. However, in the first paragraph of 4.3.2.1 the report states the river was sediment supply limited for the finer (sand and wash load) size fractions. If the sand component is supply limited (which seems reasonable especially for the 0.063, 0.125 and 0.25 mm size fractions), then these fractions should be considered wash loads. A detailed comparison of the sub-surface bed material composition, suspended load size distribution and bed load size distribution should be made to characterize what is wash load and what constitutes bed material load. This comparison is missing from the analysis.

The ISR indicates annual sediment loads will be estimated over a 61-year period from the available simplified sediment rating curves (developed from regression fits to plots of sediment load and discharge). To be meaningful, the reliability of the annual loads needs to be assessed and confidence limits need to be specified on the range of these estimates (Modification 2-1).

Section 7.2.1.3 of the final ISR indicates a "turn-over" analysis will be carried out as part of the study but does not describe what this will entail and what will be produced. In some rivers, a channel-zone sediment budget approach can be used to estimate volumes and fluxes of sediment transferred along the river. This involves relating quantities of erosion and accretion to flux by assigning sediment step lengths. One of the first efforts to estimate sediment loads on gravel-bed rivers using this morphologic approach was carried out in Alaska by Neill (1987). This approach has since been successfully applied to other gravel-bed rivers (Martin and Church, 1995; McLean and Church, 1999). The feasibility of using this approach to estimate gravel and sand bed material load along the Middle and Lower Reaches should be assessed. The method proposed by Neill requires only historic air photos and periodic channel cross sections to estimate sediment volumes and fluxes, both of which are readily available. This approach integrates sediment loads over relatively long time scales (years or decades), which is in many ways more appropriate than intermittent short-term bed load measurements.

Section 7.2.1.3 also stated that AEA will use estimates of tributary sediment loads produced from the Fluvial Geomorphology Modeling Below Watana Dam Study (ISR 6.6 Section 4.1.2.6) to refine the sediment balance in the Geomorphology Study. In order to use model results in place of measurements and direct observations requires a high degree of confidence in the model predictions and sufficient validation/calibration on tributaries to demonstrate the reliability of the predictions. It is unlikely that this can be demonstrated.

The information gained from the single point in time, P61 sampler method, would have more reliability if it was checked against a morphological approach to estimate long-term bed load transport rates.

License participants have no way of knowing whether the study was conducted under anomalous sediment supply and transport conditions or not. By supplementing the existing data with recommended morphological approach the FERC criteria of anomalous conditions would be settled.

Modification 3-3: USFWS recommends using the information in the 7.7 Glacier and Runoff changes to help predict changes in sediment supply. USFWS has requested substantial modifications to study 7.7 which are included in a separate enclosure.

Glaciers do not provide an equal quantity or size distribution of sediment to rivers over time. This is especially true of large glaciers that are receding or surging. The Susitna headwaters, the McClaren River, the Chulitna and any other tributary with significant (> 1 square mile) land area covered in ice needs to be evaluated to predict how sediment supply will change.

The potential effects of climate change on sediment supply or geomorphology have also been the subject of various studies (e.g. Walling and Webb, 1996; Moore et al, 2009; Schiefer et al 2010; Knight and Harrison 2009). Not surprisingly, these studies show a complex and variable response in different environments. In many valleys, glacier retreat has produced geomorphic hazards, including mass failures from over steepened valley walls and debris flows generated on moraines. Evidence is presented that glacier retreat will result in possibly transient increases in suspended sediment loads (Moore et al, 2009). These studies also highlight that extrapolation from even decade long sediment monitoring programs may lead to biased projections of long-term sediment yield if variations in sediment supply and catchment response to hydroclimatic and geomorphic controls are not considered (Schiefer et al, 2010).

The sediment balance assessment, which is important for assessing the overall stability of the river, is based on an inter-station comparison of annual sediment loads determined from rating curves generated from a limited number of measurements, which display a wide range of scatter. The accuracy of the estimates is unknown. Other traditional geomorphic methods should be used for assessing long-term channel trends and aggradation/degradation patterns such as (1) sediment budget methods based on comparison of historic cross sections (Martin and Church, 1995), (2) estimates from planform changes (Neill, 1987), and (3) specific gage plots at hydrometric stations (comparison of trends in stage-discharge rating curves over time).

Climate change and variability is likely to result in an increase in the frequency of extreme climate events. Extreme events often lead to immediate erosion events as in the case of abnormally intense rain, or delayed erosion events as in the case of droughts which often portend extreme fire.

To date the applicant has acknowledged that discharges may change in the next 100 years. This 5.5 Geomorphology Study does not discuss how the direction or magnitude of change in sediment supply due to either changes in glacier cover or more frequent extreme climate events.

The study was not conducted as provided for in the approved study plan because a potentially major sources of changes to sediment supply (glaciers receding) was ignored.

Objective 4: *Assess geomorphic stability and change in the Middle River and Lower River segments by comparing existing geomorphic mapping with geomorphic feature data from historical aerial photography (Modification 5-1).*

USFWS appreciates AEA's efforts to find the 1949 aerial photos and incorporate them into the analysis. While USFWS does not agree with all the characterizations of channel forms, we acknowledge it is a somewhat subjective task and the study plan did not lay out a mechanism for different parties to come to agreement.

Objective 5: *Characterize surface area versus flow relationships for riverine macrohabitat types over a range of flows in the Middle River segment from the three rivers confluence area upstream to the dam site using information mapped and digitized from aerial photography.*

The Study Plan (RSP Section 6.5.4.5.2.1) proposed to obtain three sets of aerial photography in 2012 at discharges of 23,000, 12,500, and 5,100 cfs. Subsequently, AEA decided to acquire aerials at a single target flow of approximately 12,500 cfs. AEA concluded that the combination of 2-D hydraulic modeling, bathymetry, and topography collected in the Focus Areas could be used to determine the area of the various macrohabitat types over the range of flows of interest

(ISR 6.5 Section 4.5.3). This is still to be demonstrated. The aerial photography taken at 12,500 cfs should be compared to predictions from the 2-D model to assess the accuracy of these estimates.

Modification 5-1: USFWS recommends taking aerial photos of the Middle River to document the rivers lateral extent at the range of flows that AEA intends to discharge from the dam.

Fish live in the lateral margin of the Susitna River and it is important to know how much lateral habitat will be available at post project anticipated flow in the Middle River. While HEC-RAS can make predictions, the model will be much more accurate if it can be calibrated with actual photos from some lower flows. Over time the channel will change and the photos of inundation extent will not account for that change, but it is best to start with as accurate a HEC-RAS model as possible.

Currently only a single set of photos exists for 12,500 cfs. Without a means to calibrate the model at other flows, one would assume the model would become less precise as you move away from that middle value. At the lower end of the proposed releases (4,000 cfs), it will likely do a poor job of representing lateral inundation.

The study was not conducted as provided for in the approved study plan because you cannot characterize the surface area of a river versus discharge using aerial photos taken at a single discharge.

Objective 6: *Conduct a reconnaissance-level geomorphic assessment of potential project effects on the Lower River segment and Middle River segment, considering stream flow, sediment supply and transport, and conceptual frameworks for geomorphic reach response (Grant et al., 2003; Germanoski, 1989).*

Modification 6-1: USFWS recommends conducting the literature review in the manner of Kellerhals and Gill (1973) to provide case histories and experience related to downstream effects of dams in northern climates. This information should assist in defining potential effects on the Susitna River.

Justification and Reasoning for 6-1 and 6-2 will be combined below.

Modification 6-2: USFWS recommends the use of a range of methods including case histories from past projects and site specific analysis to provide a reconnaissance level assessment of project impacts.

The ISR indicated the review will be completed and briefly discussed during the March 2016 ISR meeting. The conclusion is that each river has an individual response to dam structures.

The literature review normally would be conducted near the start of the study, particularly to develop case histories and relevant experience from similar types of projects in similar environments. This experience is useful for guiding the design of the studies and for estimating the direction and magnitude of channel effects. The value of using long-term monitoring and case history experience to assess channel response to flow regulation is illustrated in Kellerhals and Gill (1973) and Church (1995).

The ISR used the conceptual framework developed by Grant et al (2003) for assessing the project effects. The idea of incorporating geological influences in a preliminary assessment of potential downstream effects seems reasonable. The main point of Grant et al, that the broader geological context of any dam should be taken into account, is common sense. The first question that comes to mind is: Why is a general model needed rather than project-specific studies? In applying their "geological framework" it seems difficult to avoid coming up with rather vague predictions that could probably have been developed without benefit of the relations and diagrams. The Grant et al framework was subsequently abandoned and replaced with a “Hierarchy of physical and biological impacts” which is even more generalized than Grant et al. It does not allow predictions to be made of the effects.

A more site-specific approach utilizing experience from past projects is likely to provide more useful information. There are many examples of this approach (Kellerhals and Gill, 1973; Kellerhals et al, 1979; Church, 1995). For example, Church monitored the long-term response of the Peace River to regulation and found that the reduced flows caused gravel to accumulate at major tributary junctions. As a result, rather than experiencing degradation, the river has developed an overall “stepped profile”. The growth of the tributary fans into the river will affect habitat and sedimentation patterns along the tributary channels. Predicting aggradation at the tributary junctions requires understanding of the sediment supply characteristics (total load and size distribution of the load) of each tributary. It is not clear whether these inputs could be defined along the Susitna River at this time.

The study was not conducted as provided for in the approved study plan because the reconnaissance level assessment relied on generalized river concepts rather than focusing on specific knowledge gained from case histories of the effects of dams on rivers similar to the Susitna.

Objective 7: *Characterize surface area versus flow relationships for riverine macrohabitat types in the Lower River segment between the Yentna River confluence (RM 28.5) and Talkeetna (RM 98.5); the task includes conducting analyses contingent on a determination that (1) a comparison of riverine habitat in the Lower River segment under pre- and post-project flows is warranted for additional flow conditions and (2) aquatic resource studies need to be continued downstream in the Lower River segment.*

Modification 7-1: USFWS recommends taking aerial photos from the Talkeetna to the Yentna confluence to document the rivers lateral extent at the range of flows that are likely post project.

Fish live in the lateral margin of the Susitna River and it is important to know how much lateral habitat will be available at post project anticipated flow in the Lower River. While HEC-RAS can make predictions the model will be much more accurate if it can be calibrated with actual photos from some lower flows.

Currently only a single set of photos exists for 12,500 cfs at Gold Creek. Without a means to calibrate the model at other flows, one would assume the model would become less precise as you move away from that middle discharge value. Combining the reservoir operations scenarios with probable contributions from the Chulitna and Talkeetna could suggest one or two other discharges that would be checks on how well the model predicts lateral inundation.

The study was not conducted as provided for in the approved study plan because you cannot characterize the surface area of a river versus discharge using aerial photos taken at a single discharge.

Objective 8: *Characterize geomorphology within the proposed reservoir area and assess reservoir trap efficiency, sediment accumulation rates, delta formation, and erosion and mass wasting potential within the reservoir fluctuation zone and shoreline up to 100 vertical feet above the proposed full-pool elevation.*

To USFWS's knowledge the work on sediment accumulation, delta formation or mass wasting has not been completed.

No modifications are recommended for Objective 8 at this time.

Objective 9: *Assess large woody debris transport, recruitment, and influence on geomorphic forms in the Susitna River between the mouth and the Maclaren River using recent and historic aerial photography and field studies.*

This objective appears to have been completed.

No modifications are recommended for Objective 9 at this time.

Objective 10: *Characterize geomorphic conditions (i.e., channel morphology and sediment dynamics, channel migration zone, large woody debris transport, and erosion and sediment delivery) at stream crossings along access roads and transmission line alignments using data obtained from existing sources and field assessment.*

Fieldwork addressing this objective has not commenced. Nevertheless, no modifications are recommended for Objective 10.

Objective 11: *Integration of Fluvial Geomorphology Modeling below Watana Dam Study with the Geomorphology Study.*

Modification 11-1: USFWS recommends utilizing information from Study 6.5 to test and validate the accuracy of long-term (decadal) predictions from the numerical models. USFWS also recommends utilizing geomorphic methods to make predictions of channel response to changes in sediment supply and discharge so as to provide independent checks on the fluvial model predictions.

The ISR states that the results from Study 6.5 have been used to establish input data and reach boundaries for the 1-D and 2-D bed evolution models. It further states "additional study products in Section 4.11.3 will be used to ensure that the models are developed in an appropriate manner to address the key issues and to provide a reality check on the model results".

Due to the numerous well-documented limitations of morphodynamic models (Cunge, 2008), we believe it is important to fully integrate the fluvial geomorphology modeling (Study 6.6) with the geomorphic studies (6.5). The ISR does not provide a very detailed description of what integration entails or how the geomorphic modeling will make use of the information contained in 6.5. The geomorphic studies (6.5) can be used to strengthen the modeling in several ways:

- To define the most important processes that need to be represented in the models. If understanding whether the system is currently in a state of "dynamic equilibrium" is a truly important consideration, then there needs to be a good understanding of how the river is controlled by its geologic setting, its evolution over Holocene time and its response to changes in climate, vegetation, water and sediment supply over recent times (last few hundred years).
- To provide independent predictions of Project effects as a cross-check to more elaborate modeling predictions (Kellerhals et al, 1976).
- To assist in testing and validating the model predictions and helping to develop realistic assessments of the uncertainty of the predicted responses.

Study 6.5 and 6.6 at times lead USFWS to different conclusions about geomorphic effects of the project on the Susitna River. Until these two approaches suggest the same results it is safe to say one study or the other was conducted under anomalous conditions or the environmental conditions are changing in a material way.

Modification 11-2: USFWS recommends AEA provide details about how the lateral channel changes along the Middle River will be predicted if the effective discharge calculation is abandoned. Since Study 6.5 involves qualitative predictions based on past observations, this is not a request for modeling.

The effective discharge is a geomorphic concept representing that flow, or range of flows, that transport the most sediment over the long term. For the Susitna at Gold Creek, it would most likely be defined as a range of flows between 20,000 and 35,000 cfs. In the load following scenario these discharges do not occur. Presumably some lower discharges would inundate and shape the lateral margins. What flow is AEA suggesting as the new "effective discharge" for the middle river and will it actually continually change the currently lateral margins or just leave them intact as is, but dry almost all the time?

In the fast, cold middle reach of the Susitna, neither spawning adults nor juveniles spend much of their lives in the center of the main channel. What is happening on the lateral margin of the river and whether slower, shallower habitat is being created or destroyed is most important. Islands and point bars also create additional slower edge habitat.

The subroutine to HEC-RAS 5.0 which AEA proposes to use is focused on main channel aggradation and incision. While these are the building blocks for predicting other geomorphological changes, it is not really important to salmon if the center of the main channel, which might currently be 9' deep in August, aggrades or incises by two feet. AEA is focusing on questions the 1-D BED models have been designed to answer (main channel aggradation and incision). These may not be the most important questions to be asking.

The approved studies, whether or not they were conducted as provided for in the approved study plan, fail to focus on the geomorphic changes where the fish spend the majority of their time.

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6.6 Fluvial Geomorphology

Summary of Proposed Modifications and New Studies

For purposes of these comments and proposed modifications, USFWS reviewed the body of comments, meeting summaries, and meeting comments related to fluvial geomorphology. These documents included (partial list):

- Initial Study Report (ISR), June 2014;
- ISR, Part D, October 2015, Supplemental Information to June 2014 ISR;
- Updated Fluvial Geomorphology Modeling Approach TM (UFGMATM), May 2014;
- Winter Sampling of Main Channel Bed (WSTM), September 2014;
- Decision Point on Fluvial Modeling TM (DPTM), September 2014; and
- Study Implementation Report 2014–2015 (SIR) November 2015, including:
    - Fluvial Geomorphology Modeling Development TM, 2014 and
    - Appendix A: 1-D Bed Evolution Model of the Middle and Lower Susitna River.

The USFWS acknowledges receipt of Appendix B: FA-128 2-Dimensional (2-D) Bed Evolution Model but there was not sufficient time to run and review the 2-dimensional model.

The USFWS was pleased that AEA presented models and results at the March 2016 ISR meeting. This review focuses on the 1-D Bed Evolution Model (BEM) for the Middle River and Lower River under the existing and max load following OS-1B operation scenarios. Services' consultants download the models from: http://gis.suhydro.org/suwareports/SIR/06-Geomorphology/6.6-Fluvial_Geomorphology_Modeling/Initial%201-D%20BEM

The results files were not at this site, so the USFWS ran the model from the Susitna Watana hydropower site and much of the following discussion is based on the results.

Study Objectives

The following objectives were stated in the Revised Study Plan (RSP) and then agreed to in FERC's Study Plan Determination (4/1/2013):

1. Develop calibrated models to predict the magnitude and trend of geomorphic response to the Project.
2. Apply the developed models to estimate the potential for channel change for with-Project operations compared to existing conditions.
3. Coordinate with the Geomorphology Study to integrate model results with the understanding of geomorphic processes and controls to identify potential Project effects that require interpretation of model results.

4. Support the evaluation of Project effects by other studies in their resource areas providing channel output data and assessment of potential changes in the geomorphic features that help comprise the aquatic and riparian habitats of the Susitna River.

The Fluvial Geomorphology Modeling below Watana Dam study is divided into three study components:

- Component 1: Bed Evolution Model Development, Coordination, and Calibration
- Component 2: Model Existing and with-Project Conditions
- Component 3: Coordination on Model Output

These three study components are in agreement with the four specific objectives of the RSP.

USFWS Study Modifications

In order to meet the overall Fluvial Geomorphology Study objectives, USFWS recommends the following modifications. Details and justification for each USFWS requested study modifications are included in the pages that follow. (Example: Modification 2-1 indicates it is the first Modification associated with Objective 2.)

1-1 Compare the results of the 1-D and 2-D models across common cross sections and for various identical pre- and post-Project flow conditions.

1-2 Provide detailed information on the fluvial morphology modeling capabilities of HEC-RAS 5.0.0 (1-D model) and SRH-2D 3.0 (2-D model) to demonstrate the real capabilities of both models.

1-3 Limit the use of pass-through nodes to only Devil’s Canyon within the final version of the 1-D BEM.

1-4 Improve the modeling approach to include a short reach of each tributary as a lateral branch in the 1-D model, such that tributary sediment loads are dynamically computed by the model taking into account the post-Project changes in both water levels and bed levels.

1-5 Describe tributary modeling in the Susitna Middle Reach that will incorporate dynamic feedback effects between the tributaries and the main stem.

2-1 At each Focus Area, present 1-D model results of predicted bed levels for each year over the 50-year simulation period. This data should be presented in terms of location specific curves showing time on the x axis and bed elevation on the y-axis

2-2 Replace or overhaul the Sediment Delivery Index (SDI) approach by using a more physically-based approach in order to develop a more robust assessment of pre- and post-Project accretion rates.

2-3 Account for and explain why sediment gradation along the deep portion of the channel is courser than that on the shallow bar heads, as reported in the WTSM.

2-4 Extend some type of fluvial geomorphologic modeling from mile 29.9 to the Cook Inlet. USFWS agrees that the HEC_RAS based model may be an inappropriate tool for this extremely braided lowest reach which transitions into an estuary.

2-5 Assess the sedimentation and development of deltas at the mouth of the mainstem (e.g., head of the reservoir) and reservoir tributaries.

2-6 Re-evaluate how throughput load and bed load interact to move sand and gravel between Talkeetna and Mile 40.

3-1 Include the effects of climate-change induced alterations to sediment load within geomorphic and geomorphology modeling studies (similar to Modification 3-3 in Study 6.5).

3-2 Demonstrate how the outputs from the fluvial geomorphology models will be used in all other models. Every study from 7.5 Groundwater to 9.9 Aquatic Habitat is dependent on how the channel changes.

G-1(Global) Select a range of operational scenarios with the intent of bracketing the possible range of future geomorphic change with-Project impacts to fish habitat downstream of the Susitna-Watana Dam, which should include, but not be limited to: channel narrowing, bed degradation, coarsening of substrate leading to bed armoring, and decrease in fine sediment.

<u>Summary Comments</u>

Below is the summary of ISR Study 6.6 concerns:

- Only preliminary model results have been presented. We assume AEA was already planning to make some of the above modifications.
- 1-D models underestimate sediment transport in the river gravel-bed (Ferguson 2003), which could lead to underestimation of the effects of the proposed Watana Dam.
- The 1-D bed evolution model (HEC-RAS 5.0 Beta) has been “calibrated” by comparing USGS measurements of transport rates with values computed by the 1-D model. However, this does not guarantee the 1-D model can provide reliable results of bed degradation, especially considering the excessive use of pass-through (‘fixed-bed’) nodes in the model.

- The 1-D (HEC-RAS 5.0 Beta) and 2-D (SHR-2D 3.0 Beta) modeling software used for the bed evolution models in the November 2015 ISR Part D report were Beta versions not widely used, tested or documented. There is no guarantee that the results presented in the ISR using these Beta versions can be replicated later using the final public release of the software. (HEC-RAS 5.0 was released in February 2016.)
- Preliminary 1-D geomorphology modeling results of the effects of the Watana Dam in the Middle River have been presented using HEC-RAS 5.0 Beta June 2014. Because of stability problems with the software, the model uses pass-through nodes on every island in the model including the Focus Areas, which is not acceptable.
- The 1-D modeling results in the Lower Susitna River show the largest dam impacts (bed changes) farther downstream in the river, which does not seem physically realistic.
- The delay in Study 6.6 negatively affects the progress of other studies that will use the results of geomorphic modeling such as 6.5 (Geomorphology), 8.5 (Fish and Aquatics Instream Flow Study) and 8.6 (Riparian Instream Flow Study).

AEA's Proposed Study Modifications

USFWS does not object to the following study modifications proposed by AEA:

- Use of Ackers and White sediment transport equation instead of Wilcock and Crowe equation as originally planned.
- Include groundwater sources in Focus Areas 2-D hydraulic models.
- Extend Focus Area bed evolution modeling time period when additional information is needed to evaluate tributary fan development.
- Exclude dimensionless critical shear as a parameter for the sensitivity analysis as originally indicated in the RSP (based on use of Ackers White sediment transport equation).
- Do not consider Pacific Decadal Oscillation (PDO) for selection of hydrology for representative wet, average and dry years.
- Exclude Bank Energy Index (BEI) analysis for channel bank erosion, though AEAshould include more detailed evaluation of ice breakup conditions as driver of bank erosion.

Review by Objectives

This material within this objectives section is arranged differently than other USFWS study reviews. USFWS will first describe the challenges which led to the need for the study modification and then present the modification.

USFWS acknowledges that modeling channel morphology on a large river is a difficult task and it is easier to critique what was accomplished than to do it right. Since human activity has either extirpated salmon completely, or greatly diminished the number of species and individuals on most rivers that once contained salmon, it is imperative that AEA work with the USFWS and NMFS (Services) to make these models as accurate as possible.

Objective 1: *Develop calibrated models to predict the magnitude and trend of geomorphic response to the Project (Modifications 1-1, 1-2, 1-3, 1-4 and 1-5).*

Challenge 1: Selecting 1-D vs 2-D Model

Given that Ferguson (2003) demonstrated that 1-D models tend to severely underestimate bedload transport in gravel-bed rivers, the entire Susitna River study reach from PRM 29.9 to PRM 187.1 should be modeled using a 2-D Bed Evolution Model (BEM) for the 50 years of FERC licensing period. However, performing 2-D fluvial geomorphology simulations in such a large modeling domain combined with multi-year modeling periods is not practical at the moment due to current limitations in computer power and a lack of sufficiently detailed channel morphology data. Therefore, AEA's proposed use of a 1-D reach-scale (from PRM 29.9 to PRM 187.1) BEM for assessing the long-term and cumulative effects over the 50 years of FERC licensing period combined with the use of a 2-D local-scale BEM for more detail short-term (~6 months) analyses in 10 selected Focus Areas is a non-ideal, but necessary compromise for modeling the geomorphic effects of the Project. The limitations of the 1-D reach-scale and the 2-D local-scale BEM should be clearly identified and stated such that the usefulness of the modeling results is transparent. The selected Focus Areas for the 2-D local-scale BEM are supposed to be representative of each of the geomorphic reaches where they are located. The main issue with 1-D model is that there is a single width-averaged value of a hydraulic parameter (e.g. depth, velocity, shear stress) as representative of the entire cross section, neglecting the variability across the channel width. This is a good approximation only when the channel section is rectangular in shape. Because bedload transport laws are nonlinear, a disproportionate amount of the total bedload in a cross section is transported along the deepest part of the river channel where velocity and shear stress are normally highest. Figure 1 illustrates how bedload transport in a section of the Susitna River varies by orders of magnitude across the channel width.

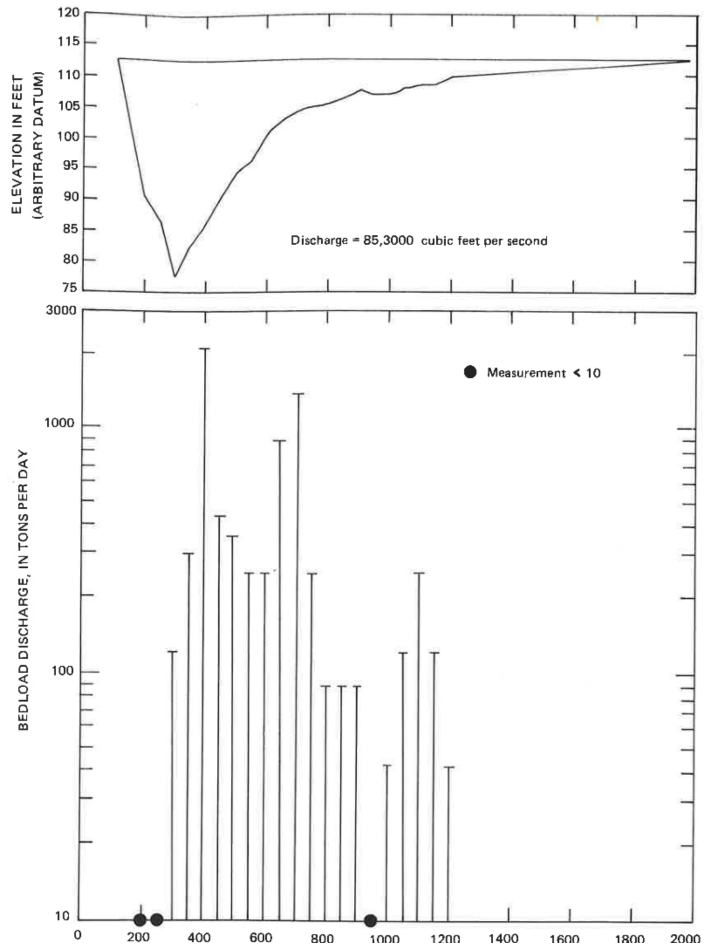


Figure 1. Cross section and distribution of bedload discharge, Susitna River at Susitna Station, August 15, 1984 (Knott et al. 1986).

According to Ferguson (2003) “simple width averaging leads to severe underestimation of bedload transport in most conditions”. Ferguson proposes “averaging only in the areas of the channel with above-average depth or shear stress”; but this may be difficult to implement as it will require changing the programming code of the 1-D model. One possibility could be to restrict the ‘effective’ or ‘active’ width for sediment transport to only the deepest part of the channel if the 1-D software has that capability; but even in that case the active width will not be constant but vary with discharge. Another suggestion could be to reduce the critical shear stress (or sediment size) to artificially increase bedload transport.

Modification 1-1: USFWS recommends comparing the results of the 1-D and 2-D models across common cross sections and for various identical pre- and post-Project flow conditions during model calibration. The values of shear stress and bedload transport computed by the 1-D model at each section should be compared with the corresponding width-averaged values computed by integrating the results of the 2-D model at the same section. If significant discrepancies are found in width-averaged transport rates between the two models, then different strategies (e.g. active width reduction, decrease in critical shear stress, etc.) should be tested in the 1-D model to try minimizing the discrepancies over the entire flow duration curve, so that the average annual bedload transport computed by both models is similar.

Currently AEA asks the licensing participants to agree that a large complex river can be represented with a 1-D model that deals with a single channel and a single Mannings N for each cross section. The Susitna is split about ½ the time.

The study was not conducted as provided for in the approved study plan because AEA made large assumptions without any data to back them up.

Challenge 2

AEA's selected models are prototypes.

The following models proposed in the ISR have been selected by AEA (TetraTech 2014).

- 1-D Reach Scale Model: HEC-RAS 5.0.0 Beta (U.S. Army Corps of Engineers) and
- 2-D Local Scale Model: SHR-2D 3.0 Beta (U.S. Geological Survey).

Although AEA had access to the Beta versions of these two modeling software packages for some time, they provided no documentation showing the application of these models in similar projects. Therefore, the capabilities of the models remain unproven.

The results of the 1-D BEM model of the Middle Susitna River, developed using the modeling software HEC-RAS 5.0, are quite sensitive to the version of software used, as summarized in the table below.

	Version of HEC-RAS 5.0 modeling software		
	Beta June 2014	**Beta August 2015**	**Official (February 2016)**
Use	Used by AEA (Tetra Tech) in the ISR report	Used by the USFWS in our review	Official version released by US Army Corps to the general public
Quantitative results	1 to 2 ft of degradation	Up to 10 ft of degradation	Unknown - Model did not run due to errors

			in input data
Qualitative results	Predicted larger degradation with dam in place, which is reasonable	Predicted larger degradation without dam, which is unreasonable	Unknown - Model did not run due to errors in input data

Early additions of complex models that do not run correctly is a common challenge and USFWS is hopeful that AEA can work through these challenges in the future.

Modification 1-2: USFWS recommends providing detailed information on the fluvial morphology modeling capabilities of HEC-RAS 5.0.0 and SRH-2D 3.0 to demonstrate the real capabilities of both models; including multi-size sediment transport and bed armoring (erosion of surface fines) processes, which are crucial for assessing pre- and post-geomorphic Project effects.

HEC-RAS 5.0 is now officially available (as of 5/26/2016). Especially relevant, are documented applications to similar gravel-bed rivers in glacial systems where the models have been satisfactory validated by reproducing observed bed changes. USFWS recommends that the proposed numerical models be validated by applying them to simulate existing documented case histories of large glacial systems. The 30-year dataset of cross sections from the dams on the Peace River would be a good place to start.

AEA is utilizing untested models on the Susitna projects; this can be viewed as using cutting edge technology or a recipe for erratic predictions of project effects – or both.

The study is not being conducted as provided for in the study plan because the Services understood AEA would use models proven by previous use on other rivers.

<u>Challenge 3</u>

Many nodes (locations where the bed elevation is fixed) were used to make the 1-D model stable and interact with other models (Figure 7).

Modification 1-3: USFWS recommends the final version of the 1-D BEM must limit the use of pass-through nodes to Devil's Canyon only.

Nodes are only appropriate when modeling rivers passing through erosive resistant bedrock such as Devil's Canyon.

AEA used nodes every time there was channel split or a focus area. This was done because the HEC-RAS 5.0.0 model cannot deal with flow splits and routes the sediment proportional to the distribution water. Also the modelers felt the 2-D needed the 1-D model not to change adjacent to the focus area. The reason to do bed evolution modeling is undermined if you are going to put in nodes every 10 miles.

If any nodes are used outside of Devil's Canyon, then the 6.6 study is not conducted as provided for in the approved study plan as the models cease to have any credibility in its ability to model channel incision or aggradation.

<u>Challenge 4</u>

How the 1-D BEM models sediments from tributaries is unclear. This is covered in following in Modifications 1-4 and 1-5.

Modification 1-4: USFWS recommends switching from treating tributaries as static point sources, to a new modeling approach to include a short reach of each tributary as a lateral branch in the 1-D model, such that tributary sediment loads are dynamically computed by the model taking into account the post-Project changes in both water levels and bed levels.

The *Updated Fluvial Geomorphology Modeling Approach Technical Memorandum* (UFGMATM) seems to suggest that tributaries may indeed be modeled as branches instead of point sources. The ISR indicates that:

> Tasks in this effort [Tributary Delta Modeling] involve creating the sediment inflow rating curves and performing a demonstration of the process to model fan development at a tributary through the 1-D modeling approach (Note: Tributaries within Focus Area will be modeled in 2-D as part of the SRH-2D Focus Area model domain and only require the sediment rating curves from this task). (Section 7.2.1.1.6)

Based on experience from the dam-regulated Peace River in Canada, USFWS mentioned that coarse sediment coming from tributaries downstream from the dam may not be transported by the reduced post-Project river discharges leading to enlargement of alluvial fans/deltas and stepped water surface profile. USFWS requested some clarification on the modeling approach of lateral tributaries, which according to the ISR appear to be modeled as point sources based on sediment rating curves estimated from pre-Project conditions, without accounting for the post-Project reduction in water levels along the Susitna River main stem. Reduced water levels along the main stem will produce a local steeping of the water surface along the tributary mouth and possibly higher flow velocities that could lead to a transient increase in sediment loads due to local erosion. AEA countered that sediment loads from tributaries are very low and they do not expect scour to occur, but sedimentation instead.

However, the intent is not clear, and it is not mentioned when results of this demonstration will be presented. The topic of Tributary Modeling is relevant to pre- and post-Project impacts, and the integration with other studies.

Especially below a dam, tributary contributions of sediment are very important to channel morphology. If tributaries are viewed as static point sources of sediment then the study is not being conduct as provided for in the approved study plan because it fails to incorporate a known crucial element.

Modification 1-5: USFWS recommends clearly describing tributary modeling in the Middle Reach that will incorporate dynamic feedback effects between the tributaries and the main stem, in a way that potential post-Project effects such as upstream progressing degradation along the tributaries (Galay, 1983) or development of stepped profiles along the main stem (Church, 1995) could indeed be reproduced by the 1-D BEM.

One process that tends to reduce the effects of degradation downstream of dams on gravel-bed rivers is the delivery of coarse sediment from tributaries downstream of the dam, as the reduced post-Project discharges become incapable of transporting such sediment, which tend then to form alluvial fans or deltas. For example, Church (1995) monitored the long-term response to regulation on the Peace River in Western Canada and found that the reduced flows caused gravel to accumulate at major tributary mouths. As a result, the Peace River has developed an overall stepped water surface profile.

The ISR describes the proposed Tributary Modeling:

> Numerical modeling of sediment supply will be carried out using software such as HEC-RAS (USACE 2010), SAMWin (Ayres Associates 2003), or spreadsheet applications coupling HEC-RAS hydraulic results with an applicable transport function. (Section 4.1.2.6)

In the ISR statement above, it is not clear if the proposed tributary modeling approach will reproduce the effects documented above because it does not demonstrate that there is a dynamic feedback between the main stem and the tributaries. It almost appears as if the tributaries will be modeled simply as point sources of sediment into the main stem, which may not be correct as pre-Project tributary supply and distribution will be different from post-Project supply.

Because post-Project water levels along the main stem of the Susitna River will be typically lower during the summer season when tributary flows are peaking and their sediment supply is highest, the water surface slope along the tributaries discharging into the Susitna Middle Reach will be locally steeper near their mouths, meaning that flow velocity and sediment transport along the tributary near the mouth will locally increase (until a new equilibrium condition is re-established). This potential post-Project increase in sediment loads from Middle Reach tributaries will be neglected if tributary loads are estimated using existing pre-Project conditions and then imposed as static fixed point sources in the 1-D main stem model. Also, if the main stem suffers from bed degradation, the bed level along the tributaries will also degrade following a process of upstream progressing degradation

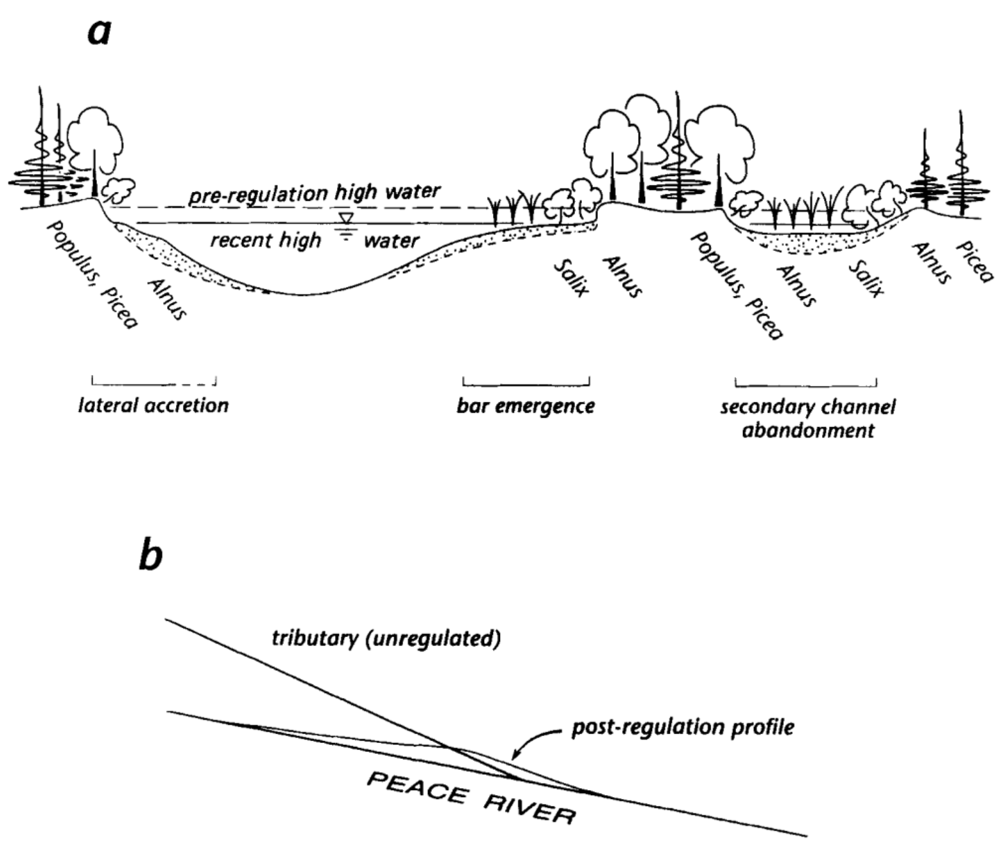


Figure 2. Morphological changes following flow regulation in Peace River: (a) Cross section. (b) Tributary mouth (Church, 1995).

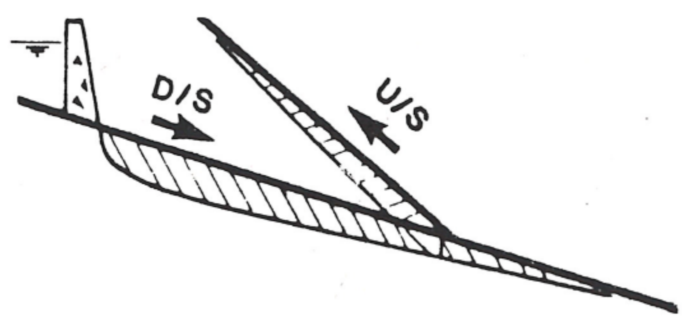


Figure 3. Example of downstream progressing degradation (D/S) caused by a dam, which in turn causes upstream progressing degradation (U/S) along a tributary (Galay, 1983).

Especially below a dam, tributary contributions of sediment are very important to channel morphology. If tributaries are viewed as static point sources of sediment then the study is not being conducted as provided for in the approved study plan because it fails to incorporate a known crucial element.

Objective 2: *Apply the developed models to estimate the potential for channel change for with-Project operations compared to existing conditions.*

General Review of Models: Bed Elevation Changes

The Updated Fluvial Geomorphology Model Development TM states that bed elevation changes in the Middle River are small with no degradation downstream of the dam:

> Figure 5.1-9 [Figure 4] shows Middle River bed elevation change at each cross section over the 50-year simulation period with the channel profile for reference. Throughout the Middle River bed elevation changes are predominantly between +/- 1 foot and rarely exceed 2 feet of change in 50 years. (pg. 30).
>
> Although sediment supply of sand and coarser sizes would be eliminated at the dam site, the channel does not appreciably degrade over the 50 year license period. This is due to the very coarse bed acting as a “static” armor. (pg. 42)

Figure 4 below shows the original Figure 5.1-9 mentioned in the report. The scale on the right vertical axis shows the magnitude of bed elevation change in the range of +4 feet (deposition) to -3 feet (erosion). In agreement with the statements made in the report, largest bed degradation reaches down to -2 feet, but in general it remains small.

Figure 5 shows the bed elevation changes computed by running the HEC-RAS model downloaded from the Susitna-Watana web server (approximately 3/1/2016), plotted in a similar format as but with the scale of the right vertical axis expanded 4 times between +16 feet and -12 feet. Notice that degradation is much stronger, reaching values of -10 feet, which is the maximum scour depth allowed in the model (i.e. the model assumes non-erodible bedrock 10 feet below initial bed level).

In order to further verify that the large degradation shown in Figure 5 was not a consequence of erroneous post-processing of the model results on our part, the transverse profiles of the most upstream cross section (Project River Mile – PRM 187.2), immediately below the proposed Watana dam site, were extracted as shown in Figure 6. The two cross section plots are direct outputs from HEC-RAS without any post-processing. They show degradation of 10 feet for the Existing condition and 8 feet for the Max LF OS-1b, which is counterintuitive as more degradation will be expected when the dam is included in the model.

These large discrepancies between the reported values (Figure 4) and the values obtained by running the posted 1-D BEM model (Figure 5) should be explained before the 1-D and 2-D BEM results can be considered valid (the 2-D model uses input from the 1-D model).

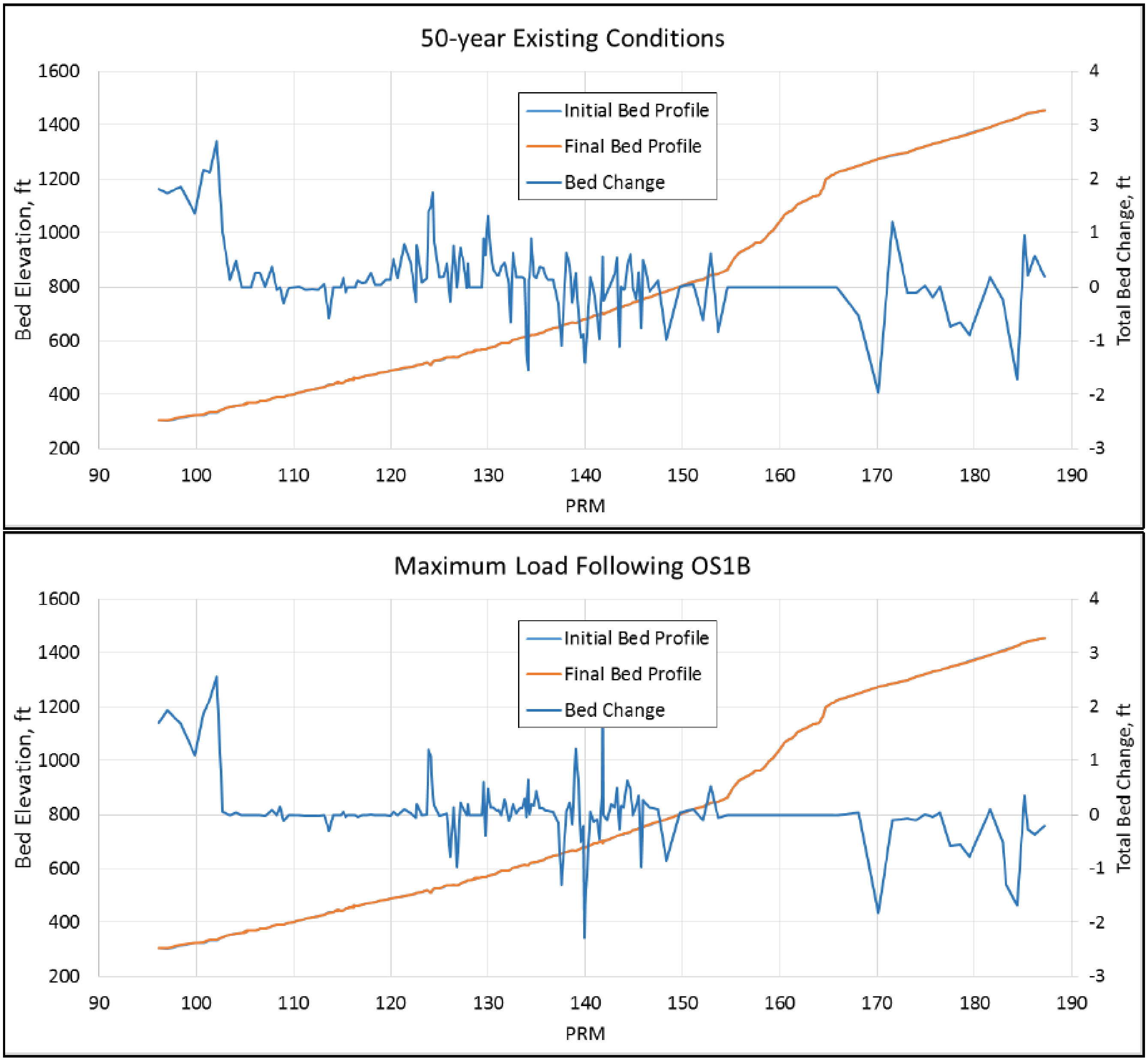
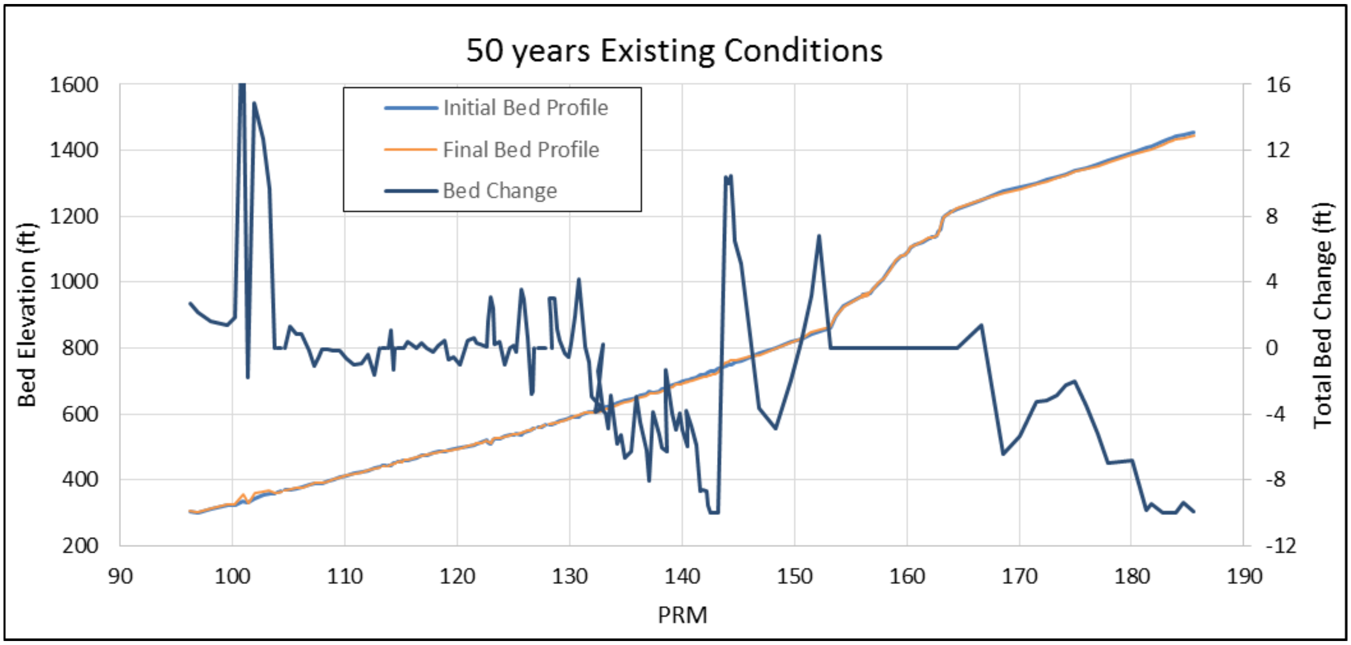


Figure 4. Bed changes along Middle Susitna River over a period of 50 years reported in Figure 5.1-9 of Fluvial Geomorphology Model Development - Technical Memorandum (Nov. 2015).



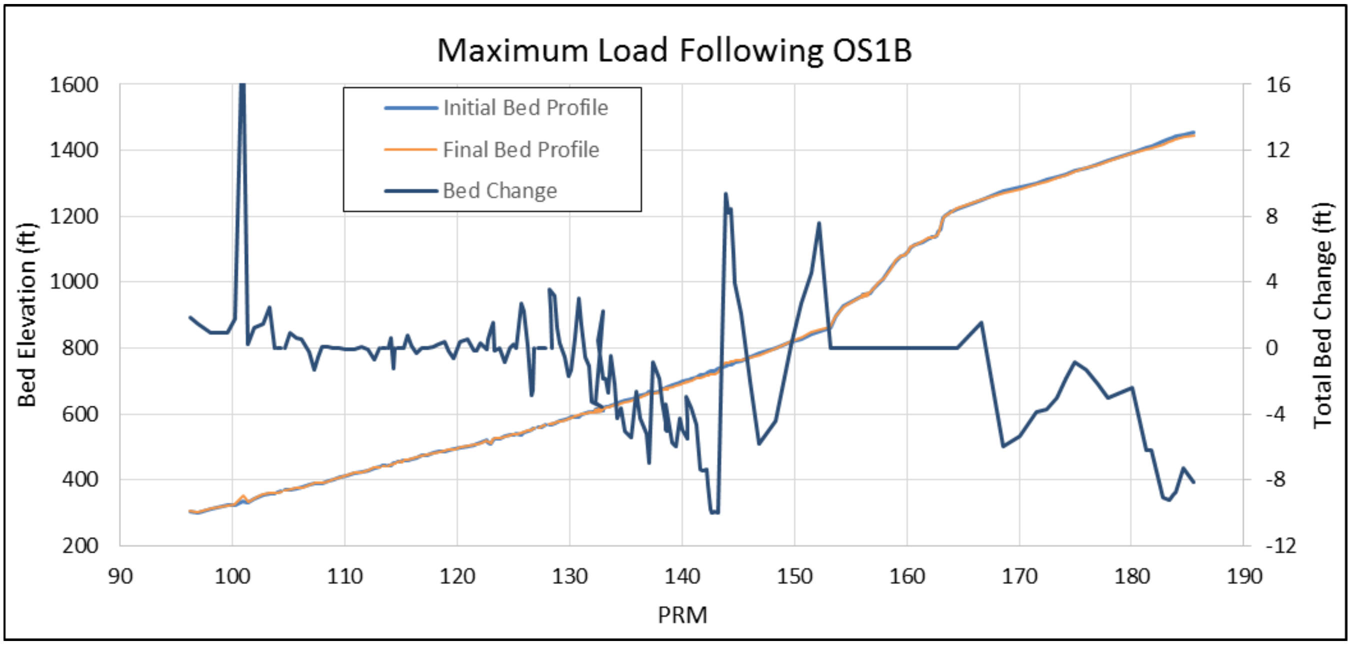


Figure 5. Bed changes along Middle Susitna River computed using 1-D BEM downloaded from Susitna-Watana web server.

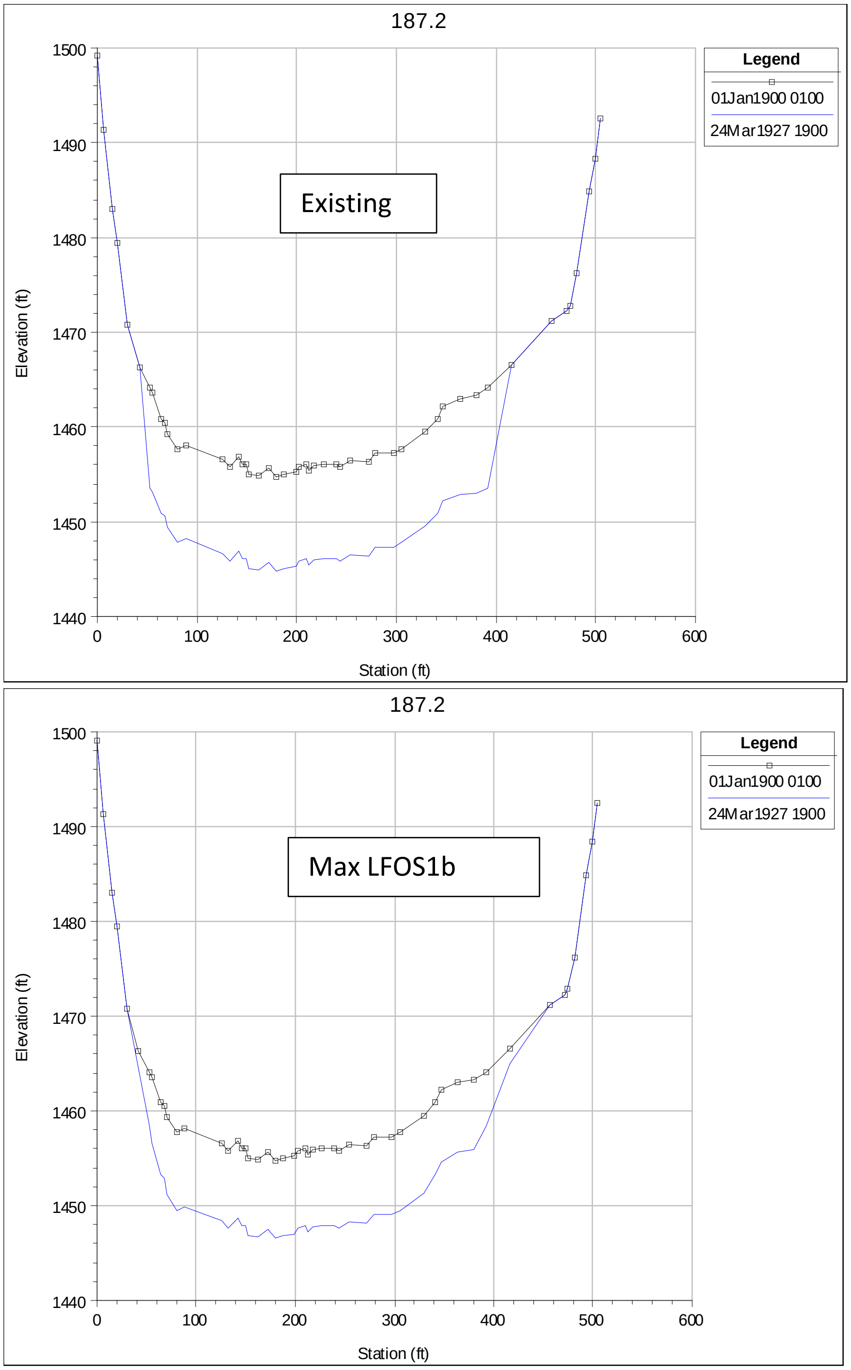


Figure 6. Changes in profile of most upstream Watana cross section (RM 187.2) for the existing conditions (without dam) and Maximum LF-OS1b (with dam) over a period of 50 years.

General Review of Models: Pass-through Nodes

Pass-through nodes are cross sections in the HEC-RAS model where incoming sediment from upstream simply passes through without causing erosion or deposition (i.e. bed change is forced to zero at a pass-through node). The use of pass-through nodes is justified in steep bedrock reaches such as Devil's Canyon, but never in alluvial reaches (the Susitna River is an alluvial system) where the bed is free to change due to erosion or deposition. In the HEC-RAS model downloaded, there are 70 pass-through nodes out of 166 cross sections, including Focus Areas FA 104, FA 113, FA 115 and FA 128. The location of pass-through nodes in the Middle River HEC-RAS model is shown in Figure 7, plotted against the bed changes computed for the Existing conditions.

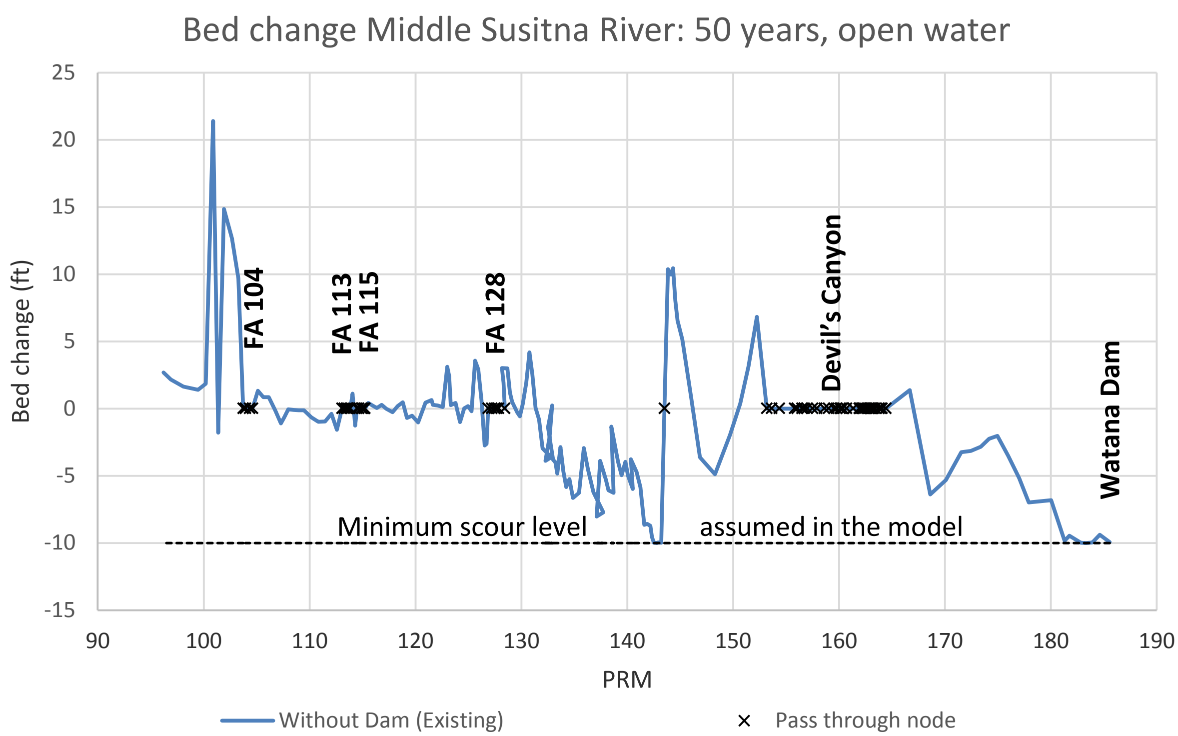


Figure 7. Bed changes in the Middle Susitna River predicted by 1-D open water model for existing conditions (without dam) over a period of 50 years, showing location of pass through nodes.

Figure 7 shows clearly how the presence of pass-through nodes forces bed changes to be zero, which outside Devil's Canyon is unwarranted and defeats the main purpose of the 1-D BEM, which is precisely to predict bed changes. The reason for using pass-through nodes in the alluvial flow split areas is due to present limitations in the HEC-RAS 5.0 beta version model, as mentioned in AEA's *Attachment 1: Appendix A. 1-D Bed Evolution Model of the Middle and Lower Susitna River*:

> …it was decided that the software [HEC-RAS 5.0 beta] is not yet able to reasonably simulate sediment routing through split flows…ultimately leading…to model instability…but for the POC effort, in the Middle River the flow splits, flow junctions, and main channel and side channel cross sections through a split flow reach were set as pass through nodes. (pg. 27)
>
> A more complete set of [12] split flow reaches will be included in the Middle Susitna River model. (pg. 34)

AEA's final model is expected to increase the number of flow splits from 4 to 12. Several pass-through nodes (where bed evolution is forced to zero) have been used in the 1-D BEM model due to numerical stability issues with the HEC-RAS Beta 2014 version used by AEA. Pass-through nodes should not be used in the final BEM, except along Devil's Canyon. Model stability issues should be addressed to allow for the removal of pass-through nodes.

The excessive use of pass-through nodes also affects the 'calibration' results presented in the report, which consisted of comparing the total load predicted by the model with measurements made near Talkeetna. Since roughly 40% of the cross sections are set as pass-through nodes, the results of the 'calibration' cannot be considered fully valid until the pass-through nodes outside Devil's Canyon are removed.

Challenge 5

The downstream geomorphic impacts will usually be most intense near the dam and will progress downstream over time (at a rate that depends on factors such as bedload transport rate, river slope, sediment size, channel width, among others). If the channel immediately below the dam is highly armored, such that the max flow in OS-1b cannot remove the armor, the above statement may not be true. Near the dam, the rate of morphological changes will be fastest immediately after dam construction, but will slowly decrease over time as the river tries to asymptotically approach a new with-Project equilibrium state (e.g. the new with-Project channel may be deeper, narrower and coarser). Providing 1-D model results at two fixed points in time (year-25 and year-50) may be reasonable for relative comparison between different scenarios; but it will not provide a clear picture of how the river will adjust to the imposed with-Project conditions and their time scales.

Modification 2-1: USFWS recommends that for each Focus Area (especially Focus Areas closer to the dam), 1-D model results of predicted bed levels be presented for each year over the 50-year simulation period. This data should be presented in terms of location specific curves which show time on the x axis and bed elevation on the y-axis. If significant with-Project changes were detected at an earlier point in time (e.g. year 5 or year 10); then this earlier time should be considered for analysis by the 2-D model.

The selection to evaluate mainstem bed incision/aggradation at 25 and 50 years was somewhat arbitrary. It may be appropriate for reaches where the effective discharge will probably be diminished by less than 40% such as below the three rivers confluence. It is not appropriate directly below the dam where annual peak flows are likely to decline by two thirds and sediment supply will be reduced even more.

Currently, adjustment to other models would only be done at 25 and 50 years.

The study is not being conducted as provided for in the approved study plan because there needs to be frequent and timely interchange of data between the 1-D BED model and the other models or it will not be a useful tool.

Challenge 6

When flows in the Susitna River spill over its banks and into vegetated floodplains and side sloughs the additional drag caused by vegetation produces a reduction in over-bank flow velocity and turbulence that induces the deposition of sand transported in suspension, leading to the vertical accretion of floodplains. Since the Watana Dam would trap all incoming sand and silt from upstream, post-Project floodplain vertical accretion downstream from the Dam will be significantly different. The Sediment Delivery Index (SDI) is the current approach proposed to qualitatively assess these changes in accretion rates. But the SDI is rather simplistic, especially considering that better quantitative models already exist (Moody and Troutman, 2000).

Modification 2-2: The SDI approach should be replaced or overhauled using a more physically-based approach in order to develop a more robust assessment of pre- and post-Project accretion rates.

USFWS is concerned that sloughs and smaller side channels which are currently juvenile habitat will over time be dewatered and/or fill in and become lowland vegetation. Whether or not this happens depends on whether water arrives in these side channels and if it is carrying sediment. A physically based approach is likely to give a more accurate deposition prediction.

The SDI was likely derived from data from rivers far removed from the Susitna with fewer ice effects.

The study is not being conducted as provided for in the approved study plan because sediment deposition, an important process to juvenile fish habitat, is being over simplified.

Challenge 7

The sediment size distribution (gradation) of bed material is very important input data for the geomorphic models of Study 6.6. Since bed sediment mobility decreases with sediment size (i.e. large sediment is more stable), the bed sediment size input in the geomorphic models has a strong influence on the predicted bedload sediment transport rate and hence bed changes. Previous sediment size sampling has been based on pebble counts from samples collected on shallow bar heads; but it remained unknown whether those bar head samples were also representative of the deepest portion of the channel.

The new winter sampling was carried out using digital photogrammetry (Winter Sampling Tech Memo (WSTM)). On average at each measuring transect, digital photographs of the bed were taken at 12 auger holes drilled through the ice cover. Nine points were selected at each hole to provide around 100 points to develop a pebble count at each transect.

The main conclusion of the winter sampling relevant for Study 6.6 is that "… bar head samples are not representative of the bed material in the deepest portions of the main channel in the Middle River. For the Middle River, the average grain size of the main channel is …larger than for the bar heads, with and average D_{50} of 83.2 mm for the main channel and 59.0 mm for the bar heads."

This means that when these larger grain sizes collected in winter are input into the geomorphic models, they would lead to smaller bed changes compared to those obtained by using the bar head samples data.

Although the WSTM provides useful and interesting factual information, it fails to provide an explanation for the reasons why sediment gradation along the deep portion of the channel is coarser than that on shallow bar heads.

Modification 2-3: USFWS recommends explaining why sediment gradation along the deep portion of the channel is courser than that on the shallow bar heads, as reported in the WSTM. USFWS further recommends explaining how the 1-D model can be modified to account for the fact that bed roughness changes laterally across the channel.

First, USFWS commends AEA for their effort to measure mainstem pebble counts through the ice; it was a solid idea that was well executed.

Understanding the physical processes and mechanisms responsible for this lateral sorting of bed material sizes across a river cross section is important to guarantee that they are properly accounted for and hence simulated by the geomorphic models. For example, if the lateral sorting is due to lateral changes in the bed shear stress across the channel width (i.e. shear stress higher in deeper portions of the channel), then this process cannot be simulated by the 1-D geomorphic model which assumes constant shear stress across the entire channel width.

The findings of the winter sampling showing variation in bed sediment size between the deep and shallow portions of the channel in the Middle River are quite important and will significantly influence the results of the geomorphic models. Using the coarser deep-channel gradation for the entire cross section would not be acceptable as it will underestimate bed changes and hence the post-Project geomorphic impact of the dam. It should be explained how the models will incorporate this size variability across the channel width; especially for the 1-D model. One possibility to bracket the possible range of changes could be to perform a sensitivity analysis using both the gradations measured in bar heads and deep channel.

To date, main channel roughness was determined by pebble counts on bar heads. It is relatively easy to adapt the model to the larger average pebble size, which determines the bed roughness parameter. The larger challenge is how to deal with clearly variable bed roughness as one moves across the channel.

The study is not being conducted as provided for in the approved study plan because an important model parameter is incorrect and oversimplified.

Challenge 8

1-D BED models results are counterintuitive as effects are most pronounced the farther downstream you are from the dam.

General Review of Models: Decision Point Technical Memorandum (DPTM)

The methodology and decision criteria for extending the model below PRM 29.9 as stated in the DPTM: "If the expected changes due to Project operations are small relative to the range of natural variability the potential impacts are considered minor and extension of the 1-D fluvial geomorphology modeling downstream is not warranted."

In order to represent Project operation, the DPTM uses the Load Following Operational Scenario 1B (OS-1b). For assessing changes due to Project, the following variables were considered in the analysis: channel width; sand and gravel transport mass; bed elevation (channel aggradation or degradation); and flow depth and velocity.

Changes in channel width were estimated based on hydrologic analysis of changes in flow discharges and assuming that the river follows the 'regime' theory. According to regime theory, channel width is proportional to the square root of discharge. Therefore, relative changes in channel width are half the relative changes in flow discharge. Table 5.1-2 of the ISR shows that since the Project will reduce the 2-year flood discharge between 4.0% and 15.0%, then channel width would be reduced somewhere between 2.0% and 7.8%. The changes in the other variables were estimated using the 1-D HEC-RAS model version 5.0 beta.

1-D Model Calibration and Validation - Regarding hydraulic calibration and validation, the HEC-RAS model seems to provide reasonable results of discharges and water levels. Therefore, it should provide reasonable estimates of changes in water depth and flow velocity. However, regarding sediment routing calibration, the results of the model do not appear to be reasonable.

The results of sand load transport predicted by the HEC-RAS model in the Lower Susitna River seem to compare well with data from measurements. However, because in the Middle Susitna River sand is transported mainly suspended as washload, without interacting with the riverbed, these results do not necessarily demonstrate that the model can predict morphological changes well, as bed changes depend mainly on gravel transport.

Predicted Bed Changes - The results of the 1-D sediment transport model along the Lower Susitna River are shown in Figure 9 (below). Due to its lower slope and proximity to the sea, the river tends to deposit sediment in this reach making it aggradational (i.e. annual bed changes are positive). This figure also shows that the dam operation following LF OS-1b decreases the degree of aggradation in the Lower Susitna River as expected, since sediment trapped from the dam will no longer be delivered to this reach. However, the geomorphic effect of dams on downstream river reaches tends to dissipate away from the dam (i.e., degradation is most intense near the dam and decreases along the river in the downstream direction). Then, AEA’s model is rather surprising that the reach LR-1 exhibits much smaller bed change that reaches LR-2 through LR-5, which are located farther downstream.

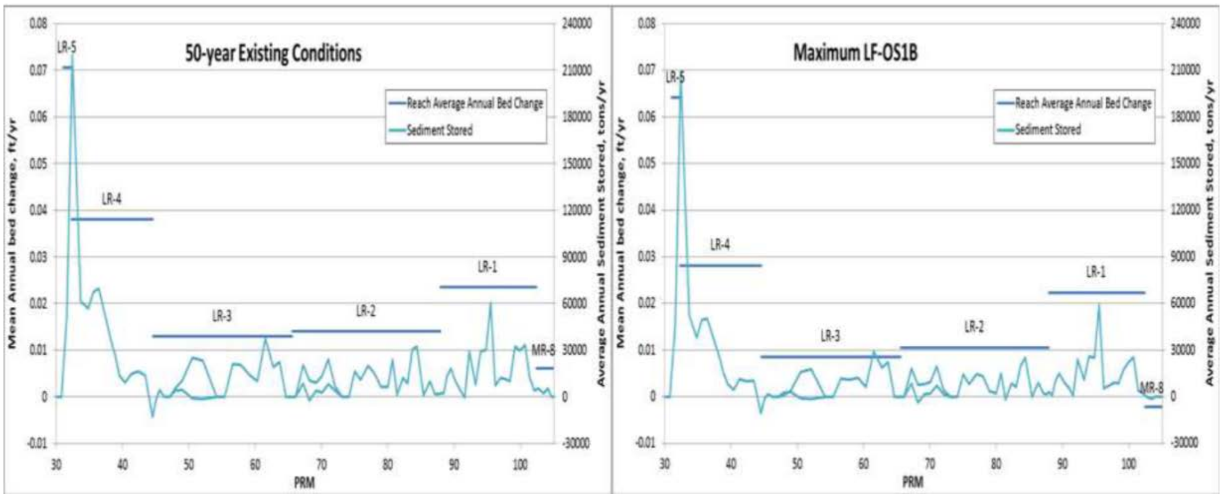


Figure 8. 50 year mean annual bed change predicted by 1-D model for both existing conditions and Maximum LF-OS1b.

Also, 9 shows the difference in bed changes predicted by the 1-D at the end of the 50-year period, computed by subtracting the bed changes with-Project (Table 5.3-2) minus the existing conditions (Table 5.3-1). These values represent the net effect of the Project. Again, bed changes increase downstream of LR-1. Surprisingly, the model predicts that Watana Dam will generate larger bed changes in reach LR-4 farther downstream than those in MR-8. These results are counterintuitive, needing clear explanation.

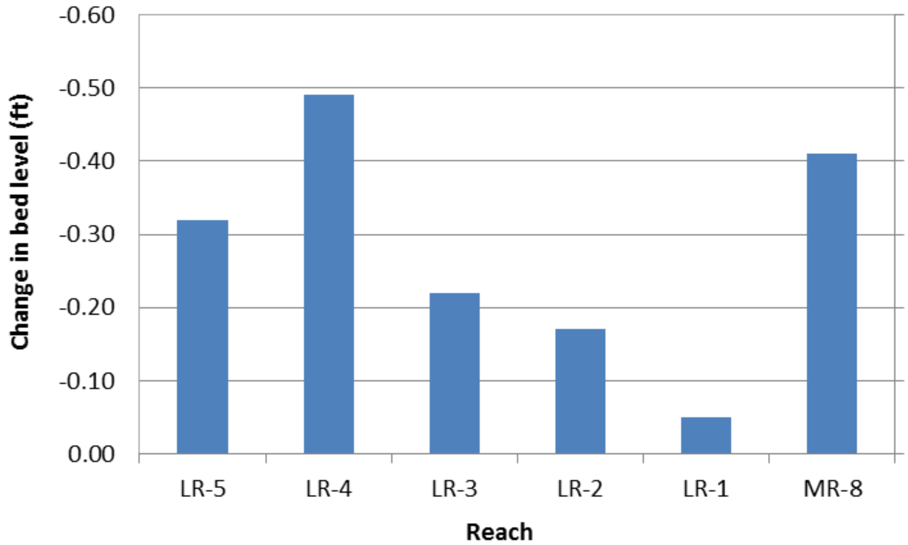


Figure 9. Bed elevation change between existing conditions and LF-OS1b as predicted by 1-D model (i.e. the impact of the Watana Dam on bed levels).

The overall decision of not extending the bed evolution model downstream of PRM 29.9 due to predicted small changes caused by the Project is not currently supported by their modeling. By AEA's own account during the March 2016 ISR meeting, this decision is also not supported by the scientific literature reporting on empirical evidence from other dammed systems. Although AEA anticipates that the influence of the large tributaries discharging into the Lower Susitna River will dissipate the effects of the dam on hydraulics and sediment transport, the predictions made by the 1-D bed evolution that bed changes increase downstream, or even are larger in reach LR-4 than MR-8, raise some doubts about AEA's 1-D model capabilities.

Modification 2-4: USFWS recommends extending fluvial geomorphologic modeling from mile 29.9 to the Cook Inlet. USFWS agrees that the HEC-RAS based model may be an inappropriate tool for this extremely braided lowest reach which transitions into an estuary.

Based on the modeling results presented above (Figure 8) the channel will aggrade at 9 inches a decade or 4 feet over the first 50-years of the project. 4 feet of bed change in a river that is at least ½ mile wide seems to be outside the range of natural variability. If the model predicts effects that are significant 150 miles below the dam, it is reasonable to expect them to effect the last 30 miles to Cook Inlet also. This rate of aggradation will shorten the length of channel that is intertidal, thereby potentially decreasing eulachon habitat.

AEA is claiming that it is unnecessary to extend any studies below mile 29.9 because there will be not effects this far below the dam. AEA wrote a Decision Point Tech Memo saying they would look at available data and make a decision. There is a *non sequitur* here in that the Decision Point TM suggests that the decision will be data based but data from a calibrated model is still not available.

The study is not being conducted as provided for in the approved study plan because decisions about the extent of study effects are coming out before the models that predict those effects are fully functional.

Modification 2-5: USFWS recommends assessing the sedimentation and development of delta growth at the mouth of the mainstem (e.g., head of the reservoir) and reservoir tributaries.

This modeling effort would be best developed in coordination with Objective 8: Reservoir Geomorphology of Study 6.5. To understand if fish will be able to exit the head of the reservoir or enter reservoir tributaries it is important to know how the deltas will form in the varial zone.

USFWS suggests that as deltas grow by deposition of coarse sand, gravel and cobbles, and backwater effects upstream, the footprint of the reservoir will grow. Also, such deltas may affect fish habitat and fish passage. AEA has stated that the 1-D model starts downstream from the dam and that reservoir sedimentation is not part of Study 6.6, but instead it is modeled by the 3D model EFDC as part of the water quality modeling studies. However, it was later stated that it is not planned to use the EFDC model to model coarse sediment or to undertake long-term simulations of reservoir or tributary sedimentation. Also, it is clear that it would be difficult and time consuming to apply this 3D water quality model to answer geomorphic questions associated with long-term deposition in the mainstem and tributaries. Therefore, the modeling of delta growth and gravel deposition in the reservoir seems to have been ignored for the moment. However, modeling of deltas using 1-D and 2-D models has been added to the current modeling plan.

The study is not being conducted as provided for in the approved study plan because changes to the channel above Watana are not being assessed.

Challenge 9

AEA showed results of ‘throughput’ sand load transport predicted by the HEC-RAS model in the Lower Susitna River, which compared well with data from measurements. These results do not demonstrate that the model can predict morphological changes since more than 90% of the load consisted of sand throughput load, and completely mask the transport and exchange of gravel through the reach. In the Middle Susitna River, sand is transported mainly suspended as washload, without interacting with the riverbed. Morphological changes such as erosion or deposition depend mainly on gravel transport.

Modification 2.6: USFWS recommends re-evaluating how throughput load and bed load interact to move sand and gravel between Talkeetna and Mile 40.

Since the Lower River bed from Talkeetna to about mile 40 is mostly gravel per the Winter Sampling TM the argument that the load is 90% sand as throughput is counterintuitive. At least some sand would settle out and be on the bed.

The study is not being conducted as provided for in the approved study plan because the model is compartmentalizing movement of sand and gravel which is not how the natural system works.

Objective 3: *Coordinate with the Geomorphology Study to integrate model results with the understanding of geomorphic processes and controls to identify potential Project effects that require interpretation of model results.*

Objective 4: *Support the evaluation of Project-effects by other studies in their resource areas providing channel output data and assessment of potential changes in the geomorphic features that help comprise the aquatic and riparian habitats of the Susitna River.*

Objective 3 and 4 will be treated as one and modifications apply to both.

Modification 3-1: USFWS recommends that the effects of climate-change induced alterations to sediment load be included in AEA's analyses (Modification 3-3 in Study 6.5 Geomorphology).

USFWS believes that the sediment supply from all tributaries with a significant portion of their land area covered with ice may change over the life of the dam.

AEA stated (ISR, March 2016) that it was not a concern because the material was mainly sand and that the river was already transporting sediment at capacity. Later on, in the discussion AEA stated that much of sand load in the river was transported as "throughput load", which is another way of saying it is wash load (i.e., the fraction of the sediment load that is supply limited). The sediments in glaciated watersheds usually consist of a wide range of material, from fine silt to gravel and boulders. On relatively steep river systems, the finer fractions (sand, silt and clay) will be supply limited, so a change in sediment supply due to glacial and climate-induced changes will result in a change in sediment load. Also, even if a river is transporting at full capacity now, it could transport more sediment if discharges increase in the future. We recommend that results from Study 7.7 be fully incorporated into the geomorphology studies to account for glacial and climate-induced changes.

The study was conducted under environmental conditions that are rapidly changing in a material way as the percentage of ice covering the upper tributaries declines.

Modification 3-2: USFWS recommends demonstrating how the outputs from the fluvial geomorphology models will be used in all other models. Every study from 7.5 Groundwater process to 9.12 Fish Barriers is dependent on how the channel changes once the dam is constructed.

This modification will be best accomplished by a new study for Model Integration. A New Study request for Model Integration is included as an enclosure.

Modification G-1: USFWS recommends AEA select a range of operational scenarios with the intent of bracketing the possible range of future geomorphic change with-Project impacts to fish habitat downstream of the Susitna-Watana Dam, which should include, but not be limited to: channel narrowing, bed degradation, coarsening of substrate leading to bed armoring, and decrease in fine sediment.

Stream narrowing due to reductions in peak open water flow discharges and consequent vegetation encroachment, channelization and disconnection from the flood plain could lead to loss of juvenile habitat. Similarly bed degradation (lowering) and associated water level lowering that could lead to partial or total abandonment of side channels or sloughs and lowering of riparian groundwater table both of which may affect juvenile fish habitat. Coarsening of the gravel/cobble substrate due to bed armoring (erosion of smaller gravels) could lead to substrate size that was too large for many salmon to spawn in. The decreased supply of fines could affect the estuary habitat for the fish species that live there which are an important food source for Cook Inlet Beluga Whales.

Currently only one operation scenario has been analyzed, OS-1b.

The study is not being conducted as provided for in the approved study plan because operation scenarios implies multiple scenarios and the study does not meet the spirit of our nations environmental laws which ask project proponents to evaluate a range of activities to balance energy development and resource protection.

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7.5 Groundwater Studies

Summary of Proposed Modifications and New studies

Introduction

United States Fish and Wildlife Service's (USFWS) comprehensive review of the Initial Study Report (ISR) and all preceding groundwater study documents began with a list of the study Objectives presented in the FERC study determination (4/1/2013) and bullets of the 11 modifications the USFWS currently recommends for the Groundwater Study.

The documents reviewed consist of the June 2014 Interim Study Report (ISR), the 2014–2015 Study Implementation Report (SIR), material presented at a technical team meeting webinar held on December 5, 2014, the Initial Study Report meetings held March 24, 2016, and two technical memos:

- Preliminary Groundwater and Surface-Water Relationships on Lateral Aquatic Habitats within Focus Areas FA-128 (Slough 8A) and FA-138 (Gold Creek) in the Middle Susitna River (AHTM); and
- Groundwater and Surface-Water Relationships in Support of Riparian Vegetation Modeling (RVTM).

Study Objectives

On May 31, 2012 USFWS and NMFS (Services) requested a groundwater study with 8 Objectives. During the next 5 months, very similar Objectives, but with changing tasks, were included in both AEA's Study Plan (SP) and Revised Study Plan (RSP). The Services requested changes in groundwater Objectives and tasks in our Study Plan Comments (11/14/2012). FERC asked AEA for two modifications (see FERC ordered modifications below). Their Study Plan determination (SPD) (4/1/13) lays out the following methods; these appear to be equivalent to Objectives. These Objectives are:

1. Synthesize historical and contemporary groundwater data available for the Susitna River groundwater and groundwater dependent aquatic and floodplain habitat, including data from the 1980s and other studies including reviews of GW/SW interactions in cold regions.
2. Use the available groundwater data to characterize large-scale geohydrologic process-domains/terrain of the Susitna River (e.g. geology, topography, geomorphology, regional aquifers, shallow groundwater aquifers, GW/SW interactions).
3. Assess the potential effects of Watana Dam/Reservoir on groundwater and groundwater-influenced aquatic habitats in the vicinity of the proposed dam.
4. Work with other resource studies to map groundwater-influenced aquatic and floodplain habitat (e.g. upwelling areas, springs, groundwater-dependent wetlands) within the Middle River Segment of the Susitna River including within selected Focus Areas.
5. Determine the groundwater/surface water relationships of floodplain shallow alluvial aquifers within selected Focus Areas as part of the Riparian Instream Flow Study. (The RSP listed in the FERC determination is more detailed.).
6. Determine groundwater/surface water relationships of upwelling/downwelling in relation to spawning, incubation, and rearing habitat (particularly in the winter) within selected

Focus Areas as part of the Fish and Aquatics Instream Flow Study. (The RSP listed in the FERC determination is more detailed.)

7. Characterize water quality (e.g., temperature, dissolved oxygen [DO], conductivity) of selected upwelling areas that provide biological cues for fish spawning and juvenile rearing, in Focus Areas as part of the Fish and Aquatics Instream Flow Study. (The RSP listed in the FERC determination is more detailed.)
8. Characterize the winter flow in the Susitna River and how it relates to groundwater/surface water interactions. (The RSP listed in the FERC determination is more detailed.)
9. Characterize the relationship between the Susitna River flow regime and shallow groundwater users (e.g. domestic wells).

FERC Ordered Modifications

The 7.5 Groundwater Study design was approved by FERC (4/1/2013) with the following two modifications:

1. We recommend that AEA include relevant projects in the literature review.
2. We recommend that AEA consult with the TWG on the construction of the necessary data sets for the MODFLOW RIP-ET package, and file no later than June 30, 2013, the following:
   - A detailed description of the specific methods to be used to relate the data of Study 11.6 (Riparian vegetation) to plant functional groups.
   - A detailed description of the specific methods to be used to relate the rooting depth data from Study 8.6 (Riparian instream flow) and the water level data from Study 7.5 (Groundwater) to extinction and saturated extinction depths.
   - A detailed description of the specific methods to be used to estimate the shape of the transpiration flux curves.
   - Documentation of consultation with the TWG, including how its comments were addressed.

The USFWS recognizes that AEA did expand their literature review to include relevant projects. At the March 24, 2016, ISR meeting AEA suggested that groundwater recharge can be simulated using simpler methods than the Modflow RIP-ET package. USFWS also concurs with this assessment.

USFWS Recommended Modifications

USFWS requests the following 11 modifications to study 7.5, which are explained in more detail and justified under their respective Objective:

1. Include a basin-scale groundwater flow assessment (Objective 2).
2. Groundwater modeling studies need to be able to simulate short-duration fluctuations (within 30 minutes) in surface water/groundwater levels (Objectives 5 & 6).
3. Upscaling of the groundwater information should be based on a hybrid upscaling approach (Objective 2).
4. In a single Pilot Scale area, AEA should demonstrate that the various models

can interact to produce useable data with realistic error bars (Objective 5 and 6). (This request is refined and justified in the Model Integration New Study Request.)

5. Evaluation of changes in groundwater temperature and dissolved oxygen from proposed project operations (Objective 5).
6. Assess the current and future flows that will be required to breach the head-of-slough barriers (Objective 6).
7. Snow survey data should be collected at selected Focus Area so snowmelts contribution to the groundwater can be included (Objective 5 & 6).
8. Study 7.5 should produce maps that show the change in quantity of flood plain macro habitats caused by changing groundwater (Objective 4).
9. Install additional wells in all Focus Areas except FA-128 so that 2-dimensional ground water maps can be completed (Objective 5 & 6).
10. Assess the effects of main channel aggradation or incision on Focus Area groundwater (Objective 5 & 6; Model Integration).
11. Measure of vertical groundwater gradients through nested observation well pairs (Objective 5 & 6).

TECHNICAL REVIEWS OF ISR, TECH MEMOS AND SIR AND EVALUATION OF 'IF THE OBJECTIVE WAS MET'

This technical review is organized by study Objective. Within the discussion for each Objective, subsections are presented providing comments on study methods, study results, and study variances from the FERC-ordered study plan as presented in project documents to date. Finally USFWS recommended study modifications are listed.

The heart of understanding the potential effects of the proposed dam on Groundwater/Surface water interaction and on aquatic habitat for juvenile salmon are contained in methods section of study Objective 6 (Methods, pg. 16 of this document). This section lists nine issues or challenges with the existing groundwater model that AEA needs to address before this model is coupled with other project models.

Objectives 5 and 6 support the Riparian Instream Flow (RIFS 8.6) and Fish and Aquatics In-Stream Flow (FAIFS 8.5) studies, respectively. The Objectives developed for each of these studies include assessment of potential hydroelectric project effects on aquatic habitat and riparian vegetation. These two Objectives are evaluated as one because of the substantial overlap.

Synthesize Historical and Contemporary Groundwater Data Available

Objective 1: Synthesize historical and contemporary groundwater data available for the Susitna River groundwater and groundwater dependent aquatic and floodplain habitat, including data from the 1980s and other studies including reviews of groundwater/surface water interactions in cold regions.

Methods

This study element consists of a broad-based literature review and database search within the University of Alaska Fairbanks (UAF) library and Alaska Resources Library and Information Services (ARLIS) databases. The latter houses documents from the original 1980s Susitna River study efforts.

Results

Section 5.1 of the Groundwater ISR presents infrared aerial imagery. These data could be potentially useful for investigating changes to the Susitna River during the 1970 – present day period of time. Images from the 1970's for presentation into the record should be annotated more specifically as to date or further explanation of the vague time reference presented.

The principal work of this study element is contained in Appendix C of the November Groundwater SIR report. In general, this review appears to be a thorough and complete compendium of information gleaned from other reports. The current study plan approach is to "expand" or "upscale" the results of groundwater models developed at selected Focus Areas. Prior studies concluded that the groundwater models are not transferable to other sloughs. The dichotomy between these two mutually exclusive methodologies is unaddressed, not reconciled, and may be a fundamental factor in the evaluation of work conducted under the FERC-ordered study. This is one important finding from the prior studies is highly pertinent to this review.

Specifically: "This report (R&M and WCC, 1985) concludes that because of the substantial differences among sloughs in the hydraulic and thermal behavior, detailed projections of slough discharge or temperature variations relative to mainstem conditions could only be made if mathematical models are constructed for each individual slough. Additional field investigations would also be necessary to generate input data for the models, and it is expected that different sloughs will have different discharge responses to project conditions."

A similar finding was produced by Harza-Ebasco (1984). The1980's investigators were not hampered by a lack of modern technology to study and understand groundwater flow systems. MODFLOW for example, was first published in 1984 and was a well-established technology at that time. A two-dimensional digital groundwater flow model and also a temperature transport model were also developed as part of the Susitna River studies during this period. The present study does not incorporate these important 1980's findings about the unique qualities and complexities of each slough and is engaged in a process of modeling, characterizing, and up-scaling (see subsequent sections of this review) that track in a different direction to those previous findings without adequate justification or demonstration of the viability for the approach and reconciliation with prior findings.

The feasibility of the current approach relies to a great extent on groundwater modeling efforts and a poorly-defined up-scaling process that have thus far not been successfully completed and demonstrated to be viable, even at the best monitored Focus Area.

Variances

This literature review was produced in November of 2015, two years behind schedule. The lack of attention to the 1980's studies may have led to not being able to foresee operational difficulties in the current study plan.

Modifications

No modifications are recommended for Objective 1.

Geo-hydrologic Process Domains

Objective 2: Use the available groundwater data to characterize large-scale geohydrologic process- domains/terrain of the Susitna River (e.g. geology, topography, geomorphology, regional aquifers, shallow groundwater aquifers, GW/SW interactions).

Methods

The methods presented for this study element are not described in detail, and are quite ambiguous. The ISR references several documents produced by the American Society for Testing and Materials (ASTM), but does not say which part of the document they plan to follow.

The ISR text states that after characterizing hydro-geologic units present in the study area, the relationship between regional and local groundwater systems would be defined, according to methods described by Anderson [1970] for the Tanana River basin. This study was primarily a basin-scale assessment of physiography, geology, groundwater availability, surface water availability, and water quality. In other words, the study of Anderson [1970] would be a more appropriate guide toward characterizing the Susitna River basin hydrology, not for linking regional and local groundwater systems.

To summarize, the methods presented in this section are not sufficiently detailed to allow for evaluation of whether project Objectives will be met.

The first two study elements of the Groundwater Study – (1) Existing Data Synthesis and (2) Geo-hydrologic Process Domains – require geologic and soils data for the broader study area and critically, along the Middle River. It should also be recognized that one of the work products from the Geomorphology Study (6.5) has been a surficial geologic map of the entire Middle River [Tetra Tech, 2014]. This data product is available in mapbook form as part of the Geomorphology ISR. This map would provide critical information in completing the first two study elements.

Results

Findings under this study Objective are almost completely unreported. Thus, it is not possible to determine the status of work towards meeting the goals of this Objective.

Expanding the results of the Focus Areas (up-scaling) appears to be highly dependent upon mapping efforts under this study element. In light of the 1980's findings about the unique characteristics of sloughs, there is a considerable lack of clarity on how or whether this is going to work, especially at the scale needed for habitat evaluations. A draft or pilot-scale work product is needed to understand this better.

Figure 5.2-1 of the ISR should be better documented.

Variances

This study element was originally scheduled for completion in Q4 2013, but has not been completed and is a variance. This variance could potentially affect completion of the study Objectives. Numerical groundwater development relies on conceptual understandings of the groundwater system. This study element is focused on developing conceptual understanding of the groundwater system, and should be a pre-requisite for development of numerical groundwater flow models. It is important to stress that successful completion of this study element is critical to completion of all other Groundwater Study Objectives.

Modifications (1 & 3)

Modification 1: Basin-Scale Groundwater Flow Assessment

USFWS recommends that Objective 2 be modified to clearly include a basin-scale groundwater flow assessment as described below.

A basin-scale analyses should include an analysis of the basin water budget and address topics that include recharge rates (and variations due to altitude or other factors throughout the basin), glaciers, permafrost, types, lithology, and transmissivity of aquifers and confining units, expected water table and/or potentiometric surface configurations, and discharge to tributaries. This type of analysis may best be conducted by sub-basin analysis, particularly the sub-basins above and below the proposed dam, or sub-basins contributing to the Focus Areas.

Owing to the paucity of data, part of this description and analysis would be conceptual. General concepts and expected processes and even quantification of flow systems as "best estimates" could be derived from more detailed studies in other relevant or similar areas. Such an analysis would provide useful and important context and explanation for understanding the processes involved in the "Broad-Scale Mapping".

Parts of this assessment appear to be contained in the groundwater study element for geo-hydrologic process-domains, but it is not clear what the outcome of that study element is going to be since it has not yet been completed. This assessment would also inform the riverine groundwater assessment component "*7.5.4.3. Upwelling / Springs Broad-Scale Mapping*" by assisting the task to "characterize the identified upwelling/spring areas at a reconnaissance level to determine if they are likely to be (1) mainstem flow/stage dependent, (2) regional/upland groundwater dependent, or (3) mixed influence."

Because this analysis should build upon the comparable analysis performed during the 1980's studies as summarized in Appendix C of the November 2015 SIR report, the level of effort is not likened to starting anew. One of the main reasons to perform this study is that it is required input to the groundwater model developed at Focus Area FA-128 and the value used for the preliminary modeling effort differs by the regional value determined from the 1980's studies by an order of magnitude. This is an unacceptable unexplained (or justified) deviation and indicates that the modeling study was conducted under anomalous environmental conditions or that environmental conditions have changed in a material way.

Such an analysis would put into context the expected quantity of upwelling in the river bottom lands and tributaries. For example, if a groundwater flux density of a certain amount is estimated or measured in a Focus Area, how does this compare to what might be expected from a basin analysis perspective? How important is groundwater to the flow of the river on a season-by-season basis?

It is common in groundwater studies involving large and small basins to include such an analysis. There are many examples of this type of analysis found in reports by the U.S. Geological Survey around the country. There are also good examples in Alaska such as Kikuchi (2013) and Dearborn and Barnwell (1975).

In summary, a large amount of effort is being put into understanding groundwater processes important to the riverine and immediately adjacent environments of the Susitna River bottomlands. A thorough understanding of these processes cannot be obtained without extending the domain, at least on a reconnaissance level, to the limits of the Susitna basin and include a more thorough analysis of regional and sub-regional groundwater flow than currently appears to be planned.

Modification 3: Hybrid Approach to Up-Scaling

The USFWS recommends that the up-scaling process used to tie information gained in the Focus Areas to the larger river use the hybrid approach described in Appendix-C, Page 21 of the SIR.

Objective 2 of the RSP contains the core of the groundwater studies' approach to the problem of upscaling: The final step will be identifying the relationship between the process-domain river segments and the planned Focus Areas. This will facilitate the expansion of the analysis of potential Project effects on groundwater/surface water interactions from the Focus Areas individual study areas back to the larger process-domain river segments.

The current study plan approach is to expand or upscale the results of groundwater models developed at selected Focus Areas, yet prior studies (1980's) concluded that the groundwater models are not transferable to other sloughs (R&M and WCC, 1985): "This report concludes that because of the substantial differences among sloughs in the hydraulic and thermal behavior, detailed projections of slough discharge or temperature variations relative to mainstem conditions could only be made if mathematical models are constructed for each individual slough. Additional field investigations would also be necessary to generate input data for the models, and it is expected that different sloughs will have different discharge responses to project conditions."

The mutually exclusive dichotomy between the current RSP approach and the 1980's conclusions is unaddressed, not reconciled, and creates doubt about the viability of the RSP groundwater study methodology. The feasibility of the current approach relies to a great extent on groundwater modeling efforts that have thus far not been successfully completed and demonstrated to be viable, even at the best monitored Focus Area.

The1980's investigators were not hampered by a lack of modern technology to study and understand groundwater flow systems. MODFLOW for example, was first published in 1984 and was a well-established technology at that time. The present study ignores the findings of the 1980's and is engaged in a process of modeling, characterizing, and up-scaling that tracks in a different direction to those previous findings without adequate justification or demonstration of the viability for their approach and reconciliation with prior conflicting findings.

The finding that all sloughs are unique and complex and would require individual models would result in an onerous and likely unworkable modeling task. Alternatively, abandoning the groundwater modeling in lieu of only qualitative evaluation of habitat impacts would likely result in unnecessarily conservative and insufficiently accurate assessments of project effects. The SIR (11/2015), as part of its review of prior studies, has suggested a hybrid approach, which we agree with, but which represents a significant modification of the current study. The hybrid approach is succinctly described in Appendix-C, Page 21of the November 2015 SIR report:

"A hydrid (sic) approach would include reviewing differentiating characteristics of sloughs (such as the presence of tributaries, upland soil/geology type, apparent influence from mainstem flows, influence from overtopped-berm flows, etc.) and their hydrologic responses to see if sloughs with similar characteristics show similar responses. If this is the case, representative sloughs could then be focused on and potentially modeled, with simulated results extrapolated to other sloughs that are expected to have similar responses."

The SIR text also suggests that sufficient data exists to perform this evaluation, but since substantive data to support this view has not yet been reported and analyzed, we do not concur that this has been demonstrated.

This proposed modification meets the criteria provided in 18 CFR 5.15 (d)(1). First, the lengthy delay in reviewing prior studies prevented identification of the problem associated with unique and complex sloughs until after modeling studies were well underway. The variance noted in the schedule has been a material reason why mid-course corrections and modifications of the study plan have not been previously identified and implemented.

Also, the modeling does not follow standard groundwater modeling methodologies as described in the references cited in the RSP by not including direct groundwater recharge during the snowmelt period in the transient simulations. Addressing this issue is clearly warranted. The lack of an acceptable calibrated transient model is a direct result of how the "approved studies were not conducted as provided for in the approved study plan". There are other problems with the modeling work described in this technical review that also support this finding.

This proposed modification also meets the criteria provided in 18 CFR 5.15 (d)(2). As previously noted, all sloughs can be regarded as "anomalous", since there is no "normal" or "typical" slough. Slough hydrologic regimes can vary from trickling flows to torrents, from frequent inundations from mainstem flows to rare inundations, or be hydrologically supported by tributary flows or completely lacking tributary flows. They can have robust groundwater upwelling or hardly any at all. These anomalous field conditions make the proposal to "up-scale" the results of the modeling work highly challenging at best, and with a significant likelihood of complete impracticability and technical invalidity of the current approach.

The proposed hybrid approach also recognizes that modeling may be an impractical methodology to perform the needed assessment. Other means of assessment may be needed. The proposed study modification includes the necessary flexibility to incorporate other methods that may be more suitable to the project. Should other methods be proposed, they should be the subject of another modification and thorough review.

As part of the modeling reevaluation proposed in this modification, the strategy of using 2-D transect, 2-D plan view, or 3-D modeling should be reevaluated in light of data collected to date that seem to indicate the presence of complex transient 3-D flow systems that could invalidate 2-D transect modeling, and therefore the entire up-scaling study plan.

Also, consideration should be given to develop a strategy to address winter ice-affected groundwater flow systems differently than summertime flow systems. Considering the seasonality of riparian vegetation activity and life stages of aquatic organisms, different types of analyses may be warranted. For example, simple statistics describing the annual number and duration of peak groundwater levels and trying to relate it to riparian growing conditions may be meaningless if most peaks occurring in the winter are a result of ice-induced backwater.

Potential Effects in the Vicinity of the Watana Dam/Reservoir

Objective 3: Assess the potential effects of the Watana dam/reservoir on groundwater and groundwater-influenced aquatic habitats in the vicinity of the proposed dam.

Methods

The methods for this study component consist primarily of characterizing hydrogeology of the area in the vicinity of the dam site. The ISR indicates that this work will consist primarily of using data collected by other studies, such as the Geology and Soils Characterization study, to develop a conceptual model of groundwater in the vicinity of the dam site. The methods section (ISR 4.3) also states that ground reconnaissance during fall 2013 and LiDAR data will be used to develop information on channel geometry and inundated area of the reservoir. However, the text of the ISR does not explain how these data relate to this study Objectives, specifically, how the effects of the dam and reservoir would affect groundwater-related aquatic habitat. More detailed information is needed to assess whether the methods presented here are adequate to address the study Objectives.

Results

The ISR describes photographs taken during a reconnaissance visit to the dam site in 2013. In the absence of interpretation, these photographs do not constitute results for this particular study element. With the results as presented, it is not possible to determine the status of work towards meeting the goals of this Objective.

Variances

There were no variances yet for this Objective.

Modifications

USFWS does not recommend modifications at this time. However, since very little work has been accomplished to meet this Objective, they could be needed at a later date.

Upwelling/Springs Broad-Scale Mapping

Objective 4: Work with other resource studies to map groundwater-influenced aquatic and floodplain habitat (e.g. upwelling areas, springs, groundwater-dependent wetlands) within the Middle River Segment of the Susitna River including within selected Focus Areas.

Methods

The proposed methodology includes multiple techniques to map groundwater features, including open-lead mapping, aerial photography, thermal infrared (TIR) imagery, and ground-based observations. These are sound approaches to identifying the presence of groundwater upwelling over such an extensive area, in part because the first three methods could be used for joint cross-comparison and cross-validation and are also conducted at different times of the year. These approaches are also appropriate for the spatial scale of interest. The last technique described, ground-based observations, would be necessary to provide confirmation of areas of suspected upwelling. This was the essence of Objective 4; however, AEA has not presented methods for this important study element.

The final activity for this study element is to “characterize the identified upwelling/spring areas at a reconnaissance level to determine if they are likely to be (1) mainstem flow/stage dependent, (2) regional/upland groundwater dependent, or (3) mixed influence”. This is more of an Objective than a method. There are numerous methods that could be used to determine the origin of groundwater discharging to springs and seeps, and this is a topic that has been studied extensively in the hydrology literature. Therefore, more details are needed to determine whether the study plan and implementation are adequate to meet this Objective.

The classification scheme proposed for upwellings/springs, as presented, may be difficult to implement and less useful than intended. The Susitna River seems to function as a regional flow system that interacts with both ground and surfacewater flow paths of various lengths. Both local and regional flow systems discharge to the river, its sloughs, and side channels. Thus, during baseflow (low-flow) conditions, most or all upwellings/springs are likely derived from upland sources or from storage in the alluvial aquifer. During higher flow events, river water may enter the groundwater system as bank storage or hyporheic flow in some locations, temporarily reversing the direction of flow at some of the upwelling/spring locations. As these high-flow events recede, water reentering the river would be classified as mixed flow. Thus, it is to be expected that many sites would be classified in different categories, depending on river stage and antecedent conditions. The details of how upwellings and springs are to be classified are not presented, thus it is not possible to evaluate whether data being collected will be adequate to achieve this Objective. Additional detail of the methods and criteria used for making the determinations should be provided. There was some localized piezometer work performed in conjunction with study 8.5, but AEA has yet to present how such local and direct measurement of ground and surface water exchange may be used to identify upwelling.

The identification and selection of river stage and antecedent conditions may also be an important factor governing the acquisition of imagery for this task.

Recent work (Technical Team Webinar, 12/5/14, slide 53 and other slides) shows the presence of three different regimes: Upland, Transitional, and Riverine in the Susitna River bottomlands. The criteria for differentiating these units are not clearly presented, nor are the boundaries delineated. This may be a useful concept for "upscaling" the results of the groundwater work, however additional work is required to determine whether these units (or some other units) are appropriate for mapping areas adjacent to the river on a larger scale. In reviewing slide 53 for example, these map units may not correlate meaningfully with other resources such as riparian vegetation or aquatic fish habitat.

As stated in the RSP, one of the work products from study Objective 4, Upwelling/Springs Broad Scale Mapping, is an “analysis of the identified upwelling/spring areas to determine if they are (1) main flow/stage dependent, (2) regional/upland groundwater dependent, or (3) of mixed influence. Given the vast number of upwelling areas already mapped in the Middle Susitna River, this will be a tremendously challenging task. Yet, this work product has received virtually no discussion in the ISR or technical meetings with regard to how it will be accomplished. It is therefore recommended that specific, detailed methods be developed regarding this work product.

Results

ISR Section 5.4 discusses acquisition and processing of TIR imagery [URS and Watershed Sciences Inc., 2013]. TIR imagery flown in October 2012 has been compiled into a mapbook currently available at http://www.susitna-watanahydro.org/type/documents/. This product will be an important component of successfully achieving the Objectives of this study element and is already being used by the FAIFS study in the development of aquatic habitat models [Miller Ecological Consultants and R2 Resource Consultants, 2014].

The proposed methodology of this element includes both air-based and ground-based approaches. Air-based approaches include open-lead mapping and identification of clear water areas from aerial photography. Ground-based approaches include riverbed and streambed temperature monitoring and measurements of vertical hydraulic gradients as part of the FAIFS study. Integrating these multiple data sources would greatly strengthen the reliability of maps showing groundwater upwelling locations on the Susitna River. However, the ISR does not discuss the process of integrating these multiple data sources.

The Final Study Plan (7/2013) states: Results will be provided in appropriate sections of the Initial Study Report. ***Information resulting from this study component was supposed to include the following***:

- GIS map layer of upwelling and groundwater influenced areas.
- Analysis of the identified upwelling/spring areas to determine if they are (1) main flow/stage dependent, (2) regional/upland groundwater dependent, or (3) of mixed influence.

No GIS map layer was provided in the ISR, nor were analyses of upwelling/spring areas presented. The 2015 SIR report states that "differentiating upwelling areas into the three categories will not be possible," (page 15, Section 5.4). There is no elaboration on why the differentiation into the categories identified in the study plan is not possible. The study plans for this task are applicable to the locations of areas in the "Middle River Segment and upper portion of the Lower River Segment that are currently influenced by groundwater inflow".

These three categories are not the same three categories mapped at FA-128 in the 2015 SIR: "Riverine Dominated, Riverine-Upland Transitional, and Upland Dominated". There seems to be a bit of confusion in the terminology and perhaps the methods and results used to identify these different areas. In any event, it seems like it should have been feasible to perform a differentiation of sources. Not performing this activity would be a variance.

A source of data (in addition to those listed) that should be considered to differentiate between different upwelling areas is detailed LIDAR-based topographic mapping. The elevation of upwelling areas above various seasonal high water or flood stages can be a useful parameter in their differentiation.

Variances

No GIS map layer was provided in the ISR or analyses of upwelling/spring areas in broad areas, which is a variance from the study plan.

The mapping of water sources in FA-128 as reported in the SIR uses different categories as specified in the study plans, and this is a variance.

Modifications

Modification 8: Map-based Impact Assessment

The USFWS recommends including an assessment of proposed project effects based on groundwater-influenced aquatic and floodplain habitat maps of the entire river corridor, where impacts may occur.

Currently, this study Objective focuses only on preparing maps for groundwater-influenced habitats; it is not clear if or how these maps will be used to determine impacts from the proposed project. The "Decision Support System" needed for this project should be much more focused on preparing resource-based maps of the river corridor and the creation of "impact zones" based on hypothetical but realistic scenarios of river and groundwater dynamics based on data collected to date, aerial imagery and field-based detailed mapping at a scale of approximately 1:6000 (1 inch = 500 feet), and models of river dynamics based on project operating scenarios.

Resource-based maps should include, for example, detailed geological mapping, vegetation mapping such as is found in Figure 5-32 of the Riparian Instream Flow Study (RIFS) (8.6, SIR, November 2015), aquatic habitat mapping such as is found in Figures 5.6.1, 5.6.2, and 5.6.3 of the Fish and Aquatics Instream Flow Study (8.5, SIR, November 2015), groundwater upwelling and groundwater influenced areas. The mapping should consider various stages of the Susitna River such as is found in Figure 5.32 of the RIFS (SIR report).

For the most part, the project has successfully documented that expected riverine and cold climate processes operate in the project area. These processes can be applied to identifiable geomorphic features along with anticipated changes to the riverine environment (including sedimentation and erosion processes) to present the likely range of project effects. The principal outputs of the process could be map based. Then, overall project impacts could be determined by a GIS process of summing areas of different impacts within a suite of categories of impacts. Because of the diversity of environments, this suite of categories should be relatively large. The degree of change in each impact category will be somewhat qualitative, but that may be the best that be done as a practical matter.

The project has embarked on a highly quantified process of attempting to determine impacts with a variety of very complex models that require large amounts of data and assumptions, but which may end up producing results that are less useful than planned. Re-evaluation of these complex models in favor of simpler and less precise but more reliable overall assessments may be in order.

Objectives 5.5 and 5.6 will be treated as one for the purpose of USFWS review.

Riparian Vegetation Dependency on Groundwater/Surface-Water Interactions

Objective 5: Determine the groundwater/surface water relationships of floodplain shallow alluvial aquifers within selected Focus Areas as part of Study 8.6 (Riparian instream flow).

The overall goal of this study component would be to collect information and data to define groundwater/surface water interactions and relationships important in structuring the distributions of target fish species and life stages and to riparian community health and function. Most attention was given toward a number of Focus Area locations so results could be used to scale up to other locations in the river. These relationships would then allow for a determination of how project operations may influence groundwater/surface water interactions and the aquatic and riparian communities at unmeasured areas. Development of physical groundwater models at Focus Areas is important for evaluating the role of ground and surface water exchange on the distributions and timing of target fish species and life stages and riparian community structure; these models would also help to understand and be predictive about the influence of the project on these relationships. Physical models, including surface water hydraulic (1-D and 2-D), geomorphic reach analyses, groundwater/surface water interactions, and ice processes would be integrated such that physical process controls of riparian vegetation recruitment and establishment could be quantitatively assessed under both existing conditions and different project operations. The Focus Areas for this study component would be limited to those exhibiting groundwater/surface water interactions that relate to the ecology of riparian and/or aquatic habitats, pending further evaluation of each of the Focus Areas.

Aquatic Habitat Groundwater/Surface-Water Interactions

Objective 6: Determine groundwater/surface area relationships of upwelling/downwelling in relation to spawning incubation, and rearing habitat (particularly in the winter) within selected Focus Areas as part of Study 8.5 (fish and aquatics instream flow).

The same general approach as described above for the riparian component would be used for evaluating how the same groundwater/surface water interactions influence aquatic habitats for Study 8.5. Habitat Suitability Criteria (HSC) and a Habitat Suitability Index (HSI) were supposed to be developed that included groundwater-related parameters such as groundwater exchange flux and vertical hydraulic gradient. The Focus Areas for this study component were to be limited to those exhibiting groundwater/surface water interactions that relate to the ecology of riparian and/or aquatic habitats pending further evaluation of each of the Focus Areas.

Methods

These two study Objectives provide technical support to the Fish and Aquatic Instream Flow Study (8.5) and the Riparian Instream Flow Study (8.6) primarily through installing and operating monitoring stations at the Focus Areas, and through the development of groundwater flow models for the purpose of predicting groundwater levels under project operations.

Monitoring stations established under this study component primarily provide information on groundwater levels and temperatures, and surface water levels and temperatures. There is limited information on soil moisture, soil temperature, and meteorological variables. Time-lapse cameras are deployed at the Focus Areas to assist interpretation of incoming data streams.

Groundwater modeling is a central component of the methods proposed for these two study Objectives. The proposed modeling approach entails developing site-specific groundwater models at the Focus Areas. Boundary forcing, primarily stage changes in the Susitna River main channel, will be used to estimate hydraulic properties of the alluvial aquifer. Additional stage change events would then be used to validate the models. There are several challenges with this proposed methodology:

1) Up-Scaling

The models are described by the RSP as useful tools to scale up the findings of the Focus Areas to unmonitored areas. The applicability of these models to different hydrogeologic environments such as hydrologically distinct types of sloughs or the areas below the three rivers confluence is not addressed. Findings previously described from the 1980s studies cast doubt on the viability of this approach. It is not clear how the modeling results will be up-scaled to the broader study area. Focus Areas are all contained in Riparian Process Domains (RPDs) 3 and 4, so it is not likely that the findings would be applicable to domains 1, 2, and 5. Also, within RPD 3 and 4, there are numerous individual vegetative communities and the degree of dependence of these vegetative communities on the water table is not clear. The methodologies for incorporating other factors such as soil type, aquifer lithology, or thickness of the unsaturated zone for which data may be lacking or sparse, are not described. (Addressed with Modification 3 under Objective 2.)

2) Water Table Maps

Construction of a 3-D groundwater model is proposed for FA-128. This would normally be based on water table maps constructed for selected time periods for calibration purposes. Construction of water table maps is not an original element of the RSP; However it has subsequently been incorporated as a work element of the Groundwater Study. Omission of the preparation of water table maps for each Focus Area is a significant flaw of the FSP which has been partially corrected by the preparation of water table maps contained in the SIR report. Problems with data coverage and quality associated with the maps are discussed subsequently in this technical memorandum.

3) Winter Conditions

It is also not stated whether the models will be capable of simulating wintertime conditions when aquifers can be locally confined by ground ice, surface ice, or icings. These phenomena are not discussed.

4) Temperature and Dissolved Oxygen of Upwelling Groundwater

The methodology for understanding future changes in surface and groundwater temperatures and dissolved oxygen is unknown. This is a complex phenomenon under existing conditions and is even more complex under proposed project conditions. The groundwater model as presented does not simulate water temperatures and there is no known bolt-on, post-processor software that would adequately simulate the processes.

5) Groundwater/Surface Water Response Functions

The ISR report states: “Task 5 of the GW plan (Study 7.5) centers on defining groundwater/surface water (GW/SW) relationships associated with riparian habitats within selected Focus Areas. This task is linked with the Riparian Instream Flow Study (R-IFS) (RSP8.6) with one of the Objectives being the development of GW/SW response functions for different locations within a Focus Area that can be used to assess upland-dominated groundwater from riverine dominated GW/SW interactions resulting from different Project operational scenarios.”

It is not clear what a "GW/SW response function" is or how they will be developed and used to assess the effects of different Project operational scenarios. This section is confusing and should be further clarified and defined.

6) 2D vs 3D Groundwater Flow Systems and Models

As a general guide to 2D transect models, Anderson and Woessner (2002) state that "the main consideration in orienting the profile is to align the model along a flow line"... so that all flow in the model occurs "parallel to and in the plane of the profile". Field situations in which this is not done introduce errors into the modeling process that should be recognized and addressed with respect to the purposes of the modeling simulations.
Previous hydrologic studies [e.g. Loeltzand Leake, 1983; Nakanishi and Lilly, 1998; Arihood and others, 2013] confirm this concept.

For example, Nakanishi and Lilly [1998] (cited in the FoSP as a template methodology for this study) used a 2D transect model along the Chena River, Alaska, and found it necessary to use a "30 percent adjustment for geometry effects" to account for the three-dimensional nature of the flow system caused by the river's large meander. In the Focus Areas, local surface water geometries are far more complex. Examination of multiple Focus Area water table maps shows that inferred directions of groundwater flow are commonly not aligned with the planned profile models, which should cause reevaluation of the adequacy of the planned 2D modeling to simulate conditions in real-world three-dimensional transient groundwater flow systems.

One of the stated Objectives of the modeling is to simulate the effects of sudden rises or lowering of river stage. These changes may be caused by river ice processes, natural flooding processes, or future dam operations and are an important part of the groundwater analysis. If water levels in the mainstem suddenly rise for example, the groundwater flow directions (in plain view) will likely change in a manner that cannot be simulated with a 2D profile model. Errors introduced by this transient situation should be addressed, especially as it pertains to simulating water-level changes caused by proposed dam operating scenarios.

These analyses call into question the validity of the key assumptions underlying the use of 2D transect models for Focus Areas on the Middle Susitna River. Compelling evidence for this approach has not yet been presented and this approach may not be adequate to meet the Objective for this study element.

In some situations, the most appropriate modeling exercise would be to construct a 2-D plan view model rather than a 2-D transect model. The distribution of water-table data and surface water geometries for use in calibrating the model at many of the Focus Areas appears to be better suited to a 2-D plan view analysis than a 2-D transect analysis. In some cases, there may be advantages to performing both types of analysis in order to achieve project Objectives.

7) Local Recharge

The modeling work describes simulating hydraulic head pulses from changing river levels, but the water table is also influenced by local recharge events at the sites of the monitoring wells and from up-gradient areas. Rain gages were installed, however the study does not discuss how the data and the accompanying soil moisture and water table data will be used in the modeling work to simulate the effects of local rainfall and snowmelt on fluctuating water tables. These rainfall and snowmelt events could affect water levels in these shallow aquifers on the same time scale as rising-river levels (minutes to hours). The absence of snow survey data to inform groundwater recharge estimates during the spring snowmelt is another significant limitation of the methodology.

8) Vertical Groundwater Gradients

Another potential limitation with the design of the groundwater modeling effort in this task is that vertical gradients within the aquifer were not measured. The comparable study cited (Nakanishi and Lilly, 1998) had multiple nested observation wells with which to calibrate the model to deeper parts of the flow system. Since these are lacking in this study, the model will only be able to be calibrated and verified for the surface of the aquifer. Thus, the transect model of Nakanishi and Lilly (1998) is only generally, not entirely, similar. If there is no water-level information at depth to guide model calibration, the modeling work, in effect, becomes more of a 1-D calibration exercise, possibly with a distributed recharge component, a variable thickness aquifer, and boundary conditions.

9) Assessment of Geomorphic River Channel Changes

The methods described do not address the effects that potential changes in river geomorphology - either aggrading or degrading streambeds, could have on the system. Any thorough groundwater model-based assessment of the project effects on groundwater levels and aquatic or riparian habitat should consider the effects of this phenomenon. For this reason NMFS requested a New Study on Model Integration

10) Icings

There is no discussion of the potential for groundwater levels to rise during the winter as a result of icings (the freezing of discharging groundwater into large masses of ice that partially "dam" groundwater and cause the water table to rise). This is a well-known phenomenon in cold regions and should have been addressed as a potential cause of the some of the observed stage fluctuations. The process of icings and observations about their occurrence and extent (if any), especially in the focus areas, should have been included in the groundwater study,

In summary, the methodology for analysis of the data is not presented in enough detail to determine whether the Objectives will be met, however the identified shortcomings of the methodology casts significant doubt that the 2-D modeling proposed would be technically valid and accomplish the project Objectives.

Results

Temperatures and Dissolved Oxygen of Upwelling Groundwater

There is no data or analysis about understanding the temperature or dissolved oxygen of upwelling groundwater under project operating conditions. These are key aquatic habitat parameters that should be addressed in the groundwater study. The suggestion that this can be evaluated with model output is vague and peculiar considering that MODFLOW does not simulate thermal properties of water and aquifers.

FA-128 Groundwater Model Results

The preliminary three-dimensional groundwater model at FA-128 has significant conceptual and technical shortcomings that are discussed in the following section.

1) Sparse and Limited Areal Coverage of Data and Data Quality

The feasibility of constructing 2D or 3D models at most Focus Areas in order to provide the inputs planned for the riparian and aquatic habitat analyses and the up-scaling process is significant hampered because of insufficient and questionable data. The water table maps at all of the Focus Areas except FA-128 have very sparse spreads of monitoring stations with which to draw water table maps and construct 3D groundwater models. Groundwater contour lines are short and discontinuous and large areas of the Focus Areas are devoid of data and contours, including at important sloughs. The original plan was to construct profile models along linear orientations perpendicular to the river; however this is likely to not be viable. Since this was previously commented at the October 2014 technical meetings and December 5, 2014, webinar, AEA has not further addressed this concern or clarified how it plans to model these Focus Areas in the future. As a result of these issues, the feasibility of constructing 2D or 3D models in order to provide the inputs planned for the Riparian and aquatic habitat analyses and the up-scaling process is in significant doubt.

There are numerous anomalous data reported on the water table maps that are omitted from contouring based on "professional judgment" (SIR Appendix A-Page 3, Section 4, Methods). Item-by-item, these should be further evaluated with descriptions of exclusion criteria and discussion regarding possible hydrodynamic influences on the data, irresolvable data errors, or other causes. Any "lessons learned" should be incorporated into future data collection efforts to ensure that a robust set of groundwater and surface water data are usable for the time periods of interest in the groundwater analyses.

The Groundwater Study has made data available from project monitoring wells, including groundwater levels and temperatures at http://gis.suhydro.org/reports/isr. Two critical pieces of information that have not been provided are the well depth and lithology. It is standard in hydro-geologic investigations to provide records of both when reporting results. Obviously, well drive points do not provide lithology data, however data from other sources such as the 1980's studies and shallow soil investigations conducted under other studies should be used to characterize the subsurface. The interpretation and groundwater modeling proposed as part of this study is limited without these data, and it is difficult for reviewers to interpret data from the groundwater stations without also having knowledge of well depth and lithology. Therefore, it is recommended that these data be made available along with other monitoring station data, and be explicitly included as appendices or figures in future reports.

2) Unsuccessful Transient Calibration

The process for calibration statistics requires further explanation for the transient run in Table 5.1. Were the statistics performed on each time step for each target well for the simulation? Was the analysis inadvertently biased by the longer quasi-steady state periods of time prior to and after the river stage pulse compared to the time period of rapidly changing pulse? One of the major purposes of the transient model is to simulate the river pulse dynamic, and a qualitative review of the most dynamic portions of the curves for FA128-4, FA128-5, FA128-6, FA128-7, FA128-11, FA128-13, FA128-21, FA128-26, and FA128-27 on Figures 5-5, B1-3, 5-6, 5-7, 5-8, 5-9, B1-10, B1-14, and B1-15 show that the model fit to the data look rather poor. This is a relatively large number of curves that appear not to be well-simulated by the model's dynamic river pulse. It should be better explained why the apparent fit for FA128-13 appears to be rather good on Figure 5-3 and rather poor on Figure 5-9. A few of the targets have relatively well-fitting curve shapes, but they are offset by a significant amount that may be explainable by approximations in the river stage modeling scheme. While one of the major purposes of the transient simulation was to simulate the river pulse, the relatively poor and anomalous fitting of numerous data sets merits closer evaluation. Re-evaluation of the model calibration statistics for the transient run and a more thorough analysis is needed to verify the findings before concluding that the calibration statistics "were relatively good" (as readers might infer incorrectly that the calibration is relatively good).

During the March 23, 2016 meeting, it was noted that the method for determining calibration statistics for the transient run should be reevaluated. Mr. Swope stated that they did not calculate calibration statistics for the transient calibration. This is an incorrect statement. Table 5.1 of the SIR shows that the Root Mean Square Error (RMSE) for the transient run is listed as 9.6%. The modeling report makes clear that the transient model is not properly calibrated. This is likely because:

- Model parameters aquifer storativity and regional groundwater recharge were given potentially unrealistic values in an attempt to make simulated water levels match measured water levels;
- An important process was not incorporated into the model formulation, that of direct groundwater recharge from snowmelt; and
- Measurements of flow in sloughs attributable to groundwater discharges should be important groundwater model calibration targets, but were not used.

These topics are described in additional detail below.

Direct Groundwater Recharge from Snowmelt

There is a potentially major conceptual flaw in the groundwater model based on the conclusion that "...the hydrologic response is exclusively related to increases in river stage..." Surprisingly, the model fails to simulate or even acknowledge the process of on-site snowmelt recharge to the water table to raise water levels in observation wells completely distinct from any changes in river stage. Springtime increases in groundwater levels from snowmelt are commonly in the range of a few feet, which is of a similar magnitude as increases caused by increases in river stage. With all of the data available at this site, the model should have incorporated direct recharge from snowmelt into the analysis. Without doing so, the comparisons of transient model head values with measured head values presented, as a measure of goodness of calibration of the model, is relatively meaningless. ***This conceptual shortcoming undermines the validity of the entire modeling process to date.***

Annual precipitation in Alaska is commonly divided into three major components: evapotranspiration, surface runoff, and groundwater recharge. For this model to assign a value for groundwater recharge based only on the difference between annual precipitation and pan evaporation without further explanation is a potentially significant conceptual problem in the structure of the model. Also, recharge tends to be highly seasonal in this area, with most recharge occurring during the fall rainy season or spring snowmelt season with additional recharge from significant summer storms. The steady state period simulated, May 20 to June 6, is described as being "...stable with little flooding or precipitation...," (Appendix B-Page 10), which raises questions whether the relatively high groundwater recharge rate simulated is characteristic of the steady-state period simulated. This needs further explanation, evaluation, and revision.

There is also a significant data gap. There appears to have been no snow survey data collected at this site. Snow survey data collected near the end of winter capture the water content of the snowpack and thus inform estimates of groundwater recharge during the snowmelt period. Because the transient period selected for hydrologic pulse simulation is the snowmelt period, these data would have been important for evaluating the local snowmelt recharge in causing water-table fluctuation and their absence creates uncertainty about the modeling.

Regional Groundwater Flow

The fluxes of groundwater into the modeled region along the sides of the model (representing regional groundwater flow inputs to the modeled area) were reduced by an order of magnitude in order "to improve the overall calibration". This requires further justification and analysis prior to acceptance of it into the model. This parameter was the result of prior estimation of these fluxes, which have not been demonstrated to be flawed, and is a very large deviation from those estimates. This parameter should not be treated as an adjustment parameter on a black box model that can be adjusted to values that simply seem to make the model work better.

Analysis of the "GW regional scale relationship to local flow systems" should include additional evaluation of the early 1980's estimate of fluxes of 2.1 ft^2/d from regional groundwater flow towards the Susitna River compared to the models use of 0.21 ft^2/d for the flux at FA-128. As part of this evaluation, the model's application of a recharge rate of 10.5 inches/year should be compared to average regional recharge rates that would reflect the different regional flux estimates towards the river.

The SIR modeling text is dismissive of estimates by 1980's studies of the regional groundwater flux towards the Susitna River (2.1 ft^2/day) based on "regional aquifer properties, gradients, and thicknesses, but not empirical data". The authors present no basis for their current 0.21 ft^2 /day parameter, which is an order of magnitude lower. The regional information used to determine the prior estimates are "empirical data" and should not be so readily dismissed in favor of the model-derived parameter. The authors do not consider that the unusually low model-derived parameter could be an artifact of some other approximation or problem with the model. This should be reevaluated during any future attempts to calibrate or validate the model.

Aquifer Storativity

The model also tweaked values of aquifer storativity as a calibration parameter of the model. The value they ended up with is characteristic of confined or semi-confined aquifers, not a water table aquifer, like the rest of the report describes. This is a very large unexplained technical shortcoming.

The text states: "The storage coefficient was initially set to 0.2, but was eventually reduced to a value of 0.001 to achieve a better match to the observed GW elevation response. This value is somewhat low for an unconfined aquifer and may suggest the aquifer is semi-confined." This is anomalous in consideration of the fact that the aquifer "is assumed to be a water table aquifer" and abundant data and prior reports show that it is. Freeze and Cherry (1979) describe aquifer storativity as having a "usual range" for unconfined aquifers of 0.01 to 0.3. The modeled value is a full order of magnitude below the lower bound of the usual range.

This parameter adjustment should be vetted against other data, such as geological information about the nature of the aquifer, well construction information, depth of frost penetration, and backhoe pits and aquifer tests that were performed in the 1980's. This parameter should not be treated as an adjustment parameter on a black box model that can be adjusted to values that seem to make the model work better. Such a deviation from values typical for a water table aquifer suggests that there may be one or more fundamental undiscovered problems with the model.

Groundwater Discharge to Sloughs

The steady state model is described as simulating a period of time when side channels are predominantly fed by groundwater. These side channels and sloughs have been the subject of considerable study, including discharge measurements of channels that have no headwater connection to the Susitna River. At the same time, these channels represent one of the major applications of the entire modeling exercise, this being the evaluation of changes to aquatic and riparian habitat in these areas. Thus, it would seem that flow data (specifically, groundwater upwelling fluxes into the side channels or sloughs) should be a calibration target in addition to head data. The model should explicitly simulate flow to these side channels and other regions of upwelling within the channel network. If it isn't, the grid spacing should be refined enough to do so, with the necessary direct measurements of VHG, exchange flux, and groundwater discharge to validate the models. This would be one of the best ways for the model to fulfill its potential, to be able to simulate changes in water quantity and temperature in side-channels and sloughs in response to potential future project operations. Without using these side-channel discharge data as calibration targets, it may be impossible to determine the reliability of future groundwater flow models and the knowledge gained from the valuable fieldwork measuring side-channel and slough flows will have not have been used to its full potential.

In summary, the studies fail to prove that calibration and verification of a three-dimensional groundwater flow model is possible, even in the best-instrumented Focus Area (FA-128). Considering the poorly understood system response to present and future short-duration hydrologic events and other limitations noted above, the studies to date create significant doubt that project Objectives are achievable with the current methodologies and progress of work.

Variances

Water table maps have been prepared, which is a variance from the FERC-ordered study plan. This study element was originally scheduled for completion in Q4 2014 and is not yet complete. The deviation from the schedule is a variation.

Data should have been provided on well depths and open intervals. This is a standard component of groundwater studies as described by the references to the FoSP and is a variance.

Technical reports to date presume that the groundwater flow model can be fully calibrated and validated. This has not been demonstrated to be achievable; therefore the assertion that the method will provide predictive simulations to evaluate the effects of different project operational scenarios is unconfirmed and is a variance from the study plan. Also, the application of the methodology to other Focus Areas with fewer data or to other reaches of the Susitna River without any detailed data are not addressed and is also a variance.

Modifications 2, 4, 6, 7, 9, 10, 11

Modification 2: Short-Duration Hydrologic Event Data Collection and Modeling

USFWS recommends including the acquisition of field data and improving the current performance of surface water/groundwater models to be able to simulate short-duration fluctuations in surface water/groundwater interactions characteristic of future proposed project operations at each Focus Area.

The current groundwater modeling effort is not capable of simulating fluctuating groundwater/ surface water interactions at short-duration time scales (hourly) that will be characteristic of proposed project operations, nor does it appear likely that it will be capable of modeling such events during the course of the approved study. This is a major limitation of the model and a variance from the approved plan to model groundwater to simulate such pulses. Approved studies were not conducted as provided for in the approved study plan.

"Short duration temporal variations" can occur "in response to the various hydrologic events" (SIR study), such as precipitation, ice dams, river rise, or snowmelt. Analysis of these types of events is extremely challenging, and the averaging procedures used in the SIR study, such as 12-hour time steps, were not sufficiently detailed to capture the responses of the groundwater system to these types of events, likely contributing to some of the anomalies that resulted from the studies. This is important because the Project is also expected to produce significant short-duration temporal variations in flow (hourly and daily) that will not be well understood without additional work identifying the responses of the natural system to these short-duration events.

The Project will affect Susitna River flow on a seasonal, daily and hourly basis and will affect downstream resources/processes including ice dynamics, channel form and function, water temperature, and sediment transport. These changes have thus far not all been incorporated into the GW model and associated other models such as OWFRM and the 2D PHABSIM models that are needed to assess project impacts. ‘Proof of Concept’ is not complete until the models can be demonstrated to adequately simulate and predict the effects of all of these physical phenomena.

The authors of the SIR groundwater modeling report describe the complexities of analyzing short-duration hydrologic events. It is not clear if there are adequate data available to analyze these phenomenon. Frequent and synchronous data on river stage, groundwater levels, precipitation and snowmelt may be required and portions of the datasets appear not to have been collected during critical times to conduct robust analyses. Part of this study modification would be to perform a data needs assessment and take steps to make sure that adequate data are available.

Modification 4: Model Integration on a Pilot Scale Study Area.

The USFWS recommends that in a single Pilot Scale area, AEA should demonstrate that the various models can interact to produce useable data with realistic error bars (Objective 5 and 6).

This request is refined and justified in the Model Integration New Study Request and will not be discussed here.

Modification 5: Evaluating Changes in Groundwater Temperature and Dissolved Oxygen

The USFWS recommends evaluating changes in groundwater temperature and dissolved oxygen from proposed project operations

The temperature and dissolved oxygen content of upwelling groundwater are important factors influencing aquatic habitat. There appears to be no task or Objective in the groundwater study for evaluating changes in these parameters under proposed operating scenarios, even using non-modeling techniques. MODFLOW, the only groundwater model proposed, does not simulate these parameters. The importance of this topic is indicated by the fact that a two-dimensional heat-flux/groundwater flow model was constructed during the 1980's studies.

Unless this topic is adequately covered in other studies, this represents a significant gap in the FERC-ordered study plan and a modification of the plan should be made in order to address this important process.

Modification 6: Assessment of Overbank, Breaching Flow, and Braidplain Side-Channel Flow on Groundwater and Aquatic and Riparian Habitat

The USFWS recommends assessing the current and future flows that will be required to breach the head-of-slough barriers to meet Objective 6.

The effects of overbank flow, breaching flows over head-of-slough sediment barriers, and flow in side channels of the braidplain in the lower river area are significant drivers of groundwater levels, however appear to be unevaluated and are not apparently included in the groundwater and surface water studies to date.

In the lower river, a comparison of proposed flows and natural flows show that there would be fewer and lower high-flow events that would inundate side channels and recharge groundwater under project operations. The absence or reduced frequency and peak of these high flows could lead to the condition found in many other dammed river systems that the water table generally becomes lower in response to dams. This persistently lower water table can then result in establishment of different vegetation regimes (like spruce and birch) that are better adapted to persistently lower water tables and reduction of aquatic habitat.

In the Middle River segment, many sloughs are headed by alluvial berms. When these are overtopped, it is expected that there would be a relatively quick and substantial impact on groundwater levels near the slough. The later recession of river levels would then be followed by much slower returns of groundwater levels to lower levels. Similarly, low bars and islands could be overtopped, also leading to groundwater recharge. In response to a question at the March 2016 session on Groundwater, investigators appeared to have little information about this process as it applied to the transient groundwater model.

A modification of the groundwater study should be initiated that would further evaluate overtopping phenomenon (especially changes that would occur under project operations) throughout the river corridor and its effects on groundwater levels and riparian and aquatic habitat. Groundwater modeling studies as described by the modeling methodologies cited in the approved study plan all require that boundary conditions of a model reasonably simulate field conditions, including overtopping. This modification is warranted on the basis that the approved studies were not conducted as provided for in the approved study plan. Also, the overtopping or breaching of surface water should be regarded as an anomalous or changed field condition, and this modification is warranted on the basis that the study was conducted under anomalous environmental conditions or that environmental conditions have changed in a material way.

One possible tool for this evaluation that should be considered is inundation mapping using existing LIDAR topographic mapping and flood stage modeling. Such an analysis can characterize the existing frequency and extent of inundation with projected future inundation under project scenarios. These characterizations could then be used to evaluate groundwater responses and impacts to habitats.

Modification 7: Snow Survey at Focus Areas.

The USFWS recommends the collection of snow survey data at representative Focus Areas.

The current groundwater modeling efforts are hampered by a lack of key data for simulating direct groundwater recharge during the spring snowmelt period. This is critical because this is the time period that was selected for the transient modeling work. A snow survey should be conducted during late March or early April before significant seasonal snowmelt occurs in order to establish appropriate transient groundwater recharge rates for the model.

Standard groundwater modeling methodologies as cited in the approved study plan are clear that appropriate data should be used to establish groundwater recharge rates for transient model simulations where recharge is an important process. This justifies approval of this study modification because "approved studies were not conducted as provided for in the approved study plan".

Modification 9: Collect Additional Water Table Data in Focus Areas other than FA-128

The USFWS recommends that additional water table data must be collected to provide sufficient spatial and temporal distribution of water table data in Focus Areas other than FA-128. In all other Focus Areas too few wells were monitored for too short a time period.

It is apparent from inspection of the water table maps for all of the Focus Areas except FA-128 that most of the groundwater data collection-stations are aligned along a single transect perpendicular to the river. This clustering of data makes for a poor water table map, which is key for three-dimensional or two-dimensional plan view groundwater flow modeling. As part of this proposed modification, a data needs assessment should be performed to optimize data collection for periods of time that will be simulated by the models.

As previously described, two-dimensional transect modeling is generally not appropriate for the Focus Areas because of up-valley or down-valley components of groundwater flow that cause significant inaccuracies in the models. Standard groundwater modeling methodologies as cited in the approved study plan provide that transect models should be aligned parallel to groundwater flow directions. This justifies approval of this study modification because "approved studies were not conducted as provided for in the approved study plan".

Modification 10: Assessment of the Impacts of Geomorphic Channel Changes on Groundwater and Habitats.

The USFWS recommends including the effects of aggrading or degrading channels or other channel changes on groundwater and associated habitats to meet Objective 6. (If the New Study Request for Model Integration was accepted, it would also cover this modification.)

The effects of the project on the geomorphology of the river (aggrading, degrading channels or other channel changes) and consequent implications for groundwater and habitats needs further development and inclusion into the groundwater study. Current groundwater modeling uses only current river channel configurations and stage for defining model boundaries. If channel down-grading or aggradation or other changes occur, this will affect groundwater. Evaluation of this effect is currently not part of the groundwater study, but it should be. Such changes in the river would mean that the current modeled conditions would be considered anomalous compared to future conditions, thus justifying this modification.

Modification 11: Measurement of Vertical Groundwater Gradients through Nested Observation Well Pairs

The USFWS recommends the installation and measurement of vertical groundwater gradients through nested observation well pairs to meet Objective 6.

The SIR report failed to identify the variance of not having installed nested monitoring wells to measure vertical groundwater gradients. The lack of nested wells and measurement of vertical groundwater gradients hampers understanding of local and regional groundwater flow system relationships. The FSP states that nested wells and shallow wells in surface water habitats will be installed as part of Objective 6, however these were not installed.

The FSP also states that simulated hydraulic gradients will be compared to observed hydraulic gradients as part of Objective 6. Without collecting data on vertical hydraulic gradients, it will not be possible to complete this analysis. It is recommended that field efforts be undertaken to get the wells in place as soon as possible.

Approved studies were not conducted as provided for in the FERC-approved study plan.

Water Quality in Selected Habitats

Objective 7: Characterize water quality of selected upwelling areas that provide biological cues for fish spawning and juvenile rearing in Focus Areas as part of Study 8.5. At selected instream flow, fish population, and riparian study sites, basic water chemistry data (temperature, dissolved oxygen, conductivity, pH, turbidity, redox potential) would be collected that define 20130401-3022 FERC PDF (Unofficial) 04/01/2013 Susitna-Watana Project No. 14241-000 B-45 habitat conditions and characterize GW/SW interactions. Water quality differences would be characterized between a set of key productive aquatic habitat types (three to five sites) and a set of non-productive habitat types (three to five sites) that are related to the absence or presence of groundwater upwelling to improve the understanding of the water quality differences and related groundwater/surface water processes.

Methods

Point-in-time water-quality data collection in the Focus Areas was conducted as part of the Baseline Water Quality Study; the sampling methods are described in ISR section 4.4.2. The Baseline Water Quality ISR shows the locations of water quality sampling transects at the Focus Areas. The surface water transects are located primarily in the Susitna River main channels and side channels. In addition, point samples, and in some cases, depth profiles, were collected in select off-channel habitats. Finally, groundwater wells were installed specifically for the purpose of water quality sampling at FA-104, FA-113, and FA-128. At each site, basic water quality parameters, including water temperature, dissolved oxygen, pH, specific conductance, turbidity, and redox potential, were collected every 2-3 weeks during the open-water period of 2013.

The Objective for this particular Groundwater Study element was to characterize water quality of selected upwelling areas that provide biological cues for fish spawning and juvenile rearing. Assessing whether the study methods are adequate to achieve this Objective entails assessing whether upwelling areas included adequate sampling points. The Focus Area water quality sampling locations shown in figures 4.4-2 through 4.4-8 of the Baseline Water Quality ISR represent a relatively small subset of possible upwelling location within the Focus Area.

To illustrate this point, figures 1a-d (Section 5.0, this document) compare the locations of water quality sampling locations within FA-128, to areas of potential groundwater upwelling identified using both TIR data and streambed vertical hydraulic gradient measurements. Figure 1a is taken from the Baseline Water Quality ISR [URS and Tetra Tech, 2014]; Figure 1b is taken from the October 2012 TIR Mapbook [URS and Watershed Sciences Inc., 2013]; and Figures 1c-d are taken from a presentation [GW Scientific, 2014] delivered at the Riverine Modeling Proof of Concept meeting in April 2014. Comparison of the figures shows numerous zones of groundwater upwelling that do not coincide with water quality sampling locations.

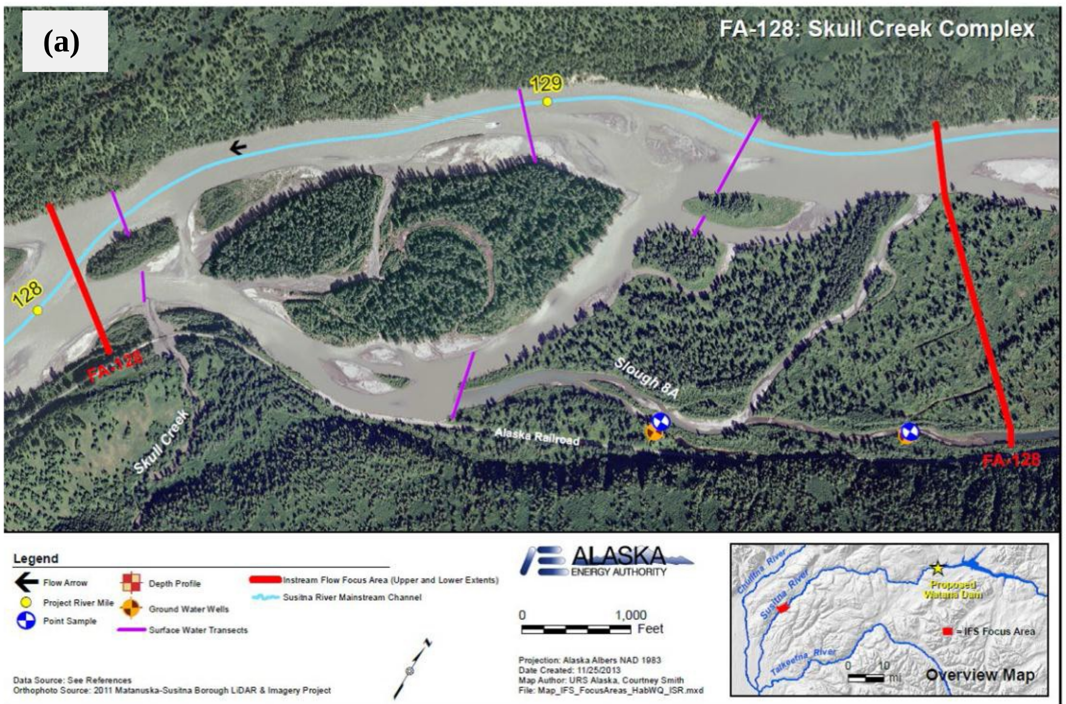
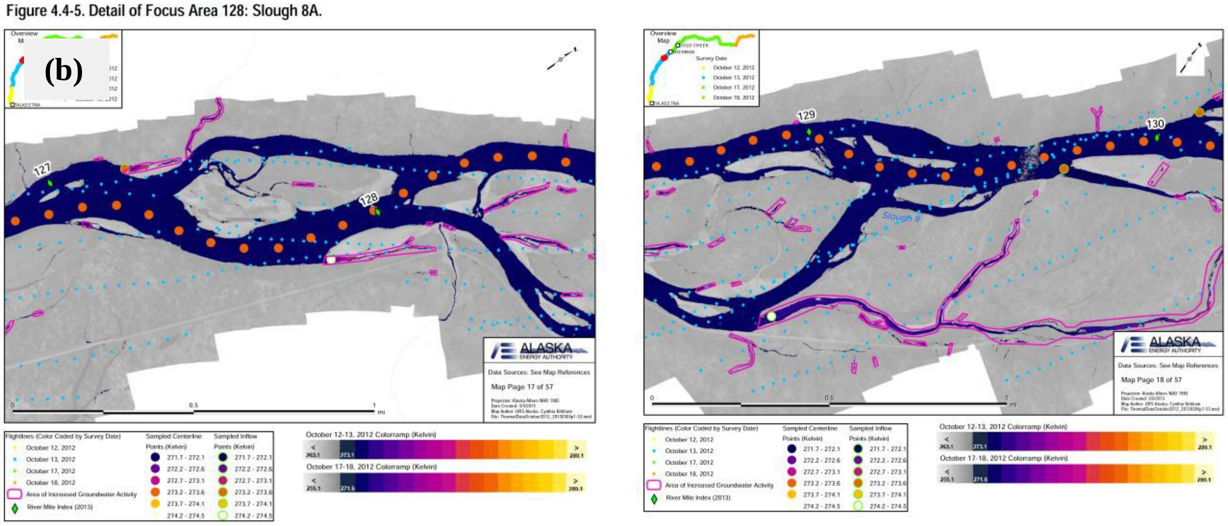


Figure 4.4-5. Detail of Focus Area 128: Slough 8A.



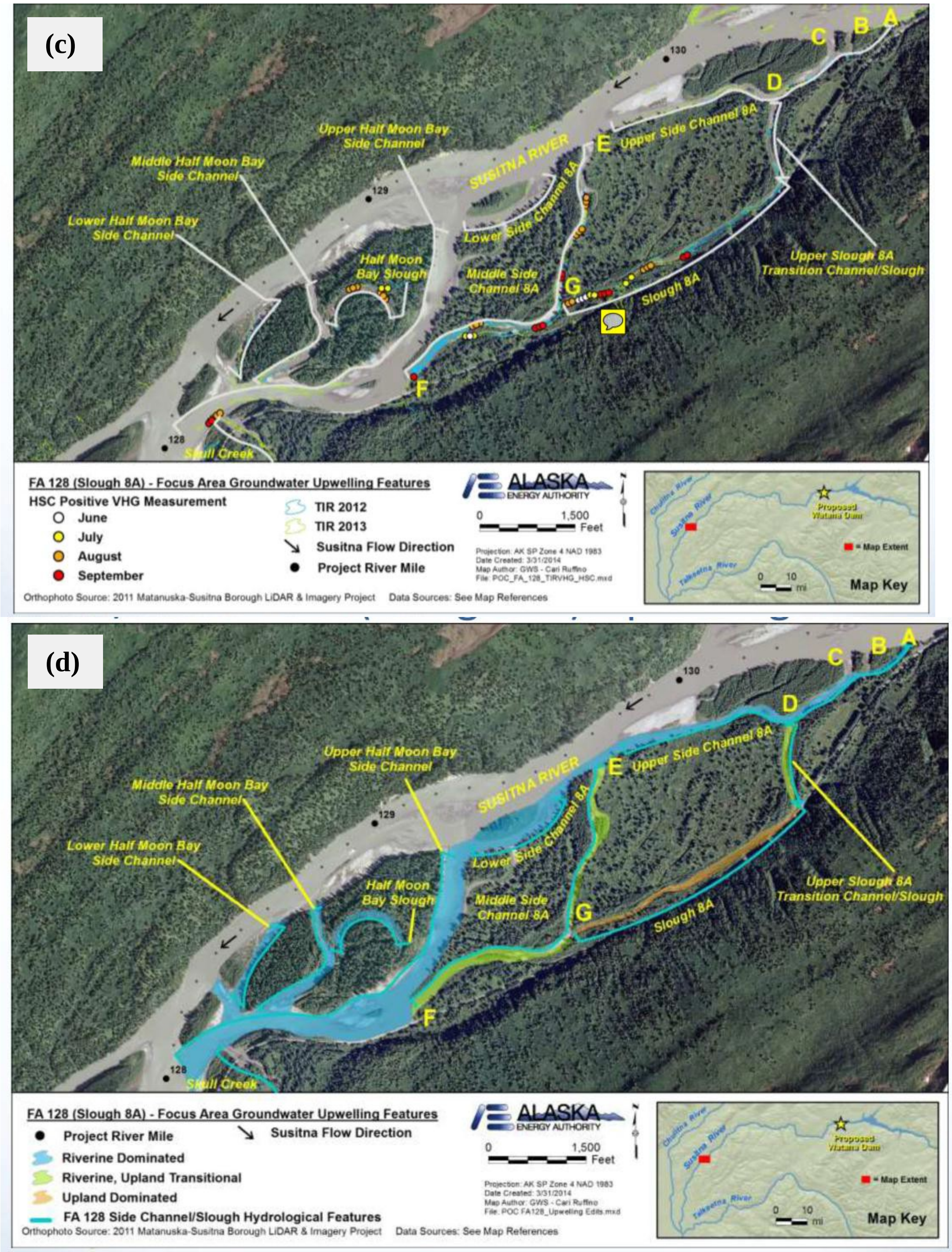


Figure 1. Comparison of water quality measurements and upwelling areas at FA-128. (a) Location of surface water quality measurements, (b) zones of possible groundwater influence identified from TIR imagery, (c) locations of positive (upward) vertical hydraulic gradient measurements during 2013, and (d) preliminary characterization of upwelling areas.

The purpose of this comparison is not to argue that water quality samples are needed for each and every area of groundwater upwelling. Instead, it should be noted that the locations of water quality sampling points probably do not completely bracket the range of conditions in the Middle River with respect to groundwater/surface-water interactions. For example, comparison of figures 1a and 1d shows that in FA-128, the water quality sampling locations (both point and transect) are located in zones delineated as “upland dominated” or “riverine dominated”. However, comparison of figures 1c and 1d shows that positive vertical hydraulic gradients were measured in numerous locations in zones delineated as “riverine, upland transitional”. These areas do not include water quality sampling locations. In order to address the Objective of this study element, it may be necessary to revisit sampling locations based on field data collected in 2013, to ensure that water quality sampling brackets the full range of groundwater-surface water conditions in the Focus Areas.

The FSP includes a work product under this task:

- Groundwater modeling archived flow models, model input and calibration data sets and files, groundwater model documentation.

It is not clear as to why this element includes such a work task. The text of the FoSP in this section does not mention any specific modeling work, and it seems as though this work product belongs elsewhere.

A limitation of the study methodology is the lack of any information about how the data collected would be used to evaluate the potential groundwater (and related surface-water) quality impacts of the proposed project. There should be clear cross-references to relevant portions of other studies so that the relationship between data collected and the ultimate use of the data can be determined.

Results

ISR Section 5.7 discusses temperature data recorded at groundwater, surface water, and streambed monitoring stations operated under the groundwater study. In general, the streambed temperature monitoring stations were sited in or near upwelling areas thought to be important for different fish life stages. Therefore, these data appear to directly support the study Objective of characterizing water quality of selected upwelling areas of biological importance.

The methods outlined in ISR section 4.7 rely heavily on the efforts of the Baseline Water Quality Study for the purposes of determining field parameters other than water temperature, such as dissolved oxygen, pH, and conductivity. Raw water quality data collected at the Focus Areas under the Baseline Water Quality study have been made available through AEA at http://gis.suhydro.org/reports/isr. These data show that for the surface and groundwater quality monitoring sites selected, the selected water quality variables were collected.

Variances

This study element was originally scheduled for completion in Q4 2014. The ISR lists two variances for this study element. The first is a change in schedule for the completion of groundwater flow models. The second is a change in schedule for water quality comparison of select productive and non-productive habitat types. The first variance is somewhat confusing. Groundwater models are listed as a work product for this study element, in the FoSP. However, the text of the FoSP (section 7.5.4.6) does not describe groundwater modeling and what role, if any, groundwater modeling would have in completion of the study Objective.

Modifications

No modifications are recommended to Objective 7.

Winter Groundwater/Surface-Water interactions

Objective 8: Characterize the winter flow in the Susitna River and how it relates to GW/SW interactions. Water levels/pressure would be measured at the continuous gaging stations on the Susitna River during winter flow periods. Winter discharge measurements would be used to help identify key sections of the mainstem with groundwater baseflow recharge to the river (upwelling). In Focus Areas, channel/slough temperature profiles would be measured to help characterize the GW/SW interactions and temporal variations over the winter flow season.

Methods

Section 4.8 of the ISR points out that the hydrologic monitoring stations installed as part of the Groundwater study operate year round. Similar to study Objectives 5 and 6, this is a study Objective for which the availability of continuous hydrologic data will be critical. The monitoring network currently deployed at the Focus Areas appears to be generally suitable for addressing the Objective of this particular study element. One item described in ISR section 4.8 requires further clarification. Paragraph 3 states that “winter discharge measurements will help identify key segments of the mainstem with groundwater baseflow recharge to the river (upwelling).” These kinds of measurements, referred to either as “synoptic differential discharge measurements” or more commonly, “seepage runs”, represent a sound approach towards characterizing reach-scale groundwater/surface-water interactions. However, successful implementation relies on also measuring tributary inflows along the study reach, and performing the discharge measurements spaced as closely (in time) as possible. These are two critical considerations of successfully performing a seepage run that should be discussed in the methodology but are not.

Results

It is not clear exactly what groundwater study work products are specified by the FSP. It appears that several items (such as discharge measurements) are items that will be conducted by others and may be reported elsewhere. Also, there appears to be no work product providing for the interpretation and analysis of data.

Only selected data was provided in the ISR and this appears to be a variance from the FSP, which appears to call for a more thorough presentation of data. The ISR does however contain some analysis and interpretation of data, which exceed the expectations set by the FSP.

Data report in the ISR includes data that are used to identify important wintertime process, such as ice-jam flooding in the mainstem and seasonal temperature variations. In general, these processes are well known and the data serves to demonstrate that they occur in the Susitna River basin. The data also serve to quantify the specific events observed at the sites monitored. What is unclear is how representative these data are of unmeasured sites. There could be challenges in this project to "up-scale" the findings to the broader study area.

ISR Section 5.8 provides examples of how time-lapse photography aids the interpretation of continuous groundwater and surface water level data during the ice-affected period. Specifically, time-lapse photos document ice formation and accumulation, and help to explain variability in groundwater and surface water levels and temperatures. The results here do not fully address the Objective of this particular study element: to characterize the winter flow in the Susitna River, and its relation to GW/SW interactions. This is because only off-channel photos of ice cover are analyzed.

One key question, perhaps falling more under the purview of the Ice Processes Study, is the relation between discharge and ice cover in the mainstem to ice processes and GW/SW interactions in the off-channel habitats. This question could be addressed by comparing the evolution of ice cover using time series from multiple cameras. For example, the results shown in ISR section 5.8 use images from stations ESCFA 104-22, looking out through slough 3B into the main channel. These images could be compared to the time-lapse images collected at ESCFA104-19, ESCFA 104-17, and ESCFA 104-18, to show the progression of ice movement into the off-channel habitat. This kind of data interpretation would more clearly relate flow in the river to GW/SW interactions in the off-channel habitats, using data that are already available.

Variances

There are no variances outside of a delayed schedule.

Modifications

No modifications are recommended to Objective 8.

Shallow Groundwater Users

Objective 9: Characterize the relationship between the Susitna River flow regime and shallow groundwater users (e.g., domestic wells).

Methods

Section 4.9 of the ISR lists a proposed approach to assess potential project impacts on shallow groundwater users. The approach includes monitoring groundwater levels and temperatures in domestic wells near the Susitna River, conducting an inventory of wells in Alaska Department of Natural Resources (ADNR) and USGS databases, and scoring the vulnerability of those wells to changes in the hydro-regime of the Susitna River. The latter task will draw upon ASTM D6030, "Standard Guide for Selection of Methods for Assessing Groundwater or Aquifer Sensitivity and Vulnerability," [ASTM, 2-08b].

The Alaska DNR and USGS databases are likely deficient in identifying most of the wells close to the Susitna River, unless prior studies have performed detailed inventories. In remote areas such as this, the percentage of wells with entries in either database is typically low. Other means should be employed, including air photo interpretation of likely structures with wells and field inventories of wells.

Results

The ISR reports that data for shallow groundwater users are available on-line, however they could not be found during this review. In any event, there is no analysis of the data.

The well data collected in the Middle River Segment is extremely limited compared to the geographic area of the Lower River segment and the diversity of riparian vegetation there. For example, the wells are located outside of the active floodplain and groundwater data are not representative of active floodplain riparian vegetation environments. It is not clear how the limited groundwater data set would provide an understanding of how Project operational changes may influence riparian vegetation.

Variances

There are no variances outside of a delayed schedule.

Modifications

No modifications are recommended to Objective 9. Future modifications could be needed once some products have been produced.

SUMMARY OF TECHNICAL REVIEWS

Overall, the groundwater studies lack clear direction and methodology. Data collections efforts at FA-128 may have enough spatial coverage, but there appear to be issues with anomalous data vales. At all other Focus Areas there simply is not enough groundwater data to construct a water table map or a 3-D groundwater model.

The groundwater modeling effort varies from common practices, inserting considerable potential error and uncertainty into the modeling processes. As a result, it is not clear that the models will be useful for the intended purposes. Sources of information are distributed throughout other studies, which presents a disjointed effort to review and understand the studies.

With many studies elements incomplete, some with almost no results reported, insufficient data and methodological descriptions are presented to determine whether study Objectives can be met in the future. It is clear that overarching study goal has not been met at this time.

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7.6 Ice Processes

Summary of Proposed Study Modifications and New Studies

The United States Fish and Wildlife Service's (USFWS) review of the Ice processes study is a compilation of previous reviews of the ice processes Study Plan (December, 2012); modifications in the Federal Energy Regulatory Commission's (FERC)Study Plan Determination (April 1, 2013); the Initial Study Report (ISR) (June, 2014); Detailed Ice Observations October 2013 – May 2014 Technical Memorandum (September, 2014); and the 2014–2015 Study Implementation Report (October 2015). It also includes material from reviews of discussions at the following meetings: Riverine Modeling Integration Meeting (November 13–15, 2013); IFS-TT: Riverine Modeling Proof of Concept Meetings, April 15–17, 2014, Initial Study Report Meetings, October 15–17, 2014; and the Initial Study Report Meeting (3/24/2016).

The study objectives in the Revised Study Plan (RSP) as stated in FERC Study Plan Determination (4/1/2013) are:

1. Document the timing, progression, and physical processes of freeze-up and break-up during 2012–2014 in the Upper River, Middle River, and Lower River segments using the following methods: historical data, aerial reconnaissance, stationary time-lapse cameras, and physical evidence.
2. Develop a predictive ice, hydrodynamic, and thermal model of the Middle River for existing conditions using the River1D17 (sic) model to simulate time- variable flow routing, heat-flux processes, seasonal water temperature variation, frazil ice development, ice transport processes, and ice-cover growth and decay. The model would be calibrated as an open-water model using known discharge events and then verified using pre-project ice data from the 1980s and data collected as part of the study for a range of climate conditions.
3. Use the River1D model to simulate conditions in the Middle River due to various project operating scenarios and predict changes in water temperature, frazil ice production, ice cover formation, elevation and extent of ice cover, and flow hydrograph. The model would also predict ice cover stability, including potential for jamming, under load-following fluctuations. For the spring melt period, the model would predict ice-cover decay, including the potential for break-up jams. Proposed operating scenarios would include, at a minimum, the load-following scenario described in the Pre-Application Document (PAD) and a base-load scenario.
4. Develop detailed models and characterizations of ice processes for selected Middle River focus areas using either River1D or River2D18 models. The model would be selected on the basis of which model better simulates the characteristics at the particular study location. The objective of this modeling would be to evaluate project effects on smaller scale habitat in the focus areas to provide physical data on winter habitat for Study 8.5

(fish and aquatics instream flow). The selected focus areas would be determined in conjunction with instream flow habitat and riparian studies.

5. Assess model accuracy and sources of error to evaluate the errors associated with measuring input data, estimating Manning's N under ice, and interpolating measured values over distances.
6. Assess the potential for change to ice cover on the Lower River both for fish habitat studies and an assessment of the potential effects of the project on winter transportation access and recreation. Project effects on the Lower River would be determined based on the magnitude of change seen at the downstream boundary of the River1D model, the estimated contributions of frazil ice to the Lower River from the Middle River from observations and modeling, and with simpler steady flow models (HEC-RAS with ice cover) for short sections of interest in the Lower River.
7. Review and summarize large river ice processes relevant to the Susitna River, analytical methods that have been used to assess impacts of projects on ice-covered rivers, and the known effects of existing hydropower project operations in cold climates.

FERC modified the above objectives in their study plan determination (April 1, 2013) and recommended the following:

- The Alaska Energy Authority (AEA) include relevant international and non-hydro sites in the literature review.
- Add an additional camera at the Susitna Landing site.
- AEA conduct one additional reconnaissance flight in January to document open leads at the same time as the field data collection to document freeze up conditions.
- The analyses include an evaluation of natural conditions, as well as a range of alternatives with the dam in place. This should include reasonable operating scenarios such as maximum load-following, run-of-river, and base load, to assess project effects. Because the natural condition model would already exist, these costs would be minimal.

AEA has consistently proposed to use mathematical models to predict the projects effects on ice. The current ice process modeling effort falls short in three overarching ways:

- There are a number of ice processes that are not and cannot be simulated by the current River 1D model: the evolution of open water leads, ice characteristics and ice thickness variability in side channels, ice interactions with bed and banks, ice jam initiation during freeze-up and breakup, ice jam effects on vegetation and sedimentation in overbank areas, and the distribution of flow from main channel to side channels.
- River2D model has been selected for use in the focus areas. This is not a model that deals with ice processes. It is an adaptation of an open water flow model that allows a user to apply a layer of ice to the top of the water. It does not deal with heat flux and cannot model change in ice cover throughout the winter season.
- Very little ice thickness data has been presented so the ice part of the models cannot be calibrated or validated.

The USFWS recommends the FERC approved study methods be conducted as required and its study modifications incorporated as provided for in the FERC approved study plan 18 CFR 5.15(d). Support for the following requested study modification summaries is included under the applicable study objective:

1. Describe how ice currently interacts with the channel bed and banks and assess (using models or other methods) how that process will function under the modified winter flows (project effects) (Objective 2).
2. Describe how and why open leads currently form, and how that process will function under the modified winter flows (project effects) (Objective 2).
3. Describe the processes that cause ice jam initiation during three time periods (freeze up, midwinter and breakup) and, either using modeling or other methods, describe how that will change under modified winter flows (project effects) (Objectives 3 and 4).
4. Expand the geographic extend of the current study to include the lowest 10 miles of the Chulitna and Talkeetna and the Yenta (Objective 3).
5. Model ice processes from the bottom of the varial zone (approximately Project river mile 222) and up to the Oshetna confluence (Objective 3).
6. Assess Project effects on ice in the side channels and sloughs. Specifically ice characteristics and ice thickness (Objective 4).
7. Expand the geographic extend of the current study to include the Lower River. This is very similar to objective 6 (Objective 6).
8. The USFWS recommends the literature search should be completed such that it covers the wider range of ice processes which occur in the Susitna (Objective 7).
9. Demonstrate how the River1D and River2D model will interact with three other physical processes models (8.5 Open Water Flow Model, 7.5 Groundwater Model, and 6.6 Geomorphology Model) considering that at this point they all function on different time steps (Global Modification).

Objective 1: Document the timing, progression, and physical processes of freeze-up and break-up during 2012–2014 in the Upper River, Middle River, and Lower River segments using the following methods: historical data, aerial reconnaissance, stationary time-lapse cameras, and physical evidence.

AEA has more than adequately documented timing and progression of freeze-up and adequately documented breakup. Nevertheless, the physical processes documentation is difficult to evaluate.

The USFWS has no modifications to Objective 1.

Objective 2: Develop a predictive ice, hydrodynamic, and thermal model of the Middle River for existing conditions using the River1D model to simulate time- variable flow routing, heat-flux processes, seasonal water temperature variation, frazil ice development, ice transport processes, and ice-cover growth and decay. The model would be calibrated as an open-water model using known discharge events and then verified using pre-project ice data from the 1980's and data collected as part of the study for a range of climate conditions (Modifications 1 and 2).

The River1D and River2D models, as currently described, fail to model many important ice processes. These next three modifications identify those deficiencies and recommend changes.

Modification 1: The USFWS recommends the objective include describing how ice currently interacts with the channel bed and banks and then, either using modeling or other methods, assess how that will change with the winter flows projected under the various operating scenarios.

The Susitna is a powerful river and large slabs of ice are primarily pushed and sometimes floated, into the side channels and sloughs. Depending on their size, they push gravels and vegetation around similar to a bulldozer blade. This process rearranges gravels, reforms banks, and keeps perennial bushes and trees from establishing on the berms at the head of sloughs. While this process is mostly documented during breakup, it happens all winter. It is not only the hydraulics of open water flows that form or maintain these macro habitats as the HEC_RAS model suggests.

The current modeling effort does not recognize the “bulldozer-like” action of a slab of ice pushing through side channels or sloughs.

This modification has some overlap with the “Model Integration New Study Request” as it does involve information from other studies including; 8.5 Instream Flow, 6.6 Geomorphology Modeling, 8.6 Riparian Vegetation and 7.6 Ice Processes. Study 7.6 should determine the magnitude of ice effects on side channel morphology today and how that would change if the project were constructed. Once that magnitude is broadly defined the model integration study would direct if or how to be integrate it into the other models.

The study was not conducted as provided for in the study plan. The model neglected this important ice process and will therefore not be an accurate predictive model.

Modification 2: The USFWS recommends the objective describe how open leads form and how the project will change this process.

Open leads are a prevalent feature in the Susitna River. They allow for heat transfer directly from the water to the extremely cold winter air. Their presence is thought to correspond to areas of warm ground water production, very high surface velocities, or a combination of the two. The tenfold increase in midwinter discharge will not only increase velocity mid channel, but will also dilute the slightly warmer ground water.

The current study documents the presence of open leads and suggests they are forming in similar locations to the 1980’s. This information does not describe how the leads form or how the modified flow regime will alter this process.

The study was not conducted as provided for in the study plan. The model neglected this important ice process and will therefore not be an accurate predictive model.

Objective 3: Use the River1D model to simulate conditions in the Middle River due to various project operating scenarios and predict changes in water temperature, frazil ice production, ice cover formation, elevation and extent of ice cover, and flow hydrograph. The model would also predict ice cover stability, including potential for jamming, under load-following fluctuations. For the spring melt period, the model would predict ice-cover decay, including the potential for break-up jams. Proposed operating scenarios would include, at a minimum, the load-following scenario described in the Pre-Application Document (PAD) and a base-load scenario (Modifications 3-5).

Modification 3: The USFWS recommends that the processes that cause ice jam initiation during three time periods (freeze up, mid-winter, and breakup) be described and then, either using modeling or other methods, describe how that will change with the winter flows projected in the various operating scenarios.

Juvenile salmon overwinter predominantly in side channels and sloughs. Ice jams force water into these habitats, hold in there, and occasionally cause it to quickly drain out. This mixture of ground water and water forced into the peripheral macrohabitats by ice jams determines the environment juveniles develop in. If project operations eliminated the formation of major ice jams or caused them to form and breakup on a quicker cycle, then either scenario would greatly effect juvenile salmon development.

The current modeling effort ignores the important ice processes that happen in the four months between freeze up and breakup. The models suggest that the ice cover is a flat lake-like surface where the only real variable is the thickness of ice. The ice characteristics in side channel, slough, and tributary mouth habitats change often midwinter and the model cannot capture this.

The study was not conducted as provided for in the study plan. The model neglected this important ice process and will therefore not be an accurate predictive model.

Modification 4: The USFWS recommends expanding the geographic extent of the current ice study to include the lowest ten miles of the Chulitna, Talkeetna and Yenta rivers.

These two confluences are not points on a map but circles of networked channels that are 2-5 miles diameter. The 2014 Study Implementation Report, Appendix A, states that it is not consistent which river freezes up first or which river breaks up first. The rate of ice production in each river can cause the initiation of lockup at Talkeetna before the ice front moving up the river reaches the confluence.

Since no ice will flow through the dam, the Upper Susitna’s ice load may diminish. If the 12,000 cfs released from the dam were to keep the Susitna ice free into January, the lowest reach of the

Talkeetna and Chulitna might follow suit. When the main channels remain open, water is not backed up into the peripheral areas and the spawning gravels may dry out.

The approved study does not completely meet Objective 3 because, by ignoring the Chulitna and Talkeetna rivers, it is likely to incorrectly predict ice processes in the Middle River directly above Talkeetna. Also, the overall study goal is to predict project effects on USFWS trust resources (anadromous fish) and those fish trying to overwinter in the lowest reach of Chulitna and Talkeetna may be affected by the dam.

Modification 5: The USFWS recommends modeling ice processes from the bottom of the varial zone (approximately Project river mile 222) and up to the Oshetna confluence. The USFWS is not recommending a particular model or a particular approach.

The "varial zone" is the reach of river that is submerged when the reservoir is full, but could function like a natural river when the reservoir is mostly empty. Ideally the reservoir is mostly full in October when the ice begins to set up on the reservoir. In the next 5 months the reservoir contracts in length by several miles. This presumably leaves large slabs of ice laying on the ground and a relatively small amount of water (100-2,000 cfs) working its way down a channel partially filled with ice slabs. In 2012, when the project was initiated, we believed no juvenile fish lived in this reach. Based on 9.5 and 9.7 studies, salmon and resident fish probably over winter in this reach.

The USFWS requested this same modification in our Study Plan comments (5/31/12) and verbally in several meeting since then. Our knowledge of environmental conditions has grown. Since Study 9.7 documented salmon in the Oshetna it is reasonable to assume they live in this reach of the Susitna, which leads to the same modification request but with a stronger justification.

Objective 4: Develop detailed models and characterizations of ice processes for selected Middle River focus areas using either River1D or River2D18 models. The model would be selected on the basis of which model better simulates the characteristics at the particular study location. The objective of this modeling would be to evaluate project effects on smaller scale habitat in the focus areas to provide physical data on winter habitat for Study 8.5 (fish and aquatics instream flow). The selected focus areas would be determined in conjunction with instream flow habitat and riparian studies (Modifications 6 &3).

This objective was not met primarily because River2D is not an ice formation or ice process model. It is a derivative of an open water flow model that allows the user to specify a thickness of ice and a roughness on the bottom side of the ice which contacts the flowing water. It does not model heat transfer, the growth or decay ice cover, ice jams formation or frazil ice production. Ice is treated as a user defined, steady state input: not a process. Additionally, River2d was applied to a single focus area rather than multiple, and the calibration and validation was done in an open water setting without ice.

Modification 6: The USFWS recommends assessing project effects on ice in the side channels and sloughs. Specifically ice characteristics and ice thickness. Either a new model or a completely new approach needs to be used to make the assessment valuable.

Juvenile Chinook spend one full winter in side channels sloughs or tributary mouths, while coho may spend several winters. Most Susitna fish species emerge from the gravels to spend their first couple of weeks in these periphery habitats outside of the main channel. These habitats are at times: 1) open water; 2) water covered by ice of variable thickness; 3) water that is a large part frazil ice; 4) water interspersed with large overlapping slabs of ice which formed elsewhere but the river brought into the peripheral habitat; or 5) dry. The current distribution (in both time and space) of these five winter environmental conditions needs to be understood. It is highly likely that one is more conducive to juvenile development than the others. Next the study must predict whether the project will increase or diminish the availability of each condition. The study should evaluate both midwinter (January and February) when juveniles are developing, and early spring (March–April) when fry are emerging from the gravel.

The two dimensional river model (River 2D) is primarily an ice "lid" on an open water flow model. It appears like it will at best model conditions 2 and 5 and perhaps it will make the whole focus area be assigned to either open water or ice cover. Since it has not been calibrated and run, it is difficult to evaluate the River2D model.

The study was not conducted as provided for in the study plan. The River1D model is not being used in the focus areas (side channels, side sloughs, upland sloughs, and tributary mouths) and River2D only deals with determining depth and velocity underneath a user defined ice layer.

Modification 3, which is described under Objective 3, also applies to Objective 4.

Objective 5: Assess model accuracy and sources of error to evaluate the errors associated with measuring input data, estimating Manning's N under ice, and interpolating measured values over distances.

These two models have not progressed far enough along in their development to assess accuracy. The first step in building and calibrating models is assessing their accuracy under open water conditions. In the calibration runs presented by AEA, both models performed well. While USFWS agrees that the open water flow calibration/validation is a necessary first step, the accuracy of the ice portion of the model cannot be evaluated.

USFWS does not recommend any modification to objective 5. However, we note that the model is not fully functional and therefore the objective it is not complete.

Objective 6: Assess the potential for change to ice cover on the Lower River both for fish habitat studies and an assessment of the potential effects of the project on winter transportation access and recreation. Project effects on the Lower River would be determined based on the magnitude of change seen at the downstream boundary of the River1D model, the estimated contributions of frazil ice to the Lower River from the Middle River from observations and modeling, and with simpler steady flow models (HEC-RAS with ice cover) for short sections of interest in the Lower River.

A prerequisite for developing the River1D model is having a calibrated and validated open water flow model. The 2.6 version of open water flow model (Hec-Ras) was not extended to the lower river, and therefore this objective could not be met.

Modification 7: The USFWS recommends implementing Objective 6 to expand the geographic extent of the current study to include the Lower River.

Under the load following scenario the dam would release up to 12,000 cfs of 4^{o}C water at the dam. Eighty miles below that, water would mix with less than 2000 cfs from the Talkeetna and the Chulitna. The amount and thickness of ice in the lower reach will change. Based on information from 8.5 Instream Flow Study, the stage in the lower river could vary daily by 2 feet mid-winter. This action will cause the hinge points on the edge of the suspended ice sheet to bend twice a day. Contrary to AEA's statement, the dam operator cannot set up a 300 m wide "bridged" ice sheet in December that will stay stationary for three months while the water flows underneath following the electric load. Such a bridge defies the laws of physics.

This part of the approved study plan as mentioned in the FERC study plan determination (4/1/13) was not conducted as provided for in the study plan.

Objective 7: Review and summarize large river ice processes relevant to the Susitna River, analytical methods that have been used to assess impacts of projects on ice-covered rivers, and the known effects of existing hydropower project operations in cold climates.

Modification 8: The USFWS recommends the literature search be completed to covers the wider range of ice processes that occur in the Susitna.

This overview and discussion of the ice processes in the Susitna River should include:

- A discussion on ice processes that can impact fish habitat;
- Effects of hydropower projects on the river ice regime;
- Impacts of other hydropower projects and non-hydropower projects on river ice regime;
- A review of ice process modelling efforts on several hydropower projects.

The current overview provides a reasonable understanding of the main channel reaches; however, a review of processes in lateral habitats of particular interest for fish habitat is lacking (e.g., back channels and sloughs that are characteristic to the focus areas). There is limited discussion on the evolution of open water leads and the various ice types (border ice, anchor ice, and frazil ice) in the back channels and on the interaction between ice processes in the main channel and ice processes in the side channels. However, an understanding of these interactions is important to inform assumptions on the coupling of 1D ice process model results in the main channel, to the 2D modelling within the focus areas. The overview of ice process models revealed that investigators on other projects (Brayall & Hicks 2009; Hicks et al. 2009) found success predicting certain ice processes, but only at the expense of a poor prediction of water level and ice thickness. This potential limitation warrants mention since water levels and ice thickness have been identified as key parameters of interest for integration with the other modelling studies and could be a potential model limitation that may be of significant importance. The literature summarizes some past literature but was not thorough enough to cover many important ice processes.

This approved study was not conducted as provided for in approved study plans and failed to summarize several important large river ice processes.

Global Modifications

Modification 9: The USFWS recommends that AEA demonstrate how the River1D and River2D model will interact with three other physical models (8.5 Open Water Flow Model, 7.5 Groundwater Model, and 6.6 Geomorpholgy Model) considering that at this point, all four function on different time steps.

An important aspect of the modelling efforts became apparent during the March 2016 Initial Study Report meeting. The 1D ice process model will not be configured for continuous simulation over the ice- affected period. Jon Zufelt explained that the ice processes occurring over the winter simply cannot be simulated by the available models (and likely not by any available ice process model).

This modification strengthens the argument for the New Study Request for Model Integration.

8.5 Instream Flow and Habitat Suitability Criteria

Summary of Proposed Modifications and New Studies

Summary

The goal of the Fish and Aquatics Instream Flow Study (IFS) is to characterize and evaluate the proposed Project's potential operational flow-induced effects on fish habitat below the proposed Project dam. The study's implementation focus is on establishing a set of analytical tools/models based on site-specific channel and hydraulic data that can be used for defining existing conditions (i.e., without Project) and how these resources and processes will respond to alternative Project operational scenarios.

The ISF ISR (as supplemented by ISR Part D for Study 8.5 and the corresponding 2014-2015 Study Implementation Report) addresses the IFS analytical framework; river stratification and study area selection; hydrologic data analysis; reservoir operations model and open-water flow routing model (OWFRM); hydraulic modeling; habitat suitability criteria development; habitat specific flow-habitat modeling; temporal and spatial habitat analyses; and instream flow study integration.

As a result of the March 2016 ISR meeting, the USFWS has several study modification requests related to Objective 4. AEA's process was not receptive to open communication on this topic. Additional recommendations for the other Objectives are found throughout this document.

Habitat Suitability Criteria (Objective 4)

AEA proposed the use of hydraulic habitat modeling to characterize existing flow-habitat relationships for priority fish species within the habitat mosaic of the Susitna River floodplain. Hydraulic habitat modeling is a general term. The specific tool/framework used by AEA follows the Instream Flow Incremental Methodology (IFIM) developed by USGS (Bovee and others, 1998) through the application of 1D and 2D hydrodynamic modeling and species-specific habitat suitability curves (HSC). Habitat-based modeling requires the development of habitat suitability criteria (HSC) that are used to develop curves for modeling habitat selection (suitability) as a function of microhabitat. Microhabitat, in hydrodynamic modeling, is universally represented by surface water depth and velocity, by necessity. These criteria can be conditioned by the presence/absence of other channel characteristics, but surface water hydraulics drive hydraulic habitat simulations. The development of reliable habitat suitability criteria is critical to the successful implementation of the Instream Flow Incremental Methodology (IFIM), or other habitat-based evaluation technology.

In large alluvial floodplain channel networks, a complex hierarchy of surface and groundwater hydraulics and water quality influences salmonid habitat selection. Secondary habitat characteristics, such as primary and secondary production, can also be influential. This diverse habitat mosaic contains a set of recurring habitat types that were viewed as macrohabitat units. Local microhabitat conditions manifested within each of these macrohabitats are remarkably distinct. Microhabitat also differs among the mesohabitats represented within each macrohabitat.

Within the Susitna River's habitat mosaic, AEA attempted to identify microhabitat criteria that were ecologically relevant to habitat selection. AEA then used those criteria to 1) develop HSC curves that represent the ranges of utilized parameter values for each criterion and 2) predict the probability of utilization within these criteria values. In order to determine the appropriateness of an IFIM habitat-based evaluation and identify what microhabitats were ecologically relevant to habitat selection, the USFWS requested a holistic evaluation of microhabitat criteria.

Thus far, questions regarding the HSC developed and proposed for this project have prevented discussions with stakeholder to advance beyond this stage. Unless valid criteria can be identified, HSC curves cannot be developed or evaluated. Without realistic HSC curves, habitat cannot be modeled, as a function of flow. If habitat cannot be modeled as a function of flow, flow-habitat relationships cannot be predicted in space and time, model integration is impossible, and no environmental assessment can be made. Because this is how AEA proposed to evaluate the impacts associated with this project, the environmental assessment is stalled at this stage of development.

Within this particular area of study, significant issues remain in the context of AEA's study design and analyses of HSC data. AEA's study design and data analyses procedures prevented an ecologically valid process for identifying relevant habitat criteria and model development. These procedures and the lack of information needed to assess the proposed models, or the criteria they rest upon, also prevented the assessment of HSC on a statistical basis. As it currently stands, the USFWS is in a position of describing how the HSC study was inadequate, given the objectives and determinations, and how necessary information has not been provided to allow a full assessment.

The Services' (USFWS and NMFS) made several requests to meet with AEA's consultants to discuss concerns regarding the HSC study design and analyses. All requests to discuss HSC for this project were scheduled and canceled, or denied. In September 2014 the Services requested a 2-day face-to face meeting with the consultants to discuss HSC development. The Service provided an agenda to help frame the discussion necessary to move forward with HSC development. AEA postponed scheduling this meeting until after the scheduled January 2015 ISR meetings (which were then also postponed). The Services then requested a two-hour teleconference with consultants for December 23, 2014 to discuss methods and analyses reported in the *Evaluation of Relationships between Fish Abundance and Microhabitat Variables* TM (September 17, 2014). AEA canceled the December 23 meeting as a result of the Governor's Administrative Order (issued December 19, 2014) halting all spending on the Susitna Project. After the recent ISR meetings, held in March 2016, AEA requested a meeting with the Services to discuss the HSC study, due to the list of questions remaining. AEA also cancelled this meeting.

Following is a summary of the USFWS's request for study modifications for Objective 4 regarding the HSC study *based on AEA's implementation* (specific details are provided in sections that follow):

Modification 1: Habitat criteria must be surveyed with regard to the Project's hierarchical habitat model, according to the approved study plan. The statistical distributions of microhabitat among the various macrohabitats differ drastically. Surface water dominated habitats are typically turbid (in summer), turbulent, and have finer-grained substrates. Groundwater dominated habitats are generally clear, tranquil, and are characterized by coarser substrates. Fish use of these criteria in these different macrohabitats differs. Unless habitat criteria are examined according to the Project's hierarchical habitat model, differences in utilization cannot be considered, habitat-specific criteria cannot be evaluated, and habitat-specific responses cannot be identified.

Modification 2: Criteria (HSC) must be analyzed according to the Projects hierarchical habitat model and HSC must be developed for individual macrohabitats. During the 1980's studies separate HSC models were developed for main and off-channel habitats, due to the gross differences in habitat and fish utilization represented within these surface and groundwater dominated environments. AEA made no attempt to develop separate HSC models for these different macrohabitats. Only when the criteria are surveyed and analyzed in the context of the approved hierarchical habitat model will AEA be able to address their approved study plan and consider the ecological relevance of the habitat criteria determined by FERC as necessary for investigation.

Modification 3: Habitat criteria must be surveyed with respect to the distribution and periodicity of fish species and life stages present on the river. Habitat utilization and "availability" were universally surveyed within the distributions of fish that AEA called "clusters" of known utilization. To identify which microhabitat criteria were ecologically relevant, the statistical distributions of utilized criteria must be compared to the statistical distribution of these criteria ***outside*** the local distributions of fish species and life stages. In other words, microhabitats must be surveyed in locations occupied by fish and in locations unoccupied by fish. Surveys of microhabitat outside the localized distributions of fish will provide AEA the ability to make valid comparisons with occupied microhabitat and analyze ecological relevance in a sound statistical and ecological manner.

Modification 4: Surveys of available habitat must be performed in habitats similar to those occupied in order for ecologically and statistically valid comparisons to be made. As executed, AEA surveyed availability in the wrong dimension (lateral instead of longitudinal) and in different habitat types, from those utilized. This was ecologically and statistically invalid. Availability could only have been assessed in unoccupied habitats within the same habitat stratum (e.g. unoccupied side slough riffles as compared to those occupied), in order to be valid. This failure was a product of AEA's disregard for their approved hierarchical habitat model that was to be used to structure data collection and analyses.

Modification 5: AEA must design their HSC study to compare the dependence of fish habitat selection on VHG. This can only be accomplished by surveying habitats with a different VGH. AEA demonstrated a misunderstanding of ground and surface water interactions on alluvial floodplains. Both utilized and "available" habitats were located within the same longitudinal positions and would have been characterized by the same regional vertical hydraulic gradient (VHG). Furthermore, AEA did not assess VHG locally, in association with spawning or rearing, and did not assess VHG hierarchically, according to the Project's hierarchical habitat model. Ground and surface water exchanges occur locally, in association with channel bedforms, at intermediate scales between main and side channels (and sloughs), and regionally at the floodplain scale. Exchanges operating at each of these scales are known to influence the distribution of spawning.

Modification 6: AEA must analyze their data in accordance with their proposed and approved hierarchical habitat model. AEA pooled all data from all habitats throughout the river to analyze habitat criteria and develop HSC. Pooling forfeits examination of habitat relationships within different habitat types where different life-history tactics are known to exist. Pooling effectively led AEA to abandon the hierarchical habitat model they developed for this project. The pooling of the data was invalid from a statistical, ecological, and evolutionary perspective.

Modification 7: FERC determined that AEA must evaluate microhabitat criteria by comparison and examination of relationships between abundance and microhabitat criteria. AEA must evaluate the statistical and ecological relevance of these relationships using statistical methods. As discussed below, AEA's 2014 Technical Memorandum did not accomplish this. As noted by AEA, there was a mismatched agenda and scales in which abundance and microhabitat data were surveyed. There were no adult salmon abundance data, microhabitat data were not integral to the collection of the abundance data, and groundwater data were incomparable. As such, AEA was emphatic about their deference to the HSC study to identify which microhabitat criteria were important to fish habitat selection. Unfortunately, AEA did not use statistical methods to identify relevant criteria in the HSC study.

Through the use of statistical methods, AEA should identify which criteria are ecologically relevant to fish habitat selection and use this subset of relevant criteria to develop HSC models (with logistic regression or otherwise). AEA used a univariate utilization curve generation process to select habitat criteria for use in multivariate modeling. This is an invalid way to select criteria.

a. Utilization does not equate to ecological relevance. Utilization will associate with any number of existing microhabitat criteria and often can simply reflect the distribution of a given criterion, irrespective of the relevance to habitat selection.

Identification of relevance requires examination of microhabitat availability outside the local distributions of species and life stages. Relevance can be found only when *utilized* criteria differ from what is truly available, in a statistically significant way. There are a number of basic exploratory statistical methods that can be used to evaluate the significance of differences between the statistical distributions of occupied and unoccupied microhabitat. The nature of the data will determine which basic method to use, through reference of any basic statistics text.

b. AEA's selection of criteria for HSC model development prevented a statistically valid examination of criteria and examination of interactions between criteria. **AEA selected criteria for multivariate modeling that were necessary for implementation of a hydraulic habitat evaluation, regardless of whether or not these criteria were ecologically relevant to habitat selection**.

Flow-Habitat Modeling

A hydraulic habitat evaluation or flow-habitat modeling involves two primary components, hydraulic and habitat simulation. Hydraulic models are utilized to simulate river hydraulics, as a function of flow, and HSC translate these estimates into habitat. These microhabitat simulations and habitat translations are performed within hydraulic modeling cells. The output of a flow-habitat analysis is weighted usable area (WUA). WUA is a habitat measure combining the quantity (area) and quality of habitat, based on surface water hydraulics, within modeling cells. Weighting is the procedure that governs the length of the modeling cells, and hence the overall area of habitat represented by each cell. WUA is simply the product of the area of each computational cell and the combined suitability of each cell, as determined by HSC modeling. WUA is expressed in terms of habitat area for a given stream length, typically 1,000 feet. It is given by the following general expression, on a cell-by-cell basis:

$$WUA = \Sigma A_i * C_i$$

Where: WUA = Weighted Useable Area

A = view area of the modeling cell

C = the composite suitability of the cell; hydraulics translated by HSC

While a hydraulic habitat evaluation can, in certain settings, serve as a useful tool for evaluating alternative flow scenarios, it cannot be applied without adequate consideration of its appropriateness. According to USGS[1], a simple hydraulic habitat analysis such as conducted in PHABSIM is only appropriate (realistic) when habitat is limited by surface water hydraulics used to represent habitat. Users must demonstrate that habitat is primarily a function of depth

[1] Waddle, T.J. (ed.). (2012) PHABSIM for Windows user's manual and exercises. Open-File Report 2001-340. Fort Collins, CO: U.S. Geological Survey. 288 p.

and velocity. If users cannot perform this demonstration, project stakeholders must be willing to make this assumption. The USFWS does not agree that this is a valid assumption and instead requested a scientific process through which habitat criteria can be weighed according to their ecological relevance.

AEA described HSC/HSI as curves that translate hydraulics into habitat suitability, based on *assumptions* made about functional relationships. These assumptions were made in the place of scientific assessments of biological/ecological relevance, necessary to discriminate between which HSC/HSI should be used to estimate habitat, as a function of flow. For a project of this scale, with the resources involved, these assumptions of ecological relevance leave stakeholders with great uncertainty about the AEA's ability to develop realistic flow-habitat relationships needed to characterize existing conditions for the proposed project. The USFWS does not support making untested assumptions about habitat criteria and HSC upon which AEA has proposed to base their entire assessment of the Project. *Modifications to the HSC study must be implemented prior to a successful demonstration of the appropriateness of PHABSIM/2D Habitat Modeling for assessing flow habitat relationships for this Project*.

Temporal and Spatial Habitat Analyses

Temporal and spatial habitat analyses have not yet been performed, nor can they be until successful modifications to the HSC study are made (see above). The supplemented ISR provides an update of AEA's development of integrated aquatic habitat models to produce a time series of biological metrics data (pertaining to fish life history strategies). The metrics would then be used to conduct a habitat-based evaluation of Project effects under existing conditions and alternative operational scenarios. In order to synthesize the multitude of results from the habitat-based evaluation, AEA described their general approach to develop a Decision Support System-type (DSS) framework to conduct a variety of post-processing comparative analyses derived from the biological and hydrological output metrics estimated under the aquatic habitat models.

There are several weak points, as proposed, in the effective combination of quantified fish response curves, measurement of physical conditions, and ability to predict physical conditions under Project alternatives that will be required to implement a future habitat-based evaluation. Representing uncertainty in the effective combination of models, analysis, assumptions and measurements has no simple or satisfactory solution. At the most general level AEA tried to evaluate alternatives in a multiple variable realm of possible outcomes associated with each proposed Project operational alternative. Precision and accuracy in measurements, parameters, and specific feasible model outputs are important and deserve attention and reporting. Fundamental spatial and temporal variation and the relevance of chosen model variables are even more important. For example, a precise and accurate estimate of habitat at a single site at a specific discharge and current channel geometry is not as relevant as some estimate of habitat at multiple locations under multiple possible sequences of discharge that might occur under a given operational alternative—further considering the multiple possible channel geometries associated with each sequence of discharges.

At this point, the feasible, but incomplete approach, is directed at estimates of output variables (such as habitat suitability for a particular species and life stage) under a set of specified "cases" defined by study site, hydrology, and channel geometry; such as, study sites (10 Focus Areas (FAs)) under 3 different discharge year-types (wet, average, dry) under 3 different possible channel geometries (present, 25 year and 50 year). From a practical perspective that is 90 different cases/simulations for each proposed operational alternative. It is not clear from the ISR how all of this information will be integrated into a final analysis of Project effects and if the analysis will provide an appropriate representation of important spatial and temporal variation in geometry, river network position, groundwater, temperature, ice formation, mechanical ice breakup, intra-annual timing of discharge and stage, and the long-term signature of extreme events. In addition, the limited scenarios and the integration of current model capabilities do not address the uncertainty surrounding concerns for fish species and life stages, invertebrates, and plants that have been a critical element of responses to dam construction and operation throughout the world. The estimates from each "case" are not really random samples of all possible outcomes, but at least can be plotted on the same graph with different colored symbols to be able to compare the variation that the proposed operational scenarios might have on instream flow habitat.

Project operational alternatives need to be compared realistically and appropriately. The USFWS is most interested in the rank order of alternatives and their general absolute magnitudes. We don't want to end up with the relatively best habitat amongst a set of habitat values all producing extirpation. We also don't want an alternative which is clearly the best under representative wet, dry, and normal years, but that produces a terrible result if we are wrong about the role of ice in channel change or ignore the trajectory of channel change that might be triggered by an unusual sequence of years. The USFWS recommends focusing the "cases" examined and portrayed to a mixture of (1) those that are most likely or "representative", and (2) those that might result in the biggest differences in the absolute magnitude and rank order among the alternatives.

Instream Flow Study Integration

As with Temporal and Spatial Habitat Analyses, Instream Flow Study Integration has not yet been conducted. It should be noted that significant steps have been made to *consider* model integration sooner and more explicitly. As a result, the overall effort appears to be on a path that is immensely better than what was originally proposed in the FSP of waiting until all final study results were completed before seriously considering exactly how to integrate models and analyses across studies (spatially and temporally). This integration component and DSS tool development has been a common, ongoing concern of stakeholders. Through numerous TT meetings, TWG meetings, and the Proof of Concept (POC) meeting, those conducting the ISF studies are making a promising and substantial effort to develop an integration strategy. However, improvements are much needed to assess Project impacts on Susitna River aquatic species including the following,

- Sampling of unaltered winter flow and hydraulic conditions through, under, and around ice
- Evaluation of winter physical habitat conditions for aquatic species
- Species/life stage sampling and observations throughout the year; periods of sampling did not adequately represent the periodicity of species and life stages that were developed for the project.
- Water quality and groundwater data collection and modeling efforts need to be better aligned with the spatial-temporal scale of fish production and instream flow studies to be useable.

Discussions with stake holders related to data analysis and integration of:

- Aquatic species/life stage specific habitat parameters (i.e., groundwater, water quality), model development, testing and validation
- Spatial and temporal scales of model inputs and resultant model output and analysis
- Data accuracies and error propagation through models
- DSS development and a detailed understanding of data analysis, model interdependencies and outputs utilized to evaluate the potential operational flow-induced effects on fish habitat below the proposed Project dam

The following documents were reviewed related to the ILP ISR process for the Instream Flow Study (8.5):

- Fish and Aquatics Instream Flow Study (Study 8.5) Initial Study Report: Part A (Sections 1-6, 8-9), Part B (Supplemental Information and Errata to Part A), and Part C (Executive Summary and Section 7)
- Fish and Aquatics Instream Flow Study (Study 8.5): 2013-2014 Instream Flow Winter Studies Technical Memorandum
- Fish and Aquatics Instream Flow Study (Study 8.5): Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables Technical Memorandum (September 17, 2014; this document has been superseded by Part D, SIR, Habitat Suitability Criteria Development, Appendix D).
- Fish and Aquatics Instream Flow Study (Study 8.5): 2013-2014 Instream Flow Winter Studies Technical Memorandum Addendum
- Fish and Aquatics Instream Flow Study (Study 8.5): Initial Study Report Part D: Supplemental Information to June 2014 Initial Study Report
- Fish and Aquatics Instream Flow Study (Study 8.5): 2014-2015 Study Implementation Report: Appendix D, Habitat Suitability Criteria Development

- AEA's "Initial Study Report Meetings March 24, 2016 Action Items", as it pertains to Fish and Aquatics Instream Flow Study Plan Section 8.5.

Specific Objectives

The objectives of the Fish and Aquatics Instream Flow Study, as specified in the ISR, Section 8.5 include the following:

1. Map the current aquatic habitat in main channel and off-channel habitats of the Susitna River affected by Project operations. This objective will be completed as part of the Characterization of Aquatic Habitats Study (9.9) (see Figure 8.5-1).
2. Select study areas and sampling procedures to collect data and information that can be used to characterize, quantify, and model mainstem and lateral Susitna River habitat types at different scales. This objective will be completed via a collaborative process involving this study, Riparian Instream Flow (8.6), Groundwater (7.5), Geomorphology (6.0), Water Quality (5.0), and Fish and Aquatics (9.0).
3. Develop a Mainstem OWFRM that estimates water surface elevations and average water velocity along modeled transects on an hourly basis under alternative operational scenarios.
4. Develop site-specific Habitat Suitability Criteria (HSC) and Habitat Suitability Indices (HSI) for various species and life stages of fish for biologically relevant time periods selected in consultation with the TWG. Criteria will include observed physical phenomena that may be a factor in fish preference (e.g., depth, velocity, substrate, embeddedness, proximity to cover, groundwater influence, turbidity). If study efforts are unable to develop robust site-specific data, HSC/HSI will be developed using the best available information and selected in consultation with the TWG.
5. Develop integrated aquatic habitat models that produce a time series of data for a variety of biological metrics under existing conditions and alternative operational scenarios.
6. Evaluate existing conditions and alternative operational scenarios using a hydrologic database that includes specific years or portions of annual hydrographs for wet, average, and dry hydrologic conditions and warm and cold Pacific Decadal Oscillation (PDO) phases.
7. Coordinate instream flow modeling and evaluation procedures with complementary study efforts including Riparian (8.6), Geomorphology (6.5 and 6.6), Groundwater (7.5), Baseline Water Quality (5.5), Fish Passage Barriers (9.12), and Ice Processes (7.6) (Figure 8.5-1). If channel conditions are expected to change over the license period, instream flow habitat modeling efforts will incorporate changes identified and quantified by riverine process studies.
8. Develop a Decision Support System-type (DSS) framework to conduct a variety of post-processing comparative analyses derived from the output metrics estimated under aquatic habitat models. These include (but are not limited to) the following:
    - Seasonal juvenile and adult fish rearing
    - Habitat connectivity
    - Spawning and egg incubation (habitat persistence)

- Juvenile fish stranding and trapping
- Ramping rates
- Distribution and abundance of benthic macro-invertebrates

Objective 1

Objective 1: Map the current aquatic habitat in main channel and off-channel habitats of the Susitna River affected by Project operations.

Methods for Objective 1:

This objective will be completed as part of the Characterization and Mapping of Aquatic Habitats Study (9.9).

FERC Study Plan Determination (SPD) comments

FERC evaluated Objective 1, river stratification and habitat classification system for aquatic studies, including consideration of microhabitats nested within mesohabitats. Our review and recommendations for Objective 1 of ISF (8.5) are included in our review of Characterization and Mapping of Aquatic Habitats (9.9) ISR.

Objective 2

Objective 2: Select study areas and sampling procedures to collect data and information that can be used to characterize, quantify, and model mainstem and lateral Susitna River habitat types at different scales. This objective will be completed via a collaborative process involving this study, Riparian Instream Flow (8.6), Groundwater (7.5), Geomorphology (6.0), Water Quality (5.0), and Fish and Aquatics (9.0).

FERC Study Plan Determination (SPD) comments

In the study plan determination (SPD) (April 2014) FERC states that, "AEA's approach to select a minimum of one Focus Area (FA) within each geomorphic reach is consistent with the intent of their habitat classification system and sampling framework, and should facilitate the meaningful extrapolation of results. This is common practice when stratifying based on physical characteristics and processes, and is appropriate for evaluating aquatic resources over broad spatial scales (section 5.9(b)(6))."

In addition, FERC suggests that FAs are intended to be sites where intensive interdisciplinary studies are proposed, and therefore, require broader consideration than salmon production alone.

FERC recommended that AEA: (1) consult with the TWG and select an appropriate FA within MR-2 to eliminate from the study; (2) consult with the TWG and establish an additional FA in geomorphic reach MR-7 that is sufficient for conducting interdisciplinary studies, possibly near Lower McKenzie Creek or below Curry on old Oxbow II; and (3) file a detailed description of the changes to the proposed FA locations in MR-2 and MR-7 by May 31 2013, and include in the filing documentation of consultation with NMFS, USFWS, and ADFG, including how the agency comments were addressed.

Methods for Objective 2:

Proposed Methods

AEA stated that FA selection was to be based on: (1) mainstem habitat types of known biological significance (i.e., where fish have been observed based on previous and/or contemporary studies); (2) locations where previous sampling revealed few or no fish (i.e., FA-141 at Slough 17); and (3) representative side channels, side sloughs, upland sloughs, and tributary mouth habitats.

Implemented Methods

Ten FAs were selected within the Middle River prior to the FERC Study Plan Determination (SPD). In response to FERCs recommendation in the SPD, AEA modified the location of one FA in consultation with the Technical Working Group (TWG). The consultation also resulted in the addition of Oxbow One (FA-113), to the Middle River segment at MR-7. The rationale for the Middle River addition was due to the relative size and importance of the geomorphic reach.

The ISR reports incomplete sampling across FAs during 2013 and inconsistent sampling efforts within individual FAs sampled. For example, the Groundwater study (7.5) proposed to collect input data to allow modeling of surface water-groundwater exchange in areas of ecological importance. The relevant ecological importance was to be determined by field efforts.

Variances for Objective 2:

The sampling design used to collect data for characterization, quantification, and modeling of mainstem and lateral habitat types of nested scales within FAs was a variance during 2013.

Incomplete and inconsistent sampling of FAs is a variance to the approved Study Plan. Groundwater studies are focused mainly in FA-128 (Slough 8A in MR-6) and FA-104 (Whiskers Slough in MR-8) only, and conclusions regarding groundwater in FAs rely more on 'expert' opinion than from results of rigid sampling design of field measurements from the FAs. The RSP identified that meso- and microhabitat data would be collected/identified on-the-ground in conjunction with the HSC and fish distribution and abundance study to assist in ground-truthing the mesohabitat classifications identified by the 2012/2013 aerial mapping. However, the ISR states that this did not occur due to time constraints and that the microhabitat data would simply be linked to mesohabitat classifications obtained by the aerial mapping. If this is true, then there is no validation data available for the mesohabitat classifications. Similar concerns in the level of data collection efforts are noted for water quality (5.5, 5.6), ice processes (7.6), and fish and aquatics studies (9.5, 9.6, 9.7, 9.8. 9.9).

Restriction of land access during 2013 resulted in unequal sampling efforts across FAs in general. While land access was not available for the three upper Focus Areas adjacent to CIRWG lands in 2013, this restriction was resolved in 2014 and AEA was able to complete detailed surveys in one of the three Focus Areas (FA-151-Portage Creek) in September 2014. However, work on FA-173 (Stephan Lake Complex) and FA-184 (Watana Dam) was deferred. AEA suggested that not initiating studies in these FAs on a consistent timeline will not have a substantive effect on the completion of this study because all field work, data analysis and modeling will ultimately be completed prior to submittal of the license application. ISR 8.5 Part

D and the SIR reports provide summary information for data collection efforts that occurred in 2014 at all 10 FAs.

The ISR (Part C, 1 of 2), states that there will be two years of study for the three FAs located on CIRWG land. This is problematic because the 2013 data which constitutes year-one of study for the Susitna Watana Project had not yet been reviewed by stakeholders prior to 2014 field efforts.

In addition the USFWS is concerned with the potential for erroneous conclusions of data from comparative relationships among inconsistent hydrologic years and conditions across FAs (i.e., 2013 and 2014). AEA has created a temporal mis-match of data collection efforts. FAs were to provide detailed understanding of river processes by geomorphic reach. Two years of data does not allow for model validation with independent data, or model condition and variation under multiple hydrologic or biologic years.

Conformance with Objective 2

The intent of the FAs is to provide geomorphic reach specific biologic and riverine process data at macro-, meso- and microhabitat scales. The hierarchical habitats nested within FAs allows for relational understanding at multiple scales.

The primary purpose of the FAs is to integrate study disciplines to gain increased understanding of physical, chemical and biological habitat relationships. Objective 2 is designed to include data from study disciplines within FAs; including Riparian Instream Flow (8.6), Groundwater (7.5), Geomorphology and Fluvial Geomorphology (6.5, 6.6), Water Quality (5.5, 5.6), Fish and Aquatics (9.5, 9.6, 9.8, 9.9, 9.11, 9.12), and Ice Processes (7.6) studies. Integrated study data is intended to be input for 2D modeling efforts in FAs. Two dimensional (2D) modeling is expected to result in an increased understanding of modeled relationships under different operational scenarios over 1D modeling, given the channel complexity of the Susitna River. Middle River sampling efforts within and across FAs over multiple years need to be achieved to meet Objective 2. Study efforts during 2013 have consisted of a significant investment of time and resources, however many important data gaps remain.

- Adult salmon spawning distribution in the lower Middle River is unknown because of limited tagging effort and no tagging of Pink Salmon. Yet, Pink Salmon have been observed in Whiskers and Slough 6A and are an integral part of the ecology of the FAs.
- A Project demonstration of hydraulic flow routing and 2D modeling has been limited to within FA-8A.
- Groundwater studies are not adequate in scope and scale to provide comprehensive understanding at a scale relevant to fish.
- Data collection is occurring in one FA to develop a 3D model capable of predicting Project operational surface-groundwater exchange at a scale relevant to fish habitat.
- Water quality studies do not provide data for lateral off-channel habitats, and do not consider the influence of surface-groundwater exchange.
- Macro-invertebrate and productivity studies are only being conducted at a subset of FAs and only two FAs that overlap with salmon distribution in the Middle River.

- Fish passage studies have not been completed and rely on 2D modeling, which may not be robust enough to evaluate passage.
- The USFWS requests multiple, consecutive and concurrent years of data for relevant disciplines be collected across FAs to be used as model inputs.

The selected Lower River study sites are locations that in the 1980s, investigators believed may present fish migration barriers. These sites are not representative of the geomorphic reach, were not randomly selected, and are not areas of known spawning and rearing. Data analysis results from these locations were presented at the Proof-of-Concept (POC) meeting as an assessment of Project effects for rearing habitat. Instream flow analyses within the Lower River should occur at locations of known spawning and rearing habitat or critical sites. Selection of critical sites would be the most cost-effective method of evaluating Project effects on the Lower River. AEA stated that specific study site locations and transects within LR-2 of the Lower River will be selected and surveyed in 2016. Prior to conducting this work, AEA and their contractors should coordinate with the TWG and make sure that the locations and associated data being collected will be able to answer the study needs in the Lower River. Lower River study site selection is currently being based on the 1980s data that identified locations that were repeatedly used by fish. Rather than selecting sites from historical 1980s data, the USFWS would like the Project to use data from the fish distribution and abundance studies that occurred in 2012 - 2015 to identify current use within the Lower River.

For reasons discussed above, the USFWS considers Objective 2 to be underdeveloped. Below are recommendations to further study efforts toward ISF Study Plan conformance. Our recommendations pertain to topics addressed by FERC in the SPD or in the FERC-approved SP, but have not been sufficiently addressed. The recommendations are in response to our review of the 2013 information provided in the ISR, related 2014 Technical Memorandums, ISR meeting notes, and the ISR Part D and supplemental SIR documents. Modifications are additional information requests as a result of our overall agency review of these same materials.

Recommendations, modifications, or new study requests for future study

Recommendations

- Two years of groundwater and water quality data and modeling (in addition to the hydraulic modeling) to develop site specific habitat models for each FA. This will require integration of 3D groundwater models and the water quality models to provide analysis at micro- and mesohabitat scales within each FA.
- FA study sites and number of sites in the Middle River and Lower River should represent the range of biological use of habitats. FA study site locations and site numbers are not adequate to determine fish distribution and identify the habitat variables within relevant macrohabitats to assess fish-habitat associations.
- **Data protocols and sampling designs of 2013 should be rectified before additional years of Project data collection occur.** Due to concerns with the 2013 data, the USFWS recommends that 2014 data not be considered as year-two Project data until FERC determines that information collected in 2013 meets the approved SPD requirements. The

recommendation is based on concerns related to the 2013 sampling design and data collection efforts, and the fact that the 2014 data was collected in a similar manner.

Modifications

- Representative site selection of adult salmon spawning and juvenile salmon rearing locations in the Lower River. Locations that were considered to be migration barriers in the 1980s were used as sampling sites. Results from the current adult escapement study should be used to identify representative spawning locations, and results from the 1980s or the current FDA study should be used to identify important juvenile rearing and overwintering locations. This modification is requested to ensure that Project effects on Lower River salmon spawning and rearing are evaluated at known salmon spawning and rearing locations. The overall development of Lower River studies falls behind that of studies in the Middle River.
- We recommend that AEA work with the TWG to identify specific habitats that are "critical" for adult and juvenile fish throughout the entire Susitna River system (and not just the Middle or Lower River).
- Measurement of ice thickness, water depth, water temperature and water velocity at multiple points along 10 or more transects in each FA are needed to accurately model ice thickness and calibrate and validate winter hydraulic models (ISF 8.5 and Ice Processes (7.6)).

Objective 3

Objective 3: Develop a Mainstem Open-water Flow Routing Model that estimates water surface elevations and average water velocity along modeled transects on an hourly basis under alternative operational scenarios.

<u>FERC Study Plan Determination (SPD) comments</u>
No modifications to the study plan were recommended by FERC (SPD April 1 2013; page B-96).

<u>Methods for Objective 3:</u>
The ISR and more recent 8.5 SIR discuss the reservoir operations model (HEC-ResSim and the newly identified MWH-ROM) development and calibration of the Open-Water Flow Routing model (OWFRM) (Version 2.0 and 2.8). AEA discussed and presented "proposed dam operations" but detailed description of operations are not in the ISR. Operational detail is critical information for determining the type and amount of spatial and temporal change that may occur due to Project operations and the effects on instream flow and habitat conditions. OS-1b and the more recently identified ILF-1 has been presented as a worst case operational scenario for load-following to demonstrate potential Project effects, however, realistic load-following operations that may occur have not been presented in detail. Information on how realistic load-following operations will be evaluated to minimize overall Project effects has also not been provided. Alternative operational scenarios should be identified, discussed, and potentially modified through TWG meetings to provide the best case scenario for both hydropower operations and species conservation. Although the reservoir operations model (MWH-ROM) is presented and development and calibration of the OWFRM (Version 2.0 and 2.8) were discussed in the ISR

and most recent SIR, only results of the OWFRM associated with pre- and OS-1b post-Project operations were presented. Verification of modeling results was not provided, therefore; post-dam operation impacts could not be evaluated.

Hydrology and Flow Routing Version 2 (TM for ISR Part C- Appendix K)
Appendix K states that outputs from the OWFRM will provide fundamental input to the ice dynamics model. The ice process models will be used to simulate flow routing hydrodynamics during the ice-affected period. However, Appendix K does not describe how the OWFRM will provide fundamental inputs to the ice process model for that purpose.

The technical memorandum (TM) (Section 3.1) identifies the model channel geometry and calibration efforts for the HEC-2 model developed in the 1980s but does not include information on how the 1980s HEC-2 model was used to inform the current model.

Methodologies of discharge measurements are discussed (Section 3.1), but the ISR TM does not include any comparisons made between discharge measurements, or expected accuracy of the discharge measurements. Section 5.3.2 discusses measurement of profiles/panels of frazil ice but the effective depth for this measurement is not provided. It is not clear if the Project's definition of depth relates to the depth below the frazil accumulation or the depth below the ice cover.

Section 5.4.1.1.1 describes the combination of data inputs that were utilized to construct the cross sections for the OWFRM. The TM states that for the majority of cross sections that had split flow or side channels, the water surface elevation of the main channel differed from the secondary channels. To properly simulate the conveyance of water in the 1D HEC-RAS model, transects with multiple channels had to be altered in order to maintain the correct cross sectional flow area. As a result, 125 of the 216 cross sections (nearly two-thirds) had portions of the channel geometry outside of the main channel adjusted vertically. The vertical adjustment was based on the difference in water levels across the section, recorded on the day of the survey. The rational presented for this shift is due to the limitation of the 1D model, and that portions of the section must be adjusted to preserve the flow area. It is unclear if the vertical adjustments were based only on the concept of preserving flow, or if some were adjusted to match computed-to-observed water levels during the calibration process. Based on the methodology described, water levels in the back channel areas will require "post-processing", or readjustment for the provision of predicted water levels in the off-channel habitats for input/integration with complimentary studies. If these adjustments are in fact necessary, they may not be appropriate for other studies that rely on channel geometry for model input (e.g., river ice process model (7.5)).

Section 5.4.2.1 does not provide clear rationale or context for characterization of the referenced *low*, *medium* and *high* flows. The ISR TM should explain how these values compare to the flow duration values and threshold values of percentage exceedence used to determine *low*, *medium* and *high* flows. While the range of flows that were measured and used for model development and calibration for the three referenced flows was shown to have good coverage (80-83%), when looking specifically at the low flow ranges only 56% of the measured data fell within the specified "low flow" range. **This raises some concern since the effective habitat in the Middle and Lower River are most affected by low flows.** The ability to accurately predict the hydraulics along the river during low flow scenarios is crucial to determine Project effects on fish habitat.

The OWFRM was calibrated under steady-state conditions. AEA stated, "Under subcritical flows conditions found in the Susitna River, the water surface elevation at a given cross section is controlled primarily by the shape and water surface elevation of the next downstream cross section and to a lesser extent by roughness coefficients (Manning's *n*) and expansion/contraction loss coefficients" (Section 5.4.2.1). The context of this statement is not clear with respect to the model calibration. If downstream effects control the water level at a particular section then this further supports the more typical approach for calibration of Manning's *n* on a reach-by-reach scale. Section 5.4.2.1 describes an unfamiliar (atypical) [e.g., not using accepted scientific methods] OWFRM calibration method. Manning's *n* was calculated section by section to achieve a specified tolerance of 0.2 feet. Adjustments to Manning's *n* were limited to a specified range of values and where further adjustments were required, *hydraulic control* sections were synthesized and added downstream of the calibration section. These synthesized sections have uncharacteristic channel geometry compared to that of the originally surveyed (e.g., vertical shift of 2.6 feet and channel width increased by factor of 2). Based on the calibration results, the ISR TM Appendix does not describe the impact on the performance of other models that rely on geometry from the OWFRM (e.g., ice processes) or how well the models will perform for conditions that are outside of the range of flows utilized in the model calibration.

The discussion within Section 5.4.2.1 emphasizes that calibrated water levels are within a specified accuracy that is appropriate for assessing fish habitat. To meet this criterion, at a "calibration" cross-section, the water surface profile is adjusted by introducing an artificial control section with geometry that is inconsistent with the actual geometry. This method may achieve the desired effect at the "calibrations" cross section; however, the resulting accuracy of the computed profile throughout the reach of interest is not explained.

In Section 5.4.2.2, the methodology used to determine flow accretions for the unsteady flow calibration is different than that used for the steady-state calibration. Flow accretions are back-calculated based on the difference between the routed hydrograph and the measured hydrograph. We recommend a comparative illustration between computed versus observed hydrographs using both methods and with no accretion be provided. Discussion on the difference between the computed and observed hydrographs, including timing of peaks and flow continuity should be provided. The green line plotted in Figure 5.4-22 is not identified in the legend, making it unclear as to what information is being presented.

Section 6.4.2, states in reference to Figures 6.4-2 and 6.4-3 that, "Excellent agreement was found at Gold Creek and Sunshine, and good agreement was found at Susitna Station." The qualitative assessment appears to be based on a visual comparison of computed versus observed hydrographs. The Project's method for accounting for the flow accretions ensures an excellent fit because they are simply backing-out the difference between observed and computed hydrographs and then applying that difference upstream. This method is not a reflection as to how well the model performs in a predictive mode because it requires the observed data to predict that same observed data. In Section 6.4.3, Figures 6.4-5 through 6.4-7 the plot scale is difficult to discern between computed and observed hydrographs. We suggest that a more quantitative assessment of model validation be presented. For example, an assessment of associated error in water level corresponding to the error in the computed discharge is needed. How this compares to the calibration target of approximately 0.2 feet should be described.

Variances for Objective 3:

Model calibration

The RSP stated that 13 mainstem water-level recording stations were to be installed to provide data for calibration of the OWFRM. The ISR states that through initial calibration of Version 1 of the OWFRM and analysis of the gaging station data, 8 of the 13 stations are considered high priority while the remaining 5 are considered low priority. No definitions of "low" and "high priority"; or the criteria for meeting either designation are provided. These types of decisions and analyses should be discussed with the TWG and agreed upon prior to discontinuing data collection at these gaging stations. The Services are unable to assess the overall affect to meeting Project objectives without the demonstrated ability of the stations to calibrate the OWFRM.

Conformance with Objective 3

Model status

The OWFRM (Version 2.8) is not adequately developed to assess pre- and post-Project effects. It is also not sufficiently developed to integrate information from other study disciplines [e.g., ice processes (7.6), fluvial geomorphology (6.6)]. Information on calibration, validation and sensitivity analysis are lacking. **Clarification in the text is needed to describe the results of the 1D HEC-Ras model used for the flow routing analysis to determine the downstream extent of Project impacts.** Initial results presented in the ISR associated with OS-1b confirm that post Project operations will drastically change the flow hydrograph in the Middle River throughout the open water portion of the year resulting in maximum potential stage changes ranging from 9.7 feet near the dam, 5.7 feet near Gold creek, and 2.1 feet near Susitna Station in the Lower River. This amount of stage change is huge in terms of river connectivity and the effects on main channel and lateral habitats. Additionally, the hourly stage effects associated with ramping rates for OS-1b (hydro-peaking) ranged from 0-2.1 feet under dry conditions and 0-8.0 feet under wet conditions near the dam site, 0-4.1 feet near Gold Creek, and 0-4.0 feet near the Sunshine gage in the Lower River. While OS-1b is considered a "worst case" scenario, this illustrates that the ramping rates associated with a hydro-peaking operation will have drastic effects on the water surface elevations throughout the river which will greatly affect habitat conditions, lateral habitat connectivity, river processes (instream flow and riparian), and ice processes (flow under and over existing ice formations).

AEA needs to determine additional operational scenarios that are likely to occur within the system in addition to the OS-1b and newly identified ILF-1 scenario to better understand the overall Project effects throughout the entire Middle and Lower River.

Recommendations and Modifications for future study:

Based on our review of the ISR, supplemental TM and Appendices, the USFWS does not consider Objective 3 to be fully met. We have the following recommendations:

- Detailed and complete modeling of ILF-1 should be developed and provided to stakeholders.
- Additional operational scenarios for pre- and post-Project information should be developed; including the evaluation of the run-of-river scenario that was required by FERC.
- The mechanism for integrating operational scenarios with other study disciplines is needed to evaluate the utility of ISF modeling efforts.
- Hec-Ras model input and output files should be provided to stakeholders. The data is needed to conduct an independent verification of conclusions made by AEA regarding the downstream extent of Project impacts as a result of proposed operational flow scenarios. The USFWS and NMFS current Memorandum of Agreement with the Alaska Department of Natural Resources and AEA, does not allow for any review of "data analysis" conducted by AEA. AEA reported that there are minimal affects downstream of PRM 29.9 and they do not propose to model the area of tidal influence from the mouth upstream to approximately PRM 10 (Fluvial Geomorphology Modeling below Watana Dam Study 6.6 Technical Memorandum, September 2014).

Objective 4:

Objective 4: Develop site-specific Habitat Suitability Criteria (HSC) and Habitat Suitability Indices (HSI) for various species and life stages of fish for biologically relevant time periods selected in consultation with the TWG. Criteria will include observed physical phenomena that may be a factor in fish preference (e.g., depth, velocity, substrate, embeddedness, proximity to cover, groundwater influence, turbidity.). If study efforts are unable to develop robust site-specific data, HSC/HSI will be developed using the best available information and selected in consultation with the TWG.

<u>FERC Study Plan Determination (SPD) comments</u>

Generating the list of parameters for HSC and HSI development

In response to agency requests for a holistic evaluation of the appropriateness of PHASBIM and the ecological relevance of habitat criteria, FERC required the investigation of additional parameters known to influence habitat use by salmonids. FERC's determination required AEA to fully evaluate recognized habitat criteria before other means of developing HSC were considered. Resource agencies requested 11 additional microhabitat variables be included in the evaluation. FERC believed that 3 of those variables (invertebrate drift density, benthic organic matter, and algal biomass) were adequately planned for in the River Productivity (9.8) study. FERC recommended that the following eight additional fish habitat microhabitat variables be assessed: surface flow and groundwater exchange fluxes, DO (intergravel and surface water), macronutrients, temperature (intergravel and surface water), pH, dissolved organic carbon, alkalinity, and Chlorophyll-a. FERC responded positively to the Services request for consideration of vertical hydraulic gradient (VHG), which is necessary to calculate flux. The calculation of flux incorporates substrate (permeability) and VHG.

FERC required that the additional microhabitat variables be assessed to determine if HSC for these variables could contribute to the required analysis of Project effects (section 5.9(b)(5)). On page B-91, FERC determined that AEA should evaluate habitat criteria by "comparison of fish abundance measures with specific microhabitat variable measurements", where sampling overlapped. This was also to include an assessment of vertical hydraulic gradient (see page B-92), in a continuous manner (not merely as a binomial of upwelling or downwelling). If strong relationships were found to exist, further HSC development was then warranted.

FERC required that the three variables (invertebrate drift density, benthic organic matter, and algal biomass) collected in the River Productivity study (9.8) be co-located with FDA (9.5, 9.6) fish sampling to provide the "detailed evaluation" of fish abundance and these microhabitat variables.

Sample size
FERC stated that the proposed sample size of up to 100 observations of each target species life stage using a stratified random sampling design is consistent with generally accepted practices in the scientific community (section 5.9 (b)(6)), and should provide a robust data set to develop the aquatic habitat models and evaluate Project effects (section 5.9 (b)(5)).

Groundwater
FERC directed AEA to incorporate vertical hydraulic gradient (VHG) as a site-specific microhabitat variable by collecting field measurements. Methods were to be developed into the site-specific HSC development process. FERC required that measurements of VHG be summarized in the ISR regardless of whether a feasible or infeasible finding is made. FERC specifically stated that, "Habitat Suitability Criteria (HSC) and a Habitat Suitability Index (HSI) will be developed that include groundwater-related parameters (upwelling/downwelling indexes). This development will follow the general procedures outlined in the Fish and Aquatics Instream Flow Study (8.5) and will include variables specific to groundwater, including turbidity, evidence of upwelling/downwelling, substrate characteristics, and water temperature. Other parameters may also be included. These parameters will be incorporated into the development of HSC type curves that reflect utilization of these variables by fish".

Winter sampling
FERC also requested an evaluation of winter sampling, (April 1, 2014 SPD page B-96), stating that there would be additional opportunities throughout the ILP pre-filling study implementation to evaluate the effectiveness of winter sampling methods and, if found to be effective, implement additional winter sampling efforts throughout the study area.

<u>Methods for Objective 4:</u>
Data for the purpose of developing HSC and HSI were collected within the FAs. The FAs were conceptually representative of a geomorphic reach; they contain hierarchical habitats, but only represent known clusters of utilization. The representativeness of these FAs is unknown, though likely not representative of the river as a whole, even the Middle River where the majority of work was conducted.

Proposed Methods

The RSP describes field data collection for site-specific HSC development based on a stratified random sampling approach using the Project's hierarchical classification system and other non-descript attributes. Data collection methods include biotelemetry, foot surveys, snorkeling, and seining. In addition, two other methods, DIDSON sonar and electrofishing, were evaluated for their effectiveness in detecting habitat use in turbid water conditions. Selected methods would vary based on habitat characteristics, season, and species/life history of interest.

AEA stated that they would generate preference curves (HSC/HSI) from site specific data for mean velocity, depth, and substrate type for each species, normalize the data and compare results to literature and 1980's curves. Empirical observations of fish habitat use were proposed to be used to develop preference curves. For species life stages that did not meet the sample size (n=100), **bootstrapping** would be used to develop curves. To complete the analysis, a group of individual observations (e.g., depth, velocity measurement for a particular species and life stage) will be resampled with replacement up to the number of the original data set.

AEA proposed that they would develop separate, habitat specific, curves based on stream-specific data (i.e., geomorphic reach, mainstem macrohabitat type, clear vs. turbid water, and upwelling areas) with winter versus summer sampling efforts. This would result in four or five separate sets of HSC curves generated for some species and life stages.

Implemented methods

HSC and HSI Development Data Collection 2013-2014. AEA performed an investigation of abundance-microhabitat relationships *(Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables TM*, 2014*)*. This investigation was apparently done out of context of the Project HSC study efforts, and completed as a requirement of the FERC determination to assess the relevance of the 11 other microhabitat variables of interest to the agencies. Comments on HSC investigations will follow under Objective 4.

In 2013, a total of 68 "randomly" selected HSC/HSI sites (50- and 100-meter sampling sites) were sampled within the Middle River FAs to assess habitat use by spawning and freshwater 'rearing' (juvenile resident and anadromous fish) or 'holding' (adult resident fish) life stages of target fish species. In 2014, an additional 72 sites were selected and sampled. The selection process was guided by land access restrictions such that targeted sampling sites were identified based on professional judgment within "randomly" selected macrohabitat units. This resulted in selection of 129 individual habitat segments representing 10 different habitat types within the 7 Middle River FAs: (FA-104 (Whiskers Slough), FA-113 (Oxbow 10), FA-115 (Slough 6A), FA-128 (Slough 8A), FA-138 (Gold Creek), FA-141 (Indian River) and FA-144 (Slough 21) (Table 4.5-4). The distribution of sampling sites between FAs was generally equal with an average of 10 sampling reaches selected within each. Additional sampling sites were added from areas outside of the FAs to ensure that highly utilized fish habitats (known spawning locations or areas identified by other study teams) were included in the sampling. The intent of the selected sites was to capture the greatest diversity of microhabitat. Gear-types used to document fish use included foot surveys, underwater snorkeling, single-pass backpack electrofishing, pole/beach seining; and backpack electrofishing with a mobile downstream blocking seine.

Groundwater
Vertical hydraulic gradient (VHG) measurements were recorded at a minimum of three locations (downstream most, center, and upstream most) within the length of each sampling site within FAs. There were multiple sampling units within an FA representing different macrohabitats. The VHG device was tested early during the survey period and found to be useful in detecting positive (upwelling) hydraulic gradients. AEA reported that the VHG device used was not sensitive enough to distinguish between neutral and negative (downwelling) hydraulic gradients.

Winter sampling (2012-2013)
In response to FERC's request for a winter sampling evaluation, AEA provided the *2012–2013 Instream Flow Winter Pilot Studies* (Part C, Appendix L) results including proposed methods and sites for the *2013–2014 Instream Flow Winter studies* TM. (Review of *2013-2014 Instream Flow Winter Studies* TM is included later in this document.)

The *2012–2013 Instream Flow Winter Pilot Studies* (Part C, Appendix L) included five or six sites in slough and side-channel habitats of Whiskers Slough and Skull Creek. These sites were used to evaluate the feasibility and effectiveness of studying fish use and habitat conditions during the ice-cover period (Part C, Appendix L: *2012-2013 Instream Flow Winter Pilot Studies*). The purpose of the Pilot study was to evaluate the feasibility of different instruments, methods, and approaches for winter data collection to inform a more robust effort during the winter 2013-2014. The Pilot study was to provide preliminary data and information regarding intergravel temperature and water quality conditions; site-specific fish habitat use and behavior; and species richness and size class composition among sampled habitats. Winter 2013-2014 HSC sampling was expanded to open-water areas within FA-104 (Whiskers Slough), FA-128 (Slough 8A) and FA-138 (Gold Creek). A detailed description of results of the 2012-2014 winter studies surveys was provided in the SIR Study 8.5, Appendix A. No new information on winter sampling was provided in SIR Appendix D. Variances for Objective 4:

AEA states that methods described in the Habitat Suitability Criteria Development section of the FERC-approved Study Plan (SP) have been implemented, with some exceptions.

- AEA did not meet their determined sample size: AEA notes that they did not meet the minimum sample size of 100 to develop HSC for target species and life stages, and applied bootstrapping to collected samples to achieve the sample size. No statistics were provided for diagnosis of bootstrapping procedures, to determine if this technique would be appropriate.

- Omission of spawning redd measurement: Spawning redd dimensions were not collected as part of the 2013-201414 HSC spawning surveys. AEA decided that additional redd measurements were not necessary to develop evaluation metrics. Redd dimension measurements were recorded as part of the 2012 HSC surveys to support the spawning and incubation analysis. The SP states "Redd dimensions (length and width in feet to nearest 0.1 foot) will be collected."

- Non-representative substrate classification: Substrate composition was homogenized to include only two gravel size classes (small and large). FERC stated that two size classifications to describe gravel are consistent with substrate classifications used on other HSC/HSI curve development studies. The classification is not representative of the existing substrate. Not accounting for all of the available substrate types may obscure relationships of fish habitat preference. The result may be that the Project would not be able to identify a relationship between substrate composition and fish habitat preference because the substrate classifications used are too coarse. The SP states that "Substrate size (dominant, sub-dominant, and percent dominant) characterized in accordance with a Wentworth grain size scale modified to reflect English units" will be used.
- Truncated water measurement: water velocity criteria inappropriately truncate the range of depth measurements collected (both shallow and deep). And most fish captures occurred using electrofishing, seining or a combination of the two gear-types which did not allow for the identification of fish focal point position (e.g., nose-to-bed) within the water column. AEA stated that the IFS habitat models rely on *mean* water column velocities and therefore not measuring focal point velocity will have no adverse impacts on HSC/HSI development or on habitat modeling. However, fish nose-to-bed position within the water column is an indicator of water depth preference for a species and/or life stage. Particularly for those species known to hold hierarchical positions within the water column based on size (age-class), such as Grayling. For preferred nose velocities of target species, it may be necessary to measure higher velocities to produce high nose velocities unsuitable for the target species (Martinez-Capel et al. 2008). It is particularly useful when 3D modeling cannot be afforded. The ISR does not describe Project intentions to calculate nose-to-bed for use in the WUA. The SP states that a Price AA current meter will be used to measure the "Location in the water column (distance from the bottom), fish focal point within the water and mean column velocity (fps to nearest 0.05 fps)". Mean water velocities are too coarse a measurement and should not be used.
  Surface and groundwater exchange fluxes: Exchange fluxes were not measured or reported, only VHG. Flux is the product of substrate permeability and VHG. There is no reporting of permeability.
- Error estimates: Mesohabitat type was not collected concurrent with fish observational and FDA (9.5, 9.6) data. Instead, mesohabitat mapping was completed as a desktop exercise as part of RSP Characterization and Mapping of Aquatic Habitats (9.9) study. After the mesohabitat mapping is complete, GIS data layers of observed HSC/HSI fish-use will be compared to GIS data layers containing mesohabitat types. Mesohabitat use by individual fish species and life stages will then be assessed. AEA states that the variance of using a GIS mapping exercise to determine mesohabitat classifications with observed fish-use will not adversely impact the ability to meet Project objectives. However, there is error related to both the accuracy of mesohabitat classification assignment and observed fish-habitat associations using unparalleled approaches. In addition, there are errors associated with (1) mesohabitat classifications provided as part of the FDA study completed by numerous field technicians without consideration of "reader error"; (2) mesohabitat's flow variation; and (3) model changes in mesohabitat

under variable Project operational scenarios. These error measurements have not yet been considered.

- Lack of co-located HSC/HSI sample sites: Sampling efforts did not meet those described in the SP. The SP states that River Productivity (9.9) macroinvertebrate "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. River Productivity sampling occurred at five stations on the Susitna River, each station with three to five sites (establishing sites at all macrohabitat types present within the station), for a total of 20 sites. Four stations were located in FAs (FA-184 [Watana Dam], FA-173 [Stephen lake Complex], FA-141 [Indian River], and FA-104 [Whiskers Slough]). Station RP-81 is located in the vicinity of the mouth of Montana Creek. The SP states that the reduction in macroinvertebrate sampling sites will not adversely impact achieving Project objectives because of the greater sample coverage per site. However, only two macroinvertebrate sampling locations are co-located with Middle River juvenile salmon distribution; thereby limiting invertebrate density input data into fish habitat models.
- Conformance with Objective 4: The FERC determination requested AEA to evaluate which of the recognized microhabitat criteria were relevant to fish habitat selection, and develop HSC models for these criteria. AEA did not do this with the level of sufficient statistical rigor. AEA used univariate HSC curve exploration to identify what criteria would be used in their multivariate HSC models (see discussion below). There are fundamental questions regarding AEA's HSC investigations that prevent the USFWS from recommending a reorganized analysis of AEA's existing data.

AEA did commission a separate analysis to investigate relationships between abundance and microhabitat parameters, based on FERC's determination to identify criteria worthy of examination and consideration for HSC modeling. This investigation was summarized within the 2014 TM[2]. Within the 2014 TM, AEA stated that "*the HSC Study is more relevant for studying fish habitat preference than other data collection efforts. Because it is clear from the FERC recommendation that FERC agrees with this characterization, habitat data collected as part of the HSC study will be considered primary*." They went on to say, "*the overall objective of the analysis was to provide a comparison of fish abundance measures with additional microhabitat variables where sampling efforts overlap spatially and temporally*." This approach did not allow for meaningful comparisons. In fact, AEA stated "*there are no surface flow and groundwater exchange flux data available and so no analysis of this variable has been completed*."

This opportunistic approach proved to spatially and temporally irrelevant and non-scientific. First, habitat measurements need to be taken only when fish are spawning or rearing, not in other periods of time when local microhabitat is irrelevant to occupancy. It is not clear whether microhabitat criteria surveys were conducted when, after, or before surveyed locations were occupied. Next, these measurements need to be taken within and outside the distribution of spawning and rearing (e.g., unoccupied/unused locations). Using transect locations within the distribution of fish to represent unused habitats prevented AEA from considering availability of habitat, outside the distribution of fish. This would not allow AEA to assess biological relevance, which would require comparison of the statistical distribution of microhabitats within and outside the spatial distributions of fish. And because habitat is hierarchical, this effort also had to be stratified by meso and macrohabitats on the longitudinal distribution of the floodplain. AEA's sampling design did not meet these criteria. Instead, it appears that AEA modeled the variability of surface hydraulics, over time (instead of space), and also at the expense of forfeiting any comparison of river and groundwater exchange, at any scale.

There was also a mismatched agenda and scales in which abundance and microhabitat data were surveyed. There were no adult salmon abundance data, microhabitat data were not integral to the collection of the abundance data, and groundwater data were incomparable, according to AEA. If the microhabitat data were not relevant to the abundance data, the influence of VHG could not be considered, and if adult data were not available, then the 2014 investigation of abundance-microhabitat relationships was irrelevant to the overall effort. AEA stated that their HSC study was more appropriate for the sole purpose of identifying relevant habitat criteria.

[2] Susitna-Watana Hydroelectric Project (FERC No. 14241), Fish and Aquatics Instream Flow Study, September 2014. Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables, Technical Memorandum. Prepared by R2 Resource Consultants, Inc.

The HSC Study: Distribution of Habitat and Fish

AEA's HSC habitat utilization surveys were not based on stratified-random sampling, structured by the Projects hierarchical habitat model, as proposed. Surveys were focused within "clusters" of known spawning. Surveys were to be systematic with regard to the Project's hierarchical habitat model. AEA's surveys were reported to be "random", but the incorporation of "randomness" into AEA's survey design is questionable. AEA noted that surveys focused on "clusters" of known spawning. If randomness was incorporated within these clusters, it is not mentionable. It is not probable that surveys could have been random, given that measurements of microhabitat were made directly in association with occupied sites. Within clusters, surveys were to be stratified according to the Project's hierarchical habitat model and the distribution of fish, in order to control for the influences of habitat and be discerning about ecological relevance of microhabitats under investigation.

The influence of microhabitat (e.g. surface-water hydraulics, river and groundwater exchange [as measured by VHG], and water quality) is uniquely manifested in the context of meso and macro habitats. For example, turbidity, local river and groundwater exchange, and cover condition the role of surface-water hydraulics in habitat selection. The influence of macrohabitat, in the form of channel complexity and regional ground and river water exchange influence local population segregation through spatial segregation of spawning tactics (see Leman 1993; Mouw et al. 2014). AEA did not stratify their surveys of microhabitat criteria in regard to the hierarchy of macro or mesohabitat present on the Susitna River. Since biological relevance of flow hydraulics, VHG, substrate, and other criteria differ amongst the various habitats of the floodplain hierarchy, AEA's ability to draw valid conclusions about flow-habitat relationships is at best, severely limited. If AEA was unable to characterize the habitat context in which HSC were surveyed, the entire effort is significantly weakened.

Microhabitat surveys were not structured with regard to the distribution of fish, which is almost always contagious, or highly clumped in space. The most effective way to survey and assess microhabitat relevance to habitat selection is by also structuring surveys with regard to the distribution of fish. This is conceptually basic to ecological study and provided the rationale behind resource agencies requests for assessment of habitat availability. If habitat is not clearly surveyed within and outside the distributions of fish, on the river's longitudinal dimension, it is not possible to be discerning of ecological relevance. Random surveys of "available" habitat, at the same longitudinal floodplain position meant that AEA could not control for VHG, and therefore could not address whether the statistical distributions of microhabitat criteria differed outside the distribution of fish, or not. This means that AEA cannot make any valid conclusions about the influence of flow hydraulics and holistic conclusions about the influences of substrate and cover.

Overall, the questions directing the HSC study were where and why fish select habitat. The survey design adopted by AEA only allowed a characterization of microhabitat utilization where fish were most common, in terms of spatial coordinates and microhabitat associations. We essentially have been presented with the distributions of microhabitat utilization, within "clusters" of utilization, with no means of sorting through which associations are relevant. The "why" question, why do fish utilize the habitats they do, has not been addressed by AEA. Unless relevant habitat criteria are isolated, environmental Project-effects cannot be assessed.

Strategic surveys are required to isolate ecological relevance. AEA's surveys were not strategic. Surveys must account for the distribution of fish and habitat, in order to be strategic.

Regarding the distribution of fish, surveys of microhabitat within and outside the distribution of spawning or rearing are needed to identify ecologically relevant criteria. This must be done on the longitudinal floodplain dimension, not the lateral dimension, as conducted by AEA. Regarding the distribution of habitat, surveys stratified by macro and mesohabitat are needed to strategically assess relevance in a valid (statistical, ecological, evolutionary) context. This stratification should have been performed on both the lateral (main-channel to upland) and longitudinal (riffle-pool sequence) dimensions.

Example→ side slough[3] spawning (Chum Salmon):

Utilized side sloughs need to be stratified by mesohabitat. The distributions of microhabitat associated with spawning on side slough riffles must be compared to the distribution of microhabitats associated with unoccupied side slough riffles, up or downstream of the utilized riffle. This would follow for all other mesohabitats, in both the context of surveys and analyses of microhabitat relevance.

AEA's comparison of the distributions of microhabitat with random side slough transects (sampled for the purpose of assessing availability [unoccupied] habitat) missed the objective in every respect. First, transects were uniformly located within the distributions of spawning. This prevented the question of 'why' (which criteria are ecologically relevant, or why are Chum Salmon spawning where they do) to be addressed. It also prevented the assessment of VHG (which would have been uniform, in a regional sense), notable in its own right.

Indiscriminant AEA surveys of side sloughs also prevented comparisons to be made with respect to the distribution of mesohabitat. Because microhabitat utilization differs among mesohabitats, comparisons were not valid and cannot be used to sort through the various microhabitats (criteria) for assessment of ecological relevance. Isolation of ecological relevance also required surveys that control for the influences associated with mesohabitat. Comparison of the distributions of utilized microhabitat on side slough riffles, with the "availability" of microhabitat in other mesohabitat types, was invalid in a statistical, ecological, and evolutionary sense. Spawning in association with riffles is confounded by surface hydraulics and flow advection (localized downwelling). Unless surveys and analyses were stratified by macro and mesohabitat, these confounding influences could not be assessed.

[3] Please note that side slough macrohabitats are simply used here as an example. The discussion that follows is valid for all macrohabitats.

AEA's analysis was further diluted by the pooling of all microhabitat data, regardless of the macro or mesohabitat context. Pooling removed the ability to make valid comparisons. The distribution of velocity, for example, will differ between main channel and slough locations, where the literature demonstrates velocity to be irrelevant. It is also widely known that spawning tactics (microhabitat associations) and periodicity differ amongst macrohabitats.

Conclusion: Unstructured surveys prevented valid comparisons. Pooling data, regardless of meso- or macrohabitat, prevented the possibility of performing comparisons where surveys may have inadvertently resulted in potential validity.

Groundwater

FERC determined that VHG should be assessed in the context of the HSC study. FERC also determined that surface and groundwater exchange fluxes, which incorporate permeability, should be evaluated. AEA measured VHG, in a very limited context, but did not measure flux. Most importantly, surveys of habitat utilization and availability were not structured with regard to the exchange of river and groundwater, at any level. Technically, this is an expansion of the general concern regarding the distribution of habitat, but since river and ground water exchange is known to be a (the) primary driver of habitat selection (particularly in Alaska) this specific concern is separately addressed. VHG is typically viewed as a binary variable, though the gradient is continuous. As such, it should typically serve as the primary basis for structuring studies of the distribution of fish and continuous microhabitat variables. AEA did not do consider VHG as a primary driver, and therefore were unable to isolate and sort out the relative relevance of flow hydraulics and other microhabitat criteria.

AEA demonstrated a misunderstanding of how river and groundwater exchanges operate in floodplains. At the most local scale, bedform topography interacts with flowing water to induce localized circulation of river water through the bed of the river, regardless of the regional vertical hydraulic gradient (VHG). This can be assessed by installing minipiezometers, in association bedforms where spawning occurs. At intermediate spatial scales, channel complexity drives the exchange of river water through bars, driving localized upwelling and downwelling in isolated reaches of primary and secondary river channels, also independent on the regional VHG. Installation of piezometers along the longitudinal dimension of the secondary channel network would have revealed any localized reaches of upwelling. At the regional scale, constrictions in the fluvial aquifer drive upwelling throughout the channel network, but most importantly in the main channel. This can be assessed, simply, by installing minipiezometers on the shoreline of the main channel. The prevalence of downwelling in the main channel will not prevent upwelling in the secondary channel network; quite the opposite is typically found.

AEA apparently did survey the "availability" of upwelling and downwelling (VHG), but it was not measured in association with utilization. VHG, therefore, was not assessed at the local level. AEA measurement of VHG was also limited to 3 shoreline measurements at each survey unit. There is no evidence that AEA considered VGH, laterally, within the channel matrix of their survey units. Because AEA did not approach their assessment of VHG hierarchically, there is no way to assess the influence of VHG, with respect to utilization. Salmonids with differing spawning periodicity have been observed spawning in association within different ground and surface water configurations. Fall populations typically spawn in association with localized downwelling, in regions of upwelling (Baxter and Hauer, 1999; Alaska Department of Fish and Game, 2005). Summer populations typically spawn in association with regional downwelling and localized upwelling in regions of downwelling (Leman 1993, Mouw et al. 2014). These different spawning tactics are manifested in the context of very different macro, meso, and microhabitat associations. AEA's study design prevented their ability to assess the relative roles of hierarchical exchanges in ground and surface water in structuring the distribution of spawning and rearing. As with the other habitat criteria, VGH was also not assessed in the context of the Project's hierarchical habitat model.

Assessment of river and groundwater exchange is critical because it drives population diversification and differences in spawning periodicity. Populations spawning in summer often exhibit two main spawning tactics that differ from that of species spawning in fall. Summer populations are known to spawn in association with downwelling in the main channel and localized upwelling in the secondary channel network. Fall spawning strategies often select regional upwelling. The differences in water quality between localized and regional upwelling water are dramatic.

AEA's failure to account for the hierarchical nature of ground and surface water exchange prevented them from assessing the biological relevance of the statistical distributions of any other microhabitat variable. Had they not been requested by FERC and resource agencies to perform studies with regard to VHG, such an oversight would have a less tangible recourse. Given the fact that FERC recommended AEA consider VHG in the context of a hierarchical habitat model, as requested by resource agencies, AEA's misunderstanding is now more problematic for the performance of realistic environmental assessment.

Limited Habitat Utilization Criteria

Accurately capturing habitat variables that influence fish habitat selection is more important than developing the "best fit" from variables that may not be ecologically relevant. AEA showed no evidence of having performed a statistical analysis of ecological relevance for any criterion investigated. This is a non-scientific approach. Utilization curves demonstrate associations with statistical distributions of microhabitats. They are not informative of the ecological relevance without comparison of the statistical distributions of the same microhabitats outside the distributions of species and life stages under investigation. Statistical comparisons are a basic step of ecological investigation.

AEA did construct univariate models for certain microhabitats, but offered no way for reviewers to examine relevance of these to fish habitat selection. There is also no way of knowing whether or not any of the other habitat criteria were equally important, or not. AEA reported AIC values for each of the univariate models, but this tells reviewers nothing of the absolute significance of each microhabitat, only the relative significance of each model. As reviewers, the Service has no way of knowing if the models were equally good or poor. Valid surveys, based on valid habitat delineations, were needed, but these were not performed. Data from these surveys would have to also been analyzed in the way, in accordance with the Project's hierarchical habitat model, but this also was not performed.

AEA also stated some limitations and assumptions about the surveys of habitat criteria. Methods for collecting fish observational data and microhabitat variables metrics have limitations and assumptions that should be explicitly identified prior to integration into habitat-specific models. For example, the AEA stated that spawning chum salmon do not show a preference for groundwater upwelling in habitats in water depths greater than two feet. It is unclear if (1) spawning areas in surface water greater than 2-feet deep were assessed or (2) VHG was measured in water greater than 2-feet deep. There are no data provided to support the conclusion that depth precludes upwelling or redd site selection. AEA previously stated, "there is some possibility that this interaction is an artifact of the difficulty in sampling VHG in deeper water. This issue will be investigated further prior to the Updated Study Report." AEA still has not performed these additional investigations. Instead, examination of VHG is left out of the results. AEA's univariate analysis of microhabitat criteria is incomplete and unscientific in what was completed.

Other limitations of the HSC/HSI criteria univariate modeling include the following:

- Results presented for chum salmon spawning were limited to clearwater habitats (NTU<30). It is not clear how the Project is accounting for turbidity and whether or not AEA considered chum salmon spawning in turbid habitats where it is known to exist.
- Turbidity was determined to be a strong predictor of Coho Salmon fry habitat preference with limited fry data from turbid environments. It is not clear how this "preference" was identified, in the absence of any statistical analysis, and how the relationship between HSC and turbidity was determined.
- VHG, temperature, DO, specific conductivity and turbidity were measured in only three locations per 50m reach length within FAs. AEA states, "during field sampling, some utilization locations that were near existing water quality measurements were not uniquely sampled." At locations where these measures were not taken it was assumed that the nearest value (on same transect) would be representative, or a linear extrapolation between measures would be representative. By assuming three measurements per 50 m reach length is adequate for each variable they also assume that those measures at meso- and microhabitat levels are homogenous on a 50m scale. This may not be a valid assumption for some variables (e.g., DO, temperature, specific conductivity), and one that should be tested prior to reducing sampling efforts.
- VHG was not considered locally, in association with spawning, nor was it considered hierarchically.
- Within FAs VHG is assumed to be either (1) upwelling or (2) 'no-upwelling' which could be negative or neutral. The Project Proponent reported that less than 6% of locations sampled had negative (downwelling) VHG. Surface-groundwater exchange is pronounced and highly variable in the Susitna River making it very questionable that only 6% of FAs are reported to be downwelling. This strongly suggests that the surveyed locations were not representative of utilized habitats and certainly not the habitat

available to salmon. Downwelling is also important to macroinvertebrate productivity and species life history stages.

- Water temperature was not found to be important for chum salmon spawning site selection, but given the fact that all data were pooled, regardless of macrohabitat, this is not surprising AEA needed to consider the role of temperature in accordance with their hierarchical habitat model. Water temperature also needed to be evaluated more robustly and under alternate operational scenarios.
- DO and specific conductivity was determined to have no influence on chum salmon spawning site selection. Given the fact that all data were pooled, regardless of macrohabitat, this is not surprising. AEA needs to consider the role of DO and specific conductivity in accordance with their hierarchical habitat model.
- Criteria were not evaluated on the basis of macrohabitat, according to the RSP.
- Criteria were not evaluated with the target sample sizes specified in the FERC determination.

The Project used the results of the univariate model to select input variables to the multivariate model. The ISR states that, “Based on the univariate model results, only depth, velocity, substrate, and upwelling would be included in the multivariate model.” We request that this determination be re-evaluated. AEA’s use of univariate habitat associations to identify which criteria to use in their multivariate models is unscientific. As previously stated (and see below in the review of Statistical Analyses), univariate utilization functions cannot be used demonstrate ecological relevance. This means that the multivariate modeling exercise was incomplete before it was started.

Multivariate Model (of Fish Habitat Suitability)
Proposed Project operational scenarios will result in conditions that are outside those of the natural system. The ISR states, “Note that these models are *not* displayed beyond the conditions under which spawning was observed (spawning observed at depths between 0.20 - 3.3 feet and velocities up to 2.2 ft/sec). Suitability criteria beyond these conditions have not yet been determined and cannot be determined using statistical methods”. The preliminary multivariate model for chum salmon, for example, does not represent conditions beyond the observed conditions (0.20 – 3.3 feet and velocities up to 2.2 ft/s). The coho salmon fry (ISR Appendix M, pages 9-12) initial curve development is limited by data collection restricted to the open water period, at depths less than 3 feet, with lower turbidity levels.

Curve development should be based on conditions beyond those observed in the natural system. For example, tails of the graph representing the curves should go to zero value at either end. Models must include values that are outside of baseline conditions in order to have predictive capabilities for anticipated Project effects.

Additionally, the model substrate inputs are limited to cobble or gravel-dominated substrate and do not consider the full spectrum of substrate heterogeneity. Therefore, not only does the model not include conditions beyond those observed, it does not include all conditions that were observable.

Macrohabitat Specific Criteria (post-Project conditions)

The ISR discussion of multivariate models points out that all macrohabitats exhibited variability. Based on the discussion, macrohabitat type within the HSC modeling efforts have not been considered and should be included. AEA stated, "Macrohabitat type has not been included [in HSC modeling], although differences in habitat preference among macrohabitat types are possible" (AEA 2014 Appendix M). AEA considered it prohibitive to account for macrohabitats within the realm of HSC modeling because replication of observations at each habitat type is needed for this purpose. They also state that the model assumes that post-Project macrohabitat relationships would be static and use this limitation as rationale against the development of macrohabitat specific criteria. This same rationale is applied related to other HSC variables, such as temperature and turbidity, representing the observations under the pre-Project conditions, but not the range of post-Project conditions. Unless AEA examines the relevance of microhabitat criteria on the basis of their hierarchical habitat model, it will be impossible to evaluate flow-habitat relationships for this project. Even in the 1980's there were separate curve sets developed for main and offchannel sites, given the extreme differences in habitat and patterns in habitat utilization among these extremely different sets of habitats.

The following are identified limitations on the HSC/HSI criteria multivariate model inputs that should be addressed to advance conformance with Objective 4:

- Water depth- initial results show that a 1.5 foot depth is the preferred depth among Coho Salmon fry. There is no analysis or discussion of data collection efforts and therefore we do not know if measurements were taken at depths beyond the 1.5 foot depth. And if so, where or to what extent the sampling effort was applied.
- Velocity- The ISR reports that velocity has a relatively low influence on habitat utilization, especially when cover is present, yet velocity is used in many models without reporting its significance, whatsoever.
- Turbidity- an inverse relationship between fish habitat preference and turbidity is indicated. The ISR also noted that habitat cover is less important in turbid waters. Cover and turbidity were combined into a 3-level cover factor consisting of (1) no cover in turbid water (lowest preference); (2) cover in clear water (highest preference); and the combined category of (3) cover in turbid water or no cover in clear water (moderate preference).
- Groundwater downwelling- The Service requested that downwelling be included in the assessment of microhabitat variables for HSC development. The Project combined downwelling with neutral gradient masking any potential relationship to fish habitat preference related to downwelling. Given the importance of surface water-ground water exchange to salmon, this approach does not provide sufficient resolution, especially when neutral gradients are avoided by spawning salmon (Leman 1993; Mull et al. 2007). Surface water temperature – A strong relationship between decreased habitat use and increasing water temperature was observed. The ISR states however, that based on the observed range of water temperatures AEA was not convinced of the importance of temperature and may exclude water temperature from future modeling efforts. This is unscientific. The data ought to dictate what is or is not significant to habitat selection.

Data collection efforts were also limited due to small sample sizes; and the analysis combines all species, life stages, and macrohabitat samples for comparison. This is also unscientific. Stakeholders went to great length with AEA to develop a relevant hierarchical habitat model and species periodicity tables to account for the great variability in habitat and periodicity of utilization on the Susitna River. AEA must survey and analyze data accordingly, not pool all data together. This is not scientifically defensible.

- DO –An inverse relationship between DO and juvenile coho salmon presence was indicated with Project data. AEA stated that this relationship didn't make ecological sense, but we suggest that this relationship is biologically valid. coho salmon fry may utilize low DO habitats to avoid competition and predation from species that are less tolerant to those conditions (e.g. Chinook salmon, rainbow trout, Dolly varden). This relationship should be tested during winter as well.
- Specific conductivity—no relationship between habitat utilization and specific water conductivity was identified. As with all other microhabitat criteria, no diagnostics were reported to support the exclusion of this variable.

Winter Sampling

The ISR presents findings from the 2012-2013 Instream Flow Winter Pilot Studies (Pilot) (Part C- Appendix L). The Pilot sought to test the proposed approach for monitoring water quality and water stage conditions at salmon spawning locations and recording fish habitat use. More specifically, the study objective was to develop winter criteria by species-lifestage and macrohabitat. A review of 2012-2013 Instream Flow Winter Pilot Studies (Part C- Appendix L is provided in Appendix 1. The 2012-2013 Pilot was a pre-cursor to the 2013-2014 Instream Flow Winter Studies. No new information was presented on the examination of winter criteria or development of winter HSC in ISR Part D, Appendix D. Separate HSC are not proposed by AEA for winter, instead the same curves are proposed for all seasons and all habitats.

2013-2014 Instream Flow Winter Studies TM

The *2013-2014 Instream Flow Winter Studies* TM was released September 17, 2014. The overall objective of the winter study was to evaluate potential relationships between mainstem Susitna River stage and the quality and quantity of winter aquatic habitats that support embryonic, juvenile, and adult life stages of fish species. For the most part, existing conditions are described, but the TM lacks a description of post-Project conditions under proposed operational scenarios. The study background indicates that winter streamflow is fed primarily by groundwater and consequently discharge is stable. This is true for the current winter conditions however, post-Project conditions will be drastically altered due to the increased winter flows and intra-daily pulse-flow fluctuations. Post-Project conditions need to be studied. For example, HSC/HSI curves for fish species have not been developed to describe the response of fish to relatively short-term flow fluctuations (i.e., ramping), especially during winter conditions.

The FAs were selected for the 2013-2014 ISF winter study because they contain a diversity of habitat types with groundwater influence. The Service requested that habitats used by fish, as well as habitats not used by fish be studied for purposes of developing HSC/HSI criteria.

Therefore, selected winter study sites should include both used and unused sites. To assess whether groundwater is influential to fish habitat site selection we need to understand whether or not fish are using winter habitats that both do and do not have groundwater influence. This cannot be determined without studying sites with groundwater influence and those without groundwater influence.

Breaching flows
AEA suggested that higher flows in the winter time will mean that habitat areas that are normally dewatered and/or disconnected from the main channel may either remain continuously wetted by Susitna River flow (if wetted during lower load following range) or be periodically wetted if within the active range of load following. It will also mean that lateral habitats (side channels and side sloughs) that under existing conditions are fed mostly by clear, stable and comparatively warm groundwater flow would be subjected to daily/hourly flow increases from the much colder Susitna River. The frequency and magnitude of these flows into these habitats would depend on the specific breaching conditions of each habitat feature. The breaching conditions are exactly what we are trying to assess under post-Project conditions and it is not clear at this point if we can actually model/predict the results. Open-water and under ice 2D hydraulic models are not yet fully developed. Higher Susitna River discharge during winter may increase the frequency and magnitude that side channel and side sloughs are breached by cold main channel streamflow, and higher stage may alter the extent of groundwater upwelling in side channel and off-channel areas. In addition, the daily fluctuation in Susitna River flow could affect conditions in areas of salmon egg incubation in terms of stage changes that may result in periodic redd dewatering as well as changes in temperature (i.e., prolonged egg incubation, potential freezing during dewatered periods). These observations are for current conditions. *Post*-Project conditions need to be considered.

The TM states that effects of Project operations on salmon spawning areas, such as redd dewatering, freezing, channel inlet breaching, scour and intergravel water quality (temperature and DO) will be evaluated as part of the “effective spawning” area analysis. There is no timeline provided for the completion of this evaluation.

The TM states that main channel Susitna River intergravel water temperatures appear to be strongly influenced by surface water at continuous monitoring sites with temperatures remaining near 0 degrees for much of the measurement period. Among continuous monitoring sites in side slough and upland slough habitats, intergravel temperatures were typically warm relative to main channel conditions (2-4 degrees C), which may represent strong influence of groundwater in these habitats. Currently there is no way to model how these conditions and relationships will change under post-Project operations.

The variation in intergravel temperature response to main channel breaching of Slough 11 between sites 138-SL 11-04, 138-SL 11-06 and 138-SL 11-2 may be an indication of the localized influence of groundwater and/or that multiple sources of groundwater may be present within a given habitat. This is a key implication for groundwater studies and model validation.

The ISR notes that temperature measurements within groundwater wells were warmer and conductivity values intermediate to other mainstem sites. Exceptions to this general trend were at side channel Site 104-SL3B-10, which exhibited specific conductance and water temperatures unlike other side channel sites, and side slough Site 104-CFSL-10 where specific conductance was more similar to mainstem habitats than other side slough habitats (Figure 12). We recommend further study to assess why this Site may not be following the trends found at other sites.

Salmonid Egg Incubation and Winter Survival

The percent winter mortality due to the dewatering of eggs in redds within the Susitna River would likely vary widely depending on the strength of groundwater influence at the different redd locations. The Susitna River studies conducted in the 1980's indicate that groundwater upwelling was the principal factor affecting salmon egg development and survival in the Middle Susitna River. This highlights the importance of understanding groundwater processes and being able to predict post-Project effects on those processes in the Middle River. This also highlights the importance of groundwater and breaching flows which will be greatly affected by the post-Project increases in winter flow conditions under hydro-peaking fluctuations.

Stranding and Trapping

Emergent salmon fry are sensitive to environmental conditions, including fluctuations in river stage. Rapid recession of river stage can result in fry stranded on the bed substrate. Previous studies of salmon stranding occurrence relative to stage fluctuations determined that stranding was size selective among salmon fry and that individuals less than approximately 50 mm in length were particularly susceptible (Bauersfeld 1977, Bauersfeld 1978, R.W. Beck and Associates 1989, Olsen 1990). The study has not yet addressed stranding and trapping and the importance of being able to model rapid and perpetual flow fluctuations in side channels and side sloughs under Project-proposed winter flow fluctuations.

Winter habitat conditions for juvenile and adult fish

Winter habitats are often used repeatedly from year to year by fish species, which may indicate that stable environments are critical during the winter period (Reynolds 1997). The need to provide spatial and temporal habitat persistence for holding/over wintering for all species has not yet been addressed.

Because of the study objective variances and limitations and because of a failure to address post-Project conditions related to Objective 4, we find that the current effort is not in conformance with the intent of Objective 4. We are concerned that habitat variables have not been adequately assessed to determine their importance to fish. The purpose of the *Evaluation of Relationships between Fish Abundance and Specific Microhabitat* Variables TM (September 17, 2014) was to address Objective 4 in further detail, however our review of the methodologies and statistical analysis presented in the TM concludes that AEA has not sufficiently abated resource agencies concerns or met FERC's SPD.

The Services' (USFWS and NMFS) made requests to meet with AEA's consultants to discuss HSC/HSI study design and analyses. Several requests to specifically discuss HSC for this project were scheduled and canceled, or denied. In September 2014 the Services requested a 2-day face-to face meeting with the consultants to discuss HSC development. The Service provided an agenda to help frame the discussion necessary to move forward with HSC development. AEA postponed scheduling this meeting until after the scheduled January 2015 ISR meetings (which were then also postponed). The Services then requested a two-hour teleconference with consultants for December 23, 2014 to discuss methods and analyses reported in the *Evaluation of Relationships between Fish Abundance and Microhabitat Variables* TM (September 17, 2014). AEA canceled the December 23 meeting as a result of the Governor's Administrative Order (issued December 19, 2014) halting all spending on the Susitna Project. After the recent ISR meetings, held in March, 2016, AEA requested a meeting with the Services to discuss the HSC study, due to the long list of questions remaining. AEA also cancelled this meeting. Continuing concerns include (1) the limited microhabitat variables being assessed by the Project, (2) the unscientific nature of microhabitat criteria selection, (3) the scale at which microhabitat criteria are being assessed, (4) the ability of the Project to model the variables pre- and post-Project, and (5) the ability to integrate the relevant variables into synthetic evaluation of alternatives and DSS. We recommend no further work be conducted until a new study is developed to address these concerns.

Because of incomplete sampling across focus areas and inconsistent sampling efforts within individual focus areas, additional studies are needed to better understand current fish populations and habitat requirements for over-wintering fish stocks including any groundwater influence winter habitat areas under current conditions in the Susitna river watershed. In addition, modeling efforts to quantify and describe current water quality conditions, groundwater flow, and fish communities within the Susitna River watershed are not sufficiently described to assess the amount of uncertainty included in model outputs.

<u>Recommendations, modifications or new study request for future study:</u>

Recommendations

- Increase replicates of macrohabitat observations for winter studies to be consistent with resource agencies request during the study plan development. Specifically, resource agencies request that winter sampling for juvenile salmon occur at a minimum of six replicate tributary mouths, main channel or side channel backwaters, side sloughs, and upland slough habitats. This sampling effort should be used to create winter macrohabitat preference criteria and habitat models for site specific habitat variables.
- Increase the number of winter seasons of macrohabitat variable data collection used to assess fish habitat. FERC requested an evaluation of winter sampling, (page B-96) stating that, "There would be additional opportunities throughout ILP prefilling study implementation to evaluate the effectiveness of winter sampling methods and, if found to be effective, apply additional winter sampling efforts throughout the study area. These sampling efforts include the summary of results of the 2012–2013 ISF winter pilot studies and proposed methods and sites for the 2013–2014 winter studies in the fall of 2013 as proposed by AEA, and in response to information contained in the Initial and Updated Study Reports (sections 5.15(c)(2) and 5.15(c)(4))." We make our recommendation based on our review of these documents and our knowledge that Susitna

River winter habitats and ice conditions are highly variable within a winter and between winters.

- HSC/HSI curves should be developed for fish behavioral response to short-term flow fluctuations (i.e., ramping) under the proposed OS-1b/ILF-1.
- Conduct monthly winter sampling at all FAs to develop HSC for winter fish habitat use by species and life stages among Middle River macrohabitats. This recommendation is based on the review of the 2012-2013 Instream Flow Winter Pilot study.
- Verification of prediction curves (predicting fish distributions from which they were derived) and validation (predicting secondary data sets from FDA data and 1980's data) of prediction curves for aquatic habitat models as a result of fish or productivity sampling and model development under Objective 5.
- Minimum of two years of macrohabitat fish data needs to be completed as described in the FERC-approved study plan.
- Numerical measurement of groundwater upwelling, downwelling, neutrality in FA's for HSC and HSI should be collected to assess the importance of relative gradients. Small differences in gradient are relevant to fish at the micro- scale.
- Sample the full suite of microhabitat variables influential to fish habitat site selection through HSC/HSI sampling in FAs. In cases where microhabitat variable assessment was incomplete, the full suite of variables should be completed at HSC/HSI sampling locations.
- Thoroughly address the ability to model stranding and trapping under the rapid and perpetual flow fluctuations in side channels and side sloughs during proposed winter flows. The SP indicates that "field surveys will be conducted at potential stranding and trapping areas on an opportunistic basis following up to three flow reduction events during 2013." Opportunistic observations of potential stranding and trapping areas were recorded during substrate classification surveys conducted during falling river stage conditions in September 2013.
- Address the need to provide habitat persistence for holding (e.g., at river mouths) and over wintering fish species by developing thresholds for lateral and longitudinal geomorphic habitat change and connectivity and alterations to the hydrograph.
- Modify data collection where appropriate to meet FERC's requirement that model conditions must be able to be demonstrated for both pre- and post-Project in order to assess Project impacts (FERC regulation section 5.9(b)(5)).

<u>Macrohabitat study modification request</u>

Develop a SP for macrohabitat specific utilization models (HSC/HSI) for open and ice covered periods for fish species and life-stages. The new study should be designed to address resource agencies concerns about the assessment of relevant microhabitat variables and their influence on fish habitat site selection. This new study will address FERC's SPD statement of the need to develop "a detailed evaluation of the comparison of fish abundance measures (e.g., number of individuals by species and age class) with specific microhabitat variable measurements, to determine whether a relationship between a specific microhabitat variable and fish abundance is evident." FERC also stated that if there is evidence of strong relationships between the microhabitat variables and fish abundance for a target species and life stage then the sampling should be expanded in future study.

Statistical Analyses of Criteria and Development of HSC Models

There were two primary concerns with the HSC study, from a statistical perspective. One problem area is the description of methods and the description of the logic underpinning the study. Although the description of the methods is distributed over multiple reports covering hundreds of pages, the methods descriptions are still quite incomplete. We could not find one place with a clear, technically correct, and complete description of the methods for the habitat suitability curves. To meet the modern standards for scientific reporting, the reader needs to be able to find the following in one place within the document:

- A complete description of where each variable in the regression equation came from and full and complete statement of how it was calculated (in this case, this is especially true of the dependent variable, ln(p/(1-p)),
- A complete and technically correct description of the method used to estimate the parameters (e.g., ordinarily least squares vs. generalized linear model using likelihood, etc., and other information necessary to need to be able to repeat the analysis),
- Technically correct equations demonstrating the models (separate from reporting on model parameters), and
- Any other information necessary to understand the methods in sufficient detail to repeat the analysis.

The second problem area has to do with reporting the results, which were found to be incomplete and not consistent with the approved study plan. Fish and Aquatics Instream Flow Study (8.5), 2014-2015 Study Implementation Report, Appendix D reports on a large number of curves developed for the purposes habitat suitability estimation. Although this report contains a considerable body of information, it does not contain adequate information to review the quality of the estimated curves, to review the adequacy of the model fit to the data, nor to review the validity of the model for use in predicting flow-habitat relationships.

The equations, such as the examples found in Appendix D, seem to be the only presentation of the numerical results of the regression analysis, and this presentation is quite incomplete and insufficient. The accompanying statistical information centered on the Akaike information criterion, or AIC value (we agree that this is a very important quantity for review) and information on multicolinearity (which is also important). Important material to judge the statistical significance of the overall model (see Zuur et al. 2009, the reference AEA directed us to for a description of the use of mixed effects models, for a discussion of how to test for statistical significance of these models), the statistical significance of the model parameters, the overall quality of the model fit, and information on model validation was not provided. There was also no reported sampling error (e.g., confidence intervals or standard errors) for the individual parameter estimates. ***It is impossible to evaluate AEA's proposed HSC models without this basic information***.

What is known about model development is extremely concerning. In the analysis of their data, AEA combined their utilization data, regardless of the habitat context, and modeled the probability of utilization in the context of availability data collected in a different dimension and habitat context (random cross section locations). This method of data analysis can only operate on the assumption that associations with local microhabitat are spatially invariant. In other words, the association between utilization and any given microhabitat variable is assumed to be the same, regardless of the habitat context (e.g. main channel or side slough). Not only would this be counterintuitive, this assumption does not fare well when exposed to the scientific literature AEA has cited (e.g. Leman 1993; Mouw et al. 2014).

No basic descriptive statistics of the range or variability of parameter values was given, globally or on a macrohabitat basis. How did the ranges and variability of occupied parameter values differ amongst habitats? How did the ranges and variability of occupied parameter values differ from unoccupied parameter values, outside the distributions of fish? AEA's inability to answer these questions makes it impossible to evaluate their study, perhaps drawing the conclusion that the study is fatally flawed. In some cases, AEA may have the data to address these questions, but it is clear that some of these, most notably whether or not the statistical distributions of occupied microhabitat parameter values differed from those outside the spatial distributions of utilization, cannot be answered by AEA. AEA did not develop a survey design that would allow them to answer this question, apparently for any species or life stage.

In addition to the invalidity these comparisons, no basic exploratory data analyses were performed to isolate which habitat criteria were ecologically relevant and which were not. Instead, AEA used univariate HSC curve exploration to identify what criteria would be used in their multivariate HSC models. Of all the issues with AEA's data analysis, this is the most problematic. Indeed it *appears* fatal. Associations with criteria are only relevant to habitat selection if the statistical distributions of occupied microhabitat differed from that of unoccupied habitat, outside the local (spatial) distributions of species and life stages under investigation.

AEA's Use of Logistic Regression

AEA used logistic regression to model probabilities of utilization, based on incomparable data, with incomplete model diagnosis. The AIC criterion, the diagnostic AEA provided, is a measure of relative quality and cannot be used to distinguish whether or not a set of models is equally poor or good. AEA seemed to have used logistic regression to test hypotheses about the biological relevance of the various HSC and their role in structuring the distribution of fish spawning and rearing. But, their models primarily utilized surface water depth and velocity, because their use of hydraulic habitat modeling required this. There was no diagnosis of the models or the model parameters (e.g., microhabitat criteria).

The AIC can be valuable when assessing the relative quality of statistical models, once their quality is known. On its own, the AIC tells nothing of the quality of the model and cannot be used to test hypotheses set, a priori, or as a result of model execution. If all candidate models fit poorly, the AIC will not provide any evidence of that. AEA needed to demonstrate the absolute quality of their proposed models using more appropriate diagnostics. Were the models significant, did they fit, and what was the classification success? The AIC statistic does little to address these questions. It becomes more useful in assessing the relative quality of significant, good fitting models achieving high classification success. Once a subset of quality models has been selected, the AIC is a good way to achieve the best of the best and the most parsimonious (with the fewest parameters in the model) of models. Given the fact that many of AEA's models include upwards of 7 model parameters, 4 microhabitat variables, some 3 times, the reported AIC's provide little to no assistance in model evaluation.

In the bigger picture of things, AEA would have benefitted from a more appropriate and strategic use of logistic regression, or not at all. Conventionally, logistic regression is utilized to model the probability of a response (e.g. pass/fail) on the basis of some influential factor (https://en.wikipedia.org/wiki/Logistic_regression). Suppose we want to model the probability of passing a test (dependent variable that is known) as a function of studying or time spent studying (independent variable). According to logistic regression, standard practice would have us stratify and query students on the time they spent studying, visiting students who did and did not study. By surveying occupancy, using this example, AEA did the equivalent of surveying students who passed, failing to structure their study around the presence of studying, the time spent studying, and the probability of passing based on study time. AEA did the equivalent of surveyed passing students instead of the variable of studying time, problem #1, and they failed to perform a valid survey of those who didn't pass, problem #2. Using VHG as an example, AEA could have surveyed sites with a positive and negative VHG, in order to assess the role of VHG in structuring habitat selection. Instead, AEA went to occupied sites and surveyed VHG. Then, ***at the same VHG***, they surveyed unoccupied sites in a different dimension and within habitat types that were not comparable.

Arguably, AEA could also have surveyed VHG at occupied sites and then moved up or downstream to unoccupied locations within the same habitat stratum (e.g. a side slough riffle) and surveyed VHG there. With replication of such valid comparisons of like habitat (apples to apples) within and outside the distribution of fish, the role of VHG would either emerge into one of relevance, or not.

Regarding strategic use of logistic regression, AEA would have benefitted from its use for exploration within their data as a whole, not to model HSC with an arbitrary subset of microhabitat parameters, or those directly associated with a hydrodynamic model (depth and velocity). Logistic regression is probably a better tool for testing hypotheses about specific microhabitats than it is for generating them. For example, if the statistical distributions of flow velocity significantly differed within and outside the distributions of spawning and rearing (step 1), can logistic regression be used to successfully predict occupancy on the basis of flow velocity (step 2)? AEA skipped the necessary step of demonstrating ecological relevance, prior to modeling habitat relationships. Instead AEA reported that they used the univariate curve generation process to sort through the various microhabitats used in the multivariate process of curve generation.

It is also difficult to interpret the random effects and constants in AEA's modeling effort. The significance of the additional factors inserted into the modeling effort, to account for site selection and longitudinal effects, was not reported. The significance of these needed to be reported, compared, and evaluated in context with the other parameters in the model. For example, if the longitudinal component was ever of equal or greater significance than any microhabitat parameter, then ecological relevance becomes questionable.

AEA stated, "The candidate models included polynomial effects when non-linear relationships were reasonable ecological hypotheses." Had AEA's data collection design resulted in data that could be analyzed in the context of their hierarchical habitat model, ecological interpretation could have been reasonable. But AEA pooled all data from every habitat context that was surveyed, making ecological interpretation impossible.

AEA wound up with models predicting ranges of probabilities as low as 0 to 0.20. Clearly these ranges in probability bring the relevance of the models into question. Low predicted probabilities of utilization may or may not be reflective of model quality, depending upon sample sizes, but they raise questions about model effectiveness, when making predictions about future conditions resulting from the operation of the proposed project. The ranges in predicted probability did range in excess of 0.9, but this was only achieved at the expense of controlling for other variables. The necessity to control for other variables in the multivariate models is, on one hand, predictable, given AEA's pooling of data from all habitats. On the other hand, the necessity to control for certain habitat criteria brings the realism of the models into question. How useful would such a model be in the prediction of future conditions?

AEA's effort also resulted in models predicting the probability of use for sets of highly narrow conditions. For example, AEA's chum salmon curve predicts the probability of spawning for a given substratum and a fixed depth of 1.2. Their inability to predict spawning as a function of velocity, regardless of, or in some way combined with depth, is very telling. The ecological relevance of AEA's curves is highly questionable, yet this was predictable, given their study design. Had AEA controlled for VHG (lurking variables), and stratified their study and data analysis, based on their hierarchical habitat model, AEA would have been able to clearly demonstrate the relevance (or irrelevance) of the variables they explored. The necessity to build models at fixed conditions is likely a product of pooling data from a wide range of habitat types with a wide combined range of all microhabitat variables involved. This pooled set of conditions is being forced to represent variable patterns of utilization that are known to significantly vary amongst the various habitats and across all seasons, where utilization also differs. AEA appeared to present their HSC models as representative of all conditions and all seasons. **There were no separate curves for winter.** This does not make sense, ecologically.

It was very confusing why AEA combined all data from all seasons and habitat types. For example, surface-layer substratum sizes are typically far coarser in sloughs than they are in the main channel. Flow hydraulics and water quality are not even in the same ballpark, when comparing the habitats amongst these two channel types. The influence of groundwater is also not comparable, whatsoever. When comparing data from these two macrohabitats, alone, the resultant data set would in no way be expected to provide for meaningful predictions, outside of placing unrealistic and artificial controls on other variables.

Furthermore, the strong physical contrasts among the various habitats within AEA's hierarchical model have been demonstrated to promote population diversification, with populations segregated into diverse life history tactics. These populations interact with physical habitat in very different ways. This is true within a given species, let alone the differences in habitat use seen among species. For example, when pooling all chum salmon spawning data, AEA considered at least two different spawning tactics, adapted to radically different habitats, amongst these radical differences, as a single response unit.

Conclusion on Objective 4

In 2012-2013, AEA began collecting habitat utilization data to develop HSC models for target species and life stages for the Susitna Project. In response to questions from agencies, regarding the ecological relevance of criteria used in their models, AEA opportunistically examined relationships between abundance and microhabitat criteria in 2014. The opportunistic nature prevented them from addressing ecological relevance and there is no evidence of integration between this effort and the HSC study. Some of the most fundamental criteria in question, namely VHG, were also excluded from their investigation of the relevance of HSC.

In order for hydraulic habitat modeling to yield valid pre and post project predictions of habitat conditions, the criteria used to develop HSC must be ecologically relevant. AEA was unable to demonstrate this, making their use of hydraulic habitat modeling, to develop flow-habitat relationships, unsubstantiated.

AEA did collect a substantial amount of microhabitat utilization data, throughout their combined efforts, but this effort was not designed around AEA's hierarchical habitat model. AEA also did not collect valid habitat availability data. These data were required to assess ecological relevance.

Most concerning was AEA's unscientific use of the univariate curve generation process to select microhabitat variables for use in the multivariate curve generation process. As previously stated, univariate utilization curves do not provide a valid basis for assessing ecological relevance. To do this, AEA would need to demonstrate that the statistical distributions of utilized microhabitat differed from the statistical distribution of microhabitat outside the spatial distributions of the species and life stages under examination. AEA's survey design prevented these comparisons from being made.

AEA also pooled their utilization and abundance data and analyzed them as if the Susitna River was a homogenous waterscape, forfeiting any benefit that would have been attained from stratifying their examination of HSC by the mosaic of habitat present on the river. Even in the 1980's it was recognized that microhabitat and patterns of microhabitat were so different among main and off-channel habitats that separate HSC were needed for these environments. Given AEA's inability to identify ecologically relevant habitat criteria, describe habitat suitability, and develop HSC models, review of this project cannot proceed into flow-habitat modeling or model integration.

Objective 5

Objective 5: Develop integrated aquatic habitat models that produce a time series of data for a variety of biological metrics under existing conditions and alternative operational scenarios.

These metrics may include (but are not limited to) the following:

- *Water surface elevation at selected river locations to assess breaching flows and lateral habitat connectivity*
- *Water depth and velocity within study areas subdivisions (cells or transects) over a range of flows during seasonal conditions*
- *Length of edge habitats in main channel and off-channel habitats*
- *Habitat area associated with off-channel habitats*
- *Clear water zone areas*
- *Effective spawning and incubation habitats*
- *Varial zone area*
- *Frequency and duration of exposure/inundation of the varial zone at selected river locations*
- *Habitat suitability curves (HSC) and habitat suitability indices (HSI) for specified species and lifestages*
- *Weighted usable area (WUA) for specified species and lifestages.*

Objective 5 addresses aquatic habitat models that use data from existing pre-Project conditions to predict and quantify post-Project conditions of habitat alteration. Post-Project conditions refer to those under any proposed operational scenario of the hydropower dam. For the purposes of this review, the only proposed operational scenario is the newly identified ILF-1.

Several empirical and numeric models are proposed to model Susitna River riverine processes and fish habitat. Objective 5 addresses the hydrodynamic component of the river habitat through the use of 1-Dimensional (1D) and 2-Dimensional (2D) numerical models. In order for the models to be useful, they must be able to model both pre- and post-Project conditions of the Susitna River, including novel conditions. Data inputs and outputs that are provided by the models must be spatially and temporally relevant in order to properly integrate each of the multidisciplinary study components. Conditions, assumptions and limitations of all models under consideration should be made transparent to understand the resolution and accuracy of model inputs and results. This is very important because model results will be used to make decisions about Project operations based on modeled results of habitat and aquatic resources. Data collection efforts must also provide appropriate data sets for model calibration as well as the ability to validate model results under existing conditions.

The various models used for the Susitna-Watana dam Project are complex. Stakeholders have not been provided proof of the ability to integrate the models and apply results for purposes of assessing overall Project effects. In order to interpret the integrity of the model results, we need to understand hydraulic conditions, operational scenarios, modeling parameters, and boundary conditions used. These are the underlying concepts and concerns related to Objective 5.

<u>FERC Study Plan Determination (SPD) comments</u>

Proposed methods for specific instream flow model selection and development include a combination of approaches depending on habitat types and their biological importance, and the particular instream flow concern being evaluated.

FERC recommended the development of biologic data time series necessary for habitat specific modeling. The recommendation included expanded monitoring of spawning within FAs to include species specific information, *especially given that the proposed Project would likely affect spawning habitat within mainstem habitats for all five species of Pacific salmon (section 5.9(b)(5))*. FERC also recommended that AEA monitor surface and intergravel water temperature, DO, and water stage at Chinook, Pink, and Coho Salmon spawning locations within Middle River FAs.[4]

<u>Methods for Objective 5:</u>

Proposed methods

MWH-ROM has been proposed for reservoir modeling, 1D HecRas for open water flow-routing, River 1D to model ice processes, and River 2D to model open water flows in the Middle River FAs. Modeling in the Lower River is proposed to be 1D modeling at "select" sites and currently there are only two FAs study sites at the upper extent of the Lower River. The remaining Lower River FA study sites are proposed to be identified during year 2 studies with input from the ISF TWG. The lower extent of modeling efforts is currently at Project River Mile (PRM) 29.9, just below the tri-rivers confluence.

Just above the proposed Watana dam site, MWH-ROM will be used to model the reservoir instream flow reservation and power curves of water delivery to provide outputs of river discharge downstream of the proposed dam. Reservoir model outputs become the inputs for the 1D Hec-Ras OWFRM which extends to the Lower River. Hec-Ras 1D allows for the modeling of mainstem open water flow routing, but is not able to properly account for the flow routing outside of the mainstem in complex lateral side channel habitats.

River 1D is proposed to model winter flows during the ice covered period. Output from the 1D Hec-Ras or River 1D, depending on the time of year, provide water elevation and discharge at a given time step (time and date) and location. Output from the 1D modeling provide the starting input data for the River 2D modeling in Middle River FAs.

The ISR states that, "Each Focus Area is the subject of intensive investigation by multiple resource disciplines including water quality (5.6), geomorphology (6.5), fluvial geomorphology modeling (6.6), groundwater (7.5), ice processes (7.6), fish and aquatics instream flow (8.5) and riparian instream flow (8.6)." (ISF ISR Appendix N p. 6.) FAs are considered to be representative of important habitat conditions and channel types. 2D modeling in FAs allows for a more detailed understanding of complex flow patterns under various Project operational scenarios.

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[4] FERC study plan determination April 2013 Page B-89

As an example, to start FA modeling in the Middle River for a given date and time during 1985, the analysis will use output from the 1D Hec-Ras OWFRM or River 1D ice process model for that particular time step. One of the 1D model outputs will consist of discharge and corresponding water surface elevation for a given location and time step (date and time) which are required as inputs to the River 2D model being used in the Middle river FAs.

Existing conditions for channel geometry (mainstem and FAs) come from ADCP and bathymetry profile data. Measured channel geometry data are used as inputs for the 1D Hec-Ras, River 1D and River 2D models. To run historical flows at time 0 (present conditions) along the mainstem Susitna River channel geometry, for example, 1D cross section measurements and LiDAR are used. In the FAs where 2D modeling is being conducted, more detailed measurements of the channel geometry have been collected using the ADCP and bathymetry profiles at a much finer scale (1-10 meters) laterally compared to the main stem (> 10 meters) and include longitudinal traces as well as lateral traces throughout the entire FA in order to define complex lateral channel habitats.

To address breaching flows and habitat connectivity, the ISR states, "The main goal of the connectivity analyses will be to evaluate the potential effects of Project operations on flow conditions that are related to the connectivity of and accessibility of fish habitats within Focus Areas and tributaries."

AEA proposed to collect data to model the varial zone, stranding and trapping, spawning and incubation, and breaching flows within FAs. A varial zone analysis would quantify frequency, magnitude, and timing of downramping rates by geomorphic reach downstream of the dam. Reach-averaged downramping rates under existing conditions and alternative operating scenarios would be provided for selected hydrologic years. Using the results of the 1D mainstem flow routing models, an algorithmic analysis would be conducted to identify specific hourly time periods when the water surface elevations are decreasing (i.e., downramping). For those time periods, the hourly reduction in water surface elevation would then be computed in units of inches per hour. A frequency analysis would be conducted on the downramping hourly reduction in water surface elevation to determine the number of downramping events exceeding a given threshold or limit of numerical indices of water surface elevations.

The frequency, number, and timing of downramping events following varying periods of inundation would be quantified to evaluate the effects on aquatic organisms. The varial zone analysis is proposed to be conducted by FA or by discrete habitat types within a FA (e.g., main channel, side channel, slough) using an hourly time step integrated over a specified period.

The analysis to evaluate ramping rates will be done for different operational scenarios, hydrologic time periods (e.g., ice-free periods: spring, summer, fall; ice-covered period: winter [will rely on Ice Processes Model – Section 7.6]), water year types (wet, dry, normal), and biologically sensitive periods (e.g., migration, spawning, incubation, rearing) and; will allow for quantification of Project operational effects on the following:

- Habitat area (e. g., main channel, side channel, slough) by species and life stage. This will also allow for an evaluation of breaching flows by habitat area and biologically sensitive periods (e.g., breaching flows in side channels during egg incubation period resulting in temperature change).

- Varial zone (i.e., the area that may become periodically dewatered due to Project operations, subjecting fish to potential stranding and trapping and resulting in reduced potential invertebrate production. This will occur under the hourly ramping rates of ILF-1 load following operation, for example).
- Effective spawning areas for fish species (i.e., spawning sites that remain wetted through egg incubation and hatching).
- Riverine processes that will be the focus of geomorphology (6.5), water quality modeling (5.5), and ice processes (7.6) studies including mobilization and transport of sediments, channel form and function, water temperature regime, ice formation and timing of ice decay. The IFS studies will be closely linked with these studies and will incorporate multi-discipline model outputs to provide comprehensive evaluation of instream flow-related effects on fish and aquatic biota and habitats.

AEA proposed to use the OWFRM in conjunction with the varial zone analysis to assess the potential for stranding and trapping. The OWFRM will be used to track hourly water-level fluctuations and calculate numerical indices of water surface elevation (WSE) representing the potential for stranding and trapping of aquatic biota. Numerical indices for predicting stranding and trapping are based on equations or thresholds that relate physical characteristics of habitats to the potential for stranding and trapping in those habitats. Physical habitat site characteristics for the stranding and trapping analysis would be derived from bathymetry and GIS mapping. GPS data collected in the field (river topography) provides elevation data used throughout the analysis of Project effects. The hourly WSEs would provide the basis for identifying when (and for how long) a habitat site becomes dewatered or disconnected from the main channel.

An effective spawning and incubation analysis is proposed to identify potential hourly use of discrete channel areas (cells) by spawning salmonids. Use of each cell by spawning fish will be assumed if the minimum water depth is suitable and velocity and substrate suitability indices are within an acceptable range defined by HSC/HSI. Species-specific HSC/HSI information used to identify potential use of a cell by spawning fish are being developed under ISF 8.5 Objective 4. If suitable spawning conditions exist, that cell would be tracked on an hourly time step from the initiating time step through emergence to predict whether eggs and alevin within that cell were subject to interrupted upwelling, dewatering, scour, freezing, or unsuitable water quality.

The effective spawning and incubation analysis was proposed for each of the FA considered to be representative of suitable spawning habitat. Results of the temporal and spatial habitat analysis would be a reach-averaged area calculated by weighting the effective spawning and incubation area derived for each FA by the proportion of FA within the geomorphic reach. The results would be calculated in terms of WUA and would not represent actual area dimensions utilized by a specific species and lifestage. The results cannot be used to calculate numbers of emergent fry for example, but instead would provide habitat indicators that would be used to conduct comparative analyses of alternative operating scenarios under various hydrologic conditions.

Temporal and spatial GIS model

An integrated resource analysis (IRA) was proposed as the decision support system (DSS). The DSS would use Project hydrology, operational scenarios, OWFRM results, and the habitat-flow response models (FA stranding and trapping, varial zone, spatial and temporal analysis, FA SWE models, effective spawning and incubation flow response curves) to estimate spatially explicit habitat changes over time. Several analytical tools would be utilized for evaluating Project effects on a temporal basis. The analysis would include habitat-time series representing quantified habitat as a result of differing flow conditions by time step (e.g., daily, weekly, monthly). Separate analyses would be conducted to address effects of ramping rates (e.g., hourly) on habitat availability and suitability.

An extrapolation process using spatial analysis of flow-habitat relationships was proposed to determine how field data from each study discipline collected at one location relates to other unmeasured locations. The spatial analysis would feed directly into the IRA proposed ‘to be completed during the 2014 study season after all data are collected and respective models have been developed’. Similar to the temporal analysis, the final procedures for completing the spatial analysis would be developed collaboratively with the TWG and with input from other resource disciplines.

The results of the IRA analyses would include various habitat indicator values (i.e., effective spawning and incubation habitat) under existing and alternative flow regimes. The analysis will be used to determine when/where there is available habitat. This can only be determined by conducting an IRA which uses the output from numerous models to determine habitat changes over time. Model results would be developed for representative hydrologic conditions and a multi-year, continuous hydrologic record to evaluate annual variations in indicator values. The availability of indicator values over a multi-year record would support sensitivity analyses of the habitat indicators used to evaluate proposed reservoir operations. Integrating the level of uncertainty in the various model components would provide an overall understanding of the robustness of individual habitat indicators. A multi-year analysis of habitat indicators would identify the sensitivity of indicators to hydrologic conditions and the level of uncertainty associated with decision-making under alternative instream flow regimes. The design of the sensitivity analyses would be developed by the Project Proponent and reviewed in consultation with the TWG. This was scheduled to happen during the fourth quarter of 2013 and implemented in the third and fourth quarters of 2014.

Implemented Methods

In the ISR a “proof of concept” (POC) is presented to demonstrate the Project’s generalized Middle river habitat modeling efforts. The POC relies on integrated studies to provide reach scale and FA scale data inputs to models to determine Project effects on Susitna River aquatic resources. Results of an effects-analysis at the FA scale were limited to FA 8a (Skull Creek) and FA-128 and did not include all interdisciplinary inputs (e. g., microhabitat scale groundwater measurement).

During 2013 and 2014, HSC/HSI preference curve development efforts included: (1) preliminary selection of target species and life stages; (2) development of draft HSC curves using existing information; and (3) collection of site-specific HSC/HSI data from selected areas. This information and these data are used to develop both habitat use and preference curves for target fish species (AEA 2014). As an example, the ISR presented results of preliminary curve development using 2013 Chum Salmon spawning and Coho Salmon (< 50 mm) rearing (during the open water period) data.

Initial univariate modeling was used to select Chum Salmon spawning microhabitat variables (8.5 Fish and Aquatics Instream Flow study, Part C 2 of 2, Appendix M: Habitat Suitability Curve Development) for input to the multivariate model. We have removed our review of Appendix M because we were told by AEA that this information has been superseded by ISR Part D, 2014-2015 SIR, Appendix D. Our review of the Part D SIR is included in this document under Objective 4.

On September 17, 2014, after the release of the June 2014 ISR, the Project released the *Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables* TM. The TM was to address FERC's requirement to assess microhabitat variables that may be used to assess Project effects. Our review of this TM was removed from this document because our understanding is that this TM is also superseded with ISR Part D, 2014-2015 SIR, Appendix D.

<u>Variances for Objective 5</u>
Inadequate data

The overarching variance for the ISF aquatic habitat modeling noted by the Service is that the time series cannot be developed until a minimum of two consecutive years of data collection has occurred. Year one of study data collection occurred during 2013, and according to the Project Proponent the second year of data collection for the majority of the FA's occurred in 2014. However, at this time the Services do not consider the 2014 data collection as "second year data" since the first year of data collection (2013) has not been officially approved by FERC through the ILP process. In addition, winter data collection across disciplines is limited.

A variance of incomplete FA interdisciplinary data collection in 2013 was reported with the statement that this would not impact the ability to achieve study objectives (also addressed under Objective 2). The absence of temporal and spatial sampling of interdisciplinary studies across FAs impacts the ability to complete Instream Flow (8.5) analyses (under other 8.5 Objectives) in reaches without sufficient data. Currently there are some FAs with two years of data for an individual discipline, (i.e., 1D and 2D hydraulic modeling data in Slough 8A for the groundwater study) but data collection in several FAs is not complete for interdisciplinary studies.

Model Extrapolation

Approaches to temporal and spatial habitat model extrapolation were scheduled to be collaboratively developed by the fourth quarter of 2013. This schedule was not met, but instead the Project hosted study integration meetings to discuss how models could be used to answer biologic questions. The first meeting was the Riverine Modeling Integration Meeting (RMIM

November 13-15, 2013) and the second meeting was the Proof of Concept Meeting (POC April 4, 2014). During the meetings it was realized that much of the information needed to develop aquatic habitat specific models was not yet available and that some studies needed modification in order to be integrative. AEA stated that not having a meeting to discuss potential methods for spatial and temporal habitat model extrapolation with the agencies in Q4 2013 would not affect the Project's ability to meet study objectives or change the schedule for completing instream flow studies. Final approaches to address stakeholders concerns were deferred to 2015.

A discussion and presentation of general concepts of approaches for model extrapolation and the development of an IRA to assess the Project effects are provided in the ISR, no detail is given. This is critical information for determining the applicability of the methods and framework that will be used to integrate numerous study results/outputs proposed to assess Susitna River Project effects on natural resources.

Conformance with Objective 5:
Although an update on ongoing habitat-specific 1D-and 2D-model development, preliminary POC application for FA-104, and initial development of WUA analyses were discussed in the ISR, habitat modeling results were not presented. As such, no detailed assessment of the habitat modeling analysis/output can be provided at this time. Although no results were presented within the ISR, the Services have concerns related to the development of the habitat-specific models, the proposed analyses in the ISR, and the Project's current state of conformance with Objectives 5-8 in order to meet the licensing process timeline. There are many complex analyses to do, and limited time under the ILP to run models, QA/QC efforts, and allow for an iterative review process before the draft and final license applications would be due. Some specific concerns related to the developmental status of models are mentioned below.

Aquatic habitat modeling is based on outputs from interdisciplinary studies—groundwater (7.5), water quality (5.5-5.7), ice processes (7.6), and geomorphology (6.5 and 6.6). Currently the HSC are being developed through a "best fit" analysis for a number of microhabitat variables to determine which are significant predictors of habitat use and preference for a given species and lifestage. If a microhabitat variable is not found to be significant then it is dropped from the HSC development. However, what might not be significant within a FA (i.e., temperature) may have significant effect post-Project or outside of the FA.

One way to account for the multitude of variables that are linked to habitat quality is to integrate these requirements/preferences in a GIS-project analysis rather than trying to include all of them in the HSC development. This could help account for the full suite of variables that resource agencies have requested. This GIS approach using a range of acceptable values (e. g., thresholds) would be implemented based on whether habitat conditions fall inside or outside of acceptable values for a given species/life stage. This would require a referenced spatial layer analysis where each habitat "condition" has to be true in order for it to be considered "good" or available habitat. The effective habitat would then be determined based on whether the habitat conditions fall within or outside of the acceptable values for a given species and life stage. The Project appears to be attempting this type of GIS analysis for variables such as groundwater upwelling, scour, substrate, cover, and distance to cover, but it is unclear if plans are in place to follow through with the GIS analysis or incorporate additional variables at requested scales. In addition, the Services have concerns about whether the data collected under each of the independent study disciplines are able to be used to address the detailed habitat criteria that is required to assess effects throughout the Project area. For example, water quality and groundwater are part of the integration component to determine effective spawning and incubation habitat, and it is not clear that the data is being collected at the appropriate scale to be able to answer that question for a given “cell” within FAs. It is also not clear what modeling steps occur when results from various physical models do not agree (e.g., 2D hydraulic model shows presence of water in off-channel locations but the water quality model shows no water present).

The metric generated from habitat-flow relationships for fish and macro-invertebrate species and lifestages is expressed as WUA. WUA is an index of habitat area provided at a given flow. The general approach and application of WUA metrics are described in the ISR in Section 8.5.6.4.1 and Figures 8.5.6-11 through 8.5.6-22. In the ISR and at the POC meeting, WUA and available/effective habitat calculations for a given time series for a given species and lifestage within a given FA (i.e., FA128) were demonstrated. However, the details of these analyses have not been described nor have they been decided for the full range of species and lifestages and study sites with input from the TWG. Additional details of model linkages and both spatial and temporal scales used to calculate WUA metrics to determine Project effects on instream flow habitat for various species and lifestages throughout the Susitna River are needed.

WUA is being used in Middle River FAs to model existing conditions and Project effects. In the Lower River, WUA is being used for limited analyses and it does not appear that the analyses will include anything in the Lower River outside of the 1D representative sites. Currently there are two Lower River WUA “study sites”, which may be too few to represent the entire Lower River.

Proposed methods for conducting habitat modeling under winter ice conditions in the Lower River are not included in the ISR. The Project’s ability to model flows under winter ice conditions is a significant concern that is yet to be resolved.

Model Extrapolation (from FAs throughout the river)
The ISR states that there are four options under consideration for extrapolating temporal and spatial habitat analysis outside of FAs. Extrapolation of FA conditions would lead to system-wide analysis, and made possible by developing a DSS. It is concerning at this point that the Project is without an understanding of how the habitat data will be used or integrated; or how outcomes from analytical methods are anticipated to influence results. There are several weak points presented regarding the effective combination of quantified fish habitat preference (e. g., fish observational data) and utilization curves, measurement of physical conditions, and ability to predict physical conditions under Project alternatives that are required for successful implementation of the aquatic habitat modeling. Weaknesses that the Services identified in the aquatic habitat modeling are discussed below.

Lateral habitat groundwater and water quality—Scale

Based on the description in the ISR the lateral habitat (off-channel habitat) and water quality analysis will provide categorical zones (e.g. “bins”) of groundwater flux (upwelling, downwelling, neutral), temperature, and DO for most of these habitats. These categorical zones for the unmodeled habitat variables in off-channel habitats associated with groundwater and water quality will not be comparable to the much finer scale individual cell-specific hydraulic conditions (i.e., depth and velocity) associated with the 2D hydrodynamic modeling. This is because the groundwater and water quality data and models are at a much coarser scale and therefore the results for a given area are applied over a much larger scale. The 2D hydrodynamic model results are on a scale of 1-10 meter grids while the water quality results are on a 30-100 meter grid, and the groundwater is on an even larger scale. Therefore a single “cell“ value for water quality gets applied to 30-100 cells in the hydraulic model. Detecting and estimating how the categorically zoned variables change under post-Project conditions (different stages, main channel temperatures, and bed topography) will be very difficult. We do not understand how a robust analysis of all relevant habitat variables will be achieved. This is especially problematic because off-channel habitats are very important for fish and because the unmodeled physical variables are significant (relative to depth and velocity) and influential to fish use of these habitats.

Winter Habitat—Scale and Unobservable conditions

The winter habitat assessment has the same potential scale issues as the lateral habitat assessment (e.g., water quality and groundwater upwelling) with additional concerns surrounding sampling effort and fish habitat response curve characterization. The winter habitat assessment lacks the ability to predict winter fish habitat preference for novel conditions that are currently unobservable (e.g., new mid-winter ice-free reaches under post-Project operations).

The ISR describes long-term 1D moveable bed simulation, short-term 2D moveable bed simulation, 1D ice-formation simulation, and short-term breakup simulation experiments related to channel alteration. It will be challenging to integrate multiple alterations of channel geometry with habitat valuations calculated from *fixed* geometry – especially given the episodic and difficult-to-model or observe geomorphic effects of mechanical ice breakup. It is likely that ice breakup may cause more channel disturbance than what occurs during open-water conditions. If we are not able to model predictively how ice breakup and ice dams alter the channel geometry then we can’t really assess how Project operations will change the channel geometry or resulting habitats. This will result in massive uncertainty in predicted post-Project impacts.

Varial zone analysis

“Varial” zones resulting from intra-daily flow fluctuations (i.e., down ramping) have dramatic primary and secondary effects on fish. Primary effects include fish stranding while secondary effects include mixing of mainstem surface water with longer-residence water and groundwater in lateral habitats. Effects on fish habitat include reduced habitat complexity and disconnection of habitats (e.g., proximal feeding and rearing areas). Even if we could confidently predict the resulting physical habitat conditions, there are no Susitna River field data specific to effects of down ramping to support fish response curves or the development of HSC for repeated intra-daily flow fluctuation. This is a problem for both model prediction and validation capabilities for the proposed load-following operational scenario.

Recommendations, modifications or new study for second year of study:
Based on our review related to resource concerns, the Services conclude that conformance with Objective 5 under the SP is poor. Below are recommendations to further study efforts toward ISF SP conformance. Recommendations pertain to topics addressed by FERC in the SPD or in the SP, but they have not been addressed sufficiently.

Recommendations

- Groundwater transect data within and along FA boundaries so that predictive 3D groundwater models can be developed at a scale relevant to fish and fish habitat. This is necessary to provide information to aquatic habitat models that are based upon groundwater discharge. For example, Chum Salmon spawning is associated with upwelling, yet detailed data on current upwelling conditions and predictive modeling of future conditions under Project operations is not available. Since we do not know the current conditions, we cannot predict how upwelling will change in Chum Salmon spawning habitats.
- Uncertainty analysis results of aquatic habitat models should be transparent to stakeholders to understand limitations of each model used to assess potential Project - effects. During the November 2013 study integration meetings, the Services expressed concern that an uncertainty analysis was not proposed for habitat models for effects-analysis. The Services requested an uncertainty analysis in our Proposed Study Plan (PSP) for ISF study (8.5).
- Minimum two consecutive years of data collection for integrated riverine and physical process studies; and water quality and biologic studies in each FA. This data is necessary to populate and test predictive capabilities of aquatic habitat models for spawning and rearing fish.
- Instream flow WUA metrics and model linkage details at both spatial and temporal scales used in the analysis should be provided. Information that describes how WUA will be calculated and modeled is not provided. The WUA value proposed to be used in the final integration analysis to determine Project effects on habitat for various species and lifestages is not discussed.
- Breaching flows and habitat connectivity analysis should be conducted on biologically relevant timelines; such as the five and ten year time frames, which is the average generational lifespan of a Susitna River Chinook Salmon. Alterations to channel geometry conditions should address breaching flows of both main channel *and* lateral habitats because these habitats support critical life stages including spawning, incubation, rearing and migration.
- Predictive modeling of water quality and surface-groundwater exchange is necessary for developing aquatic habitat utilization models related to fish productivity. One of the major data gaps identified at the November 2013 Riverine Modelers Integration Meeting (RMIM) was the inability of the river water quality monitoring study to provide post-Project estimates for off-channel habitats. Since off-channel habitats are important for

spawning and rearing salmon, as well as resident fish, predicting Project effects on water quality in these habitats is crucial.
- Breaching flows analysis should be done at the 25, 50 year, and other predicted channel geometries which show significant change from the geomorphology channel change modeling.
- Additional Lower River WUA "study sites" should be added to provide adequate representation. Currently there are only 2 Lower River study sites identified.
- The inability to predict winter fish habitat preference for novel conditions that are currently unobservable (e.g., new mid-winter ice-free reaches under post-Project operations) should be addressed.

Modifications
- Include measures of ice thickness, water depth, water temperature and water velocity in ISF (8.5) and ice processes studies (7.6). Measurements should be taken at multiple points along 10 or more transects in each FA for input, calibration and validation of winter hydraulic models.
- Increase sampling effort of subsurface water temperature and DO measurements at each FA to address Chum Salmon incubation. Subsurface water temperature and DO data should be integrated with the 3D groundwater models to develop HSC curves and WUA analyses. These water quality metrics are currently not proposed to be part of the predictive modeling necessary for Project effects analysis of aquatic resources.
- Compile a comprehensive aquatic habitat model water quality report of interdisciplinary data collection efforts. This should include all QA/QC procedures and results (calibration dates, quality objectives, accuracy and precision calculations) as part of the ISF (8.5) study, or Water Quality (5.5, 5.6, 5.7) studies or new Model Integration study.

Objective 6

Objective 6: Evaluate existing conditions and alternative operational scenarios using a hydrologic database that includes specific years or portions of annual hydrographs for wet, average, and dry hydrologic conditions and warm and cold Pacific Decadal Oscillation (PDO) phases.

<u>FERC Study Plan Determination (SPD) comments</u>
FERC requires that the run-of-river (ROR) operational scenario be evaluated for the Susitna-Watana Dam hydropower Project.

<u>Methods for Objective 6:</u>

Proposed
The Project Proponents proposed to evaluate the Susitna-Watana hydropower Project under the OS-1b load-following operational scenario.

Implemented
The ISR and supporting documents do not provide sufficient information related to how the Project will be operated (scenarios) during construction or after construction. The only Project

scenario provided in the initial ISR was related to Max-load following (OS-1b) which was described as a worst case scenario but would most likely not be how the project would be operated. In the latest 8.5 SIR (Nov 2015) OS-1b was replaced with a modified scenario to reduce powerhouse discharge variability through assigning peak mode operation to other existing hydropower plants on the Railbelt grid (Integrated Load Following [ILF]-1). AEA states that other ILF operations may be evaluated during the impact assessment but currently is only modeling the ILF-1 scenario.

Overall the OWFRM (Version 2.8) results demonstrate the general ability to simulate the flow hydrograph through the main channel of the Susitna River during open-water conditions. Comparison of hydrographs and stage changes associated with pre- and post-Project (OS-1b) operations at Gold Creek and Susitna Station locations throughout the Middle River are presented and provide adequate information to address the study objectives in the Middle River under the OS-1b operations. Other than the newly identified ILF-1 operational scenario which will replace OS-1b in the final OWFRM (Version 3.0), no additional operational scenarios are discussed or presented.

Initial flow routing results confirm that post-Project OS-1b operations will drastically change the flow hydrograph in the Middle River throughout the open-water portion of the year resulting in maximum potential stage changes ranging from 9.7 feet near the dam, 5.7 feet near Gold creek, and 2.1 feet near Susitna Station in the Lower River. This amount of stage change is significant in terms of river connectivity and the effects on main channel and lateral off-channel habitats. Additionally, the hourly stage affects associated with ramping rates for OS-1b ranged from 0-2.1 feet under dry conditions and 0-8.0 feet under wet conditions near the dam site, 0-4.1 feet near Gold Creek, and 0-4.0 feet near the Sunshine gage in the upper extent of the Lower River. While OS-1b is considered a “worst-case” scenario**,** this illustrates that the ramping rates associated with a hydro-peaking operation will have drastic effects on the water surface elevations throughout the river greatly affecting habitat conditions, lateral habitat connectivity, river processes (instream flow and riparian), ice processes (flow under and over existing ice formations), aquatic habitats and fish species and populations.

During the September 9-11, 2014 Fish Passage Brainstorming Workshop the Project’s consultant Mr. John Happla (MWH) presented a new Operational Scenario referenced as “ILF-1 Intermediate Load Following”. ILF-1 was also briefly presented by Jon Zufelt (HDR) during a seminar hosted by USGS on Susitna River Ice Processes (January 15, 2015). Mr. Zufelt stated that this operational scenario would also result in “significant jumps and surges” in discharge throughout the Susitna River. The ILF-1 scenario assumes that the other Railbelt hydropower plants (Bradley Lake, Eklutna Lake and Cooper Lake) will provide load-following to the extent possible. Susitna-Watana would be assigned the remainder of the load-following, with none assigned to the thermal resources.” The presentation summarized Project operational scenarios analyzed, based on the Physical, Hydrologic & Engineering Information (Information Items P3 – P5), Operating Scenarios OS-1b and ILF-1, [Sept 9-11, 2014 by MWH information posted to AEA’s Susitna-Watana web site]. OS-1b is a maximum load-following scenario being used as a boundary case with maximum variation on hourly, daily, and seasonal time scales. Flow duration curves were presented, along with flow through the turbines, flow through fixed cone valves and reservoir elevation duration curves. ILF-1 is an intermediate load-following scenario that includes using load following at other Railbelt hydropower resources which can accommodate approximately one half of the Railbelt's load variation. In addition, spring inflow forecasting was added to the model. Flow duration curves and reservoir elevation duration curves were presented for both scenarios. Under both operating scenarios the spillway gates are designed to not operate at less than the 50-year flood during full pool conditions. During simulation using 61 years of load and flow data at an hourly time scale, the spillway was never used. The simulations predict the turbines will run 100 percent of the time. The FPTT requested a summary of daily variation in outflow by month for both weekdays and weekends as a data request.

Mr. Happla noted that the simulation does not include ramping rate restrictions and uses environmental flow requirements from the 1980s studies. Resource agencies asked when those assumptions might be updated. AEA indicated that due to the ongoing nature of the studies that will support the development of environmental flows, there is not an ETA for an operational scenario with updated environmental flows. Resource agencies asked how ROR scenarios were being considered. This question was characterized by AEA as a "sideboard discussion" and not addressed further. The ILF-1 scenario appears to be a consideration driven by power generation and one that has not at all been evaluated for Project effects on aquatic resources.

<u>Variances for Objective 6:</u>
The ROR operational scenario has not been analyzed for pre- and post-Project scenarios as required by FERC.

<u>Conformance with Objective 6</u>
In the initial ISR, OS-1b load following scenario was presented as a worst-case scenario to demonstrate potential Project effects. In the latest SIR the OS-1b has been replaced with the ILF-1 scenario but no additional realistic operational scenarios, such as the ROR, have been presented. Options for minimizing overall Project effects from operational scenarios is not provided. In order to appropriately study the Project effects associated with post-Project operations, additional alternative operational scenarios in addition to the ILF-1 scenario must be evaluated. Alternative analyses are needed to better understand the overall Project effects throughout the extent of the Middle and Lower River. Understanding of operational scenarios should be linked temporally and spatially with the life history strategies of Susitna River fish species. This is critical information for determining the type and amount of alteration and the associated effects on instream flow and habitat conditions. Alternative operational scenarios should be evaluated to provide the best-case scenario for hydropower operations and species and habitat conservation.

<u>Recommendations, modifications or new study for second year of study:</u>

- Evaluate the ROR scenario
- Evaluate changes to habitat classifications under differing Project operational scenarios.
- Evaluate other potentially valid operational scenarios to address protection, mitigation and enhancement (PM&E).

Objective 7

Objective 7: Coordinate instream flow modeling and evaluation procedures with complementary study efforts including Riparian (see Section 8.6), Geomorphology (see Sections 6.5 and 6.6), Groundwater (see Section 7.5), Baseline Water Quality (see Section 5.5), Fish Passage Barriers (see Section 9.12), and Ice Processes (see Section 7.6) (see Figure 8.5-1). If channel conditions are expected to change over the license period, instream flow habitat modeling efforts will incorporate changes identified and quantified by riverine process studies.

<u>FERC Study Plan Determination (SPD) comments</u>
The FERC SPD did not require additional information related to integration methodology or study detail. However, FERC noted that requests for study modifications can be made through the ISR review process.

FERC regulations specify that the need for additional years of studies would include, whether: (1) the study objectives were met during the two-year study period, (2) there was substantial variability in study results between study years, (3) the study was implemented under anomalous environmental conditions, and (4) the data collected are insufficient to conduct the environmental analysis pursuant to NEPA and inform the development of license requirements.

<u>Methods for Objective 7</u>

Proposed Methods
Objectives 5 and 7 are closely linked because the habitat specific models (Objective 5) rely on integration of multiple riverine, physical, and biologic studies.

The Instream Flow Study (ISF 8.5) is designed to characterize the existing, unregulated flow regime and the relationship of instream flow to riparian and aquatic habitats under alternative operational scenarios. The SP states that the proposed Project will alter stream flow, sediment and large woody debris (LWD) transport downstream of the proposed dam site. These stressors will affect channel morphology and the quantity, quality, and timing of downstream habitats. The ISF framework will be used to assess Project effects on downstream habitats under existing channel conditions, and the prediction of future channel conditions under alternative operational scenarios.

Alternative operational scenarios will differentially affect fish habitats and riverine processes on both spatial and temporal scales. The Project's habitat and process models will therefore be spatially discrete (e.g., by FA, reach, and segment) yet integrated to allow for a holistic evaluation by alternative operational scenario. Effects of alternate operational scenarios stressors on resources are proposed to be assessed using measurable indicators of changes in habitat suitability, quality, and accessibility**.** The assessment requires an understanding of fish habitat use, including where and why fish preferentially select certain habitats over others.

Implemented Methods
There has been no demonstration, outside of the POC meeting, how the study will holistically evaluate Project effects. AEA stated that Project effects on Susitna River resources will require

inventive modeling approaches that integrate aquatic habitat modeling with evaluation of riverine processes such as groundwater-surface water interactions, water quality, and ice processes.

Resource data collection was initiated in Q2 2013 and will continue during at least one more year of study. Model development is ongoing and will be completed during the next year of study prior to the USR under the ILP. Substantial effort, with involvement of stakeholders, is needed to advance the model integration effort. Model integration capabilities may be the limiting factor for Project effects assessment.

Variances to Objective 7:

Project Proponents state that they have implemented the methods as described in the SP with no variances. As of March 2016 no integration of studies has occurred to convincingly demonstrate the effectiveness of the process.

Conformance with Objective 7

The Service's RSP comments asked for more detail related to how field data, models, and assumptions from individual studies would be integrated to produce a set of metrics to support a comparison of alternatives. Currently, many of our concerns related to model integration stem from (1) the level of data collection is insufficient to support model development; (2) model capabilities are not established for both pre- and post-Project conditions; and (3) the demonstrated ability to integrate models to quantify Project effects on fish habitat is lacking.

The relative time allocated to overall studies and study integration is an additional concern. No substantial progress has been made between 2012-2016. Flow routing and habitat mapping results did inform 2013 planning and adjustments (extension into Lower River reach and evaluation of representativeness of FAs), however, the time line was extremely compressed with some study results produced just before the plans for 2013 work were done (e.g., ice processes, 7.6). Some of the integration challenges will involve more sophisticated analyses and more fundamental influences of one study on another. An integrated analysis requiring synthesis across studies will require more time than is available in the planned licensing schedule. The overarching concern is that effective integrated analysis will not be achieved, with the end result being a collection of un-relatable information.

Another concern is that two years of biological and physical process sampling are insufficient to capture natural variability, collect adequate site-specific data, and build models to predict how Project operations will affect ecological relationships. Furthermore, proposed changes to the sampling designs may occur following one year of study, making year-to-year data comparisons difficult. Original requests were for a minimum of five years for all studies related to anadromous fisheries resources to cover the average lifespan of a Susitna River Chinook Salmon, the range of annual environmental variability, and collect sufficient data for model validation.

At the request of the Services and other stakeholders, AEA held a November 2013 Riverine Modeling Integration Meeting (RMIM) and an April 2014 POC meeting to demonstrate the viability of their approach to study integration.

The POC provided examples of how data from different disciplines will be used to evaluate potential Project effects on fish habitat. The POC meetings presented integration examples using the ISF flow routing study (8.5) to account for river flows leaving the dam, and for tributary and groundwater inputs resulting in data outputs providing water surface elevations, water depths, and water velocities at multiple cross-sections. The fluvial geomorphology (6.6) study uses the output from ISF flow routing (8.5) studies (1D open and ice covered models) and applies a 2D hydraulic model to estimate water depth, or stage, and water velocity through FAs. The ice processes (7.6) study uses a 1D model to estimate ice development through the winter. During winter, the ice process study uses a 2D hydraulic model, with a static and constant ice cover thickness which is a "best guess" as to the ice conditions at a FA, to estimate water depth and velocity throughout each FA. The reservoir and riverine water quality modeling (5.6) will be populated with measures of water quality and the 1D flow routing data, and 2D hydraulic data from the fluvial geomorphology (6.6) study to model water temperatures, and other parameters, in each FA. The groundwater study (7.5) uses locational data of groundwater discharge and showed how changes in mainstem flow altered sub-surface water temperatures to provide changes in water quality due to changes in surface-groundwater exchange.

Biological modelling presented in the POC used habitat suitability curves to evaluate potential Project effects on Chum Salmon spawning habitat and juvenile Coho Salmon (< 50 mm) summer habitat within FA-128 (Slough 8A). HSC for habitat suitability indices (HSI) were developed from field sampling results which measured fish presence along with multiple physical and water quality habitat components. HSC curves were developed for two species and life stages. HSC curves for Chum Salmon spawning included parameters for upwelling, substrate, water depth, water velocity, and site location. HSC curves for juvenile Coho Salmon included parameters for cover (present or absent) in clear water, turbidity (>50 NTU), water depth, and velocity.

The major limitations of the POC examples provided were (1) estimates of water depth and velocity during winter as a result of assuming a static 1m thick ice layer across the channel surface, (2) the lack of HSC curves and WUA analyses for Chum Salmon egg incubation that depend on subsurface water temperatures and DO, (3) HSC curves for juvenile Coho Salmon that do not assess variables influential to growth and survival and which can be altered by the Project, (4) HSC curves for juvenile Coho Salmon developed during the summer and applied equally during the winter, (5) the application of HSC curves for juvenile Coho Salmon which do not account for the different proportions of age class sizes over time, (6) confidence intervals in modeled water depth and velocity that are greater than the precision needed for HSC curves, (7) lack of water quality data and modeling in off-channel habitats, (8) lack of groundwater and water quality data for all FAs, (9) lack of Lower River Project data that will provide useful analyses of Project effects on salmon spawning and rearing.

After review of the POC and the difficulty in conducting study integration we are increasingly concerned that the current ILP licensing process does not allow time to develop useful integrated models capable of assessing Project effects.The Services consider conformance toward meeting Objective 7 to be significantly under developed.

Recommendations, modifications or new study for second year of study:

Recommendations

- Move beyond conceptual stage of study integration, to demonstrate how the integration will work, including an uncertainty analysis.
- Building off of the POC meetings, conduct a pilot study that would utilize all the new information that has been presented (ILF-1 scenario, OWFM2.8, draft final HSC development, GW/WQ/Ice models, etc) and apply it to two different FAs (FA-128 Slough 8A and FA-138) for a single species (Chum Salmon) and critical lifestages (spawning and incubation) to conduct a complete temporal and spatial habitat analysis and provide an example of how FA model results would be extrapolated to areas outside the FA to determine species specific project effects throughout the middle Susitna River.

New study

- Develop a new Model Integration Study to identify methods and mechanisms that will be used to integrate studies and to implement a DSS. We recommend that the Model Integration Study be the next step for the Project, prior to moving forward with additional field studies.

Objective 8

Objective 8. Develop a Decision Support System-type framework to conduct a variety of post processing comparative analyses derived from the output metrics estimated under aquatic habitat models. These include (but are not limited to) the following:

- *Seasonal juvenile and adult fish rearing*
- *Habitat connectivity*
- *Spawning and egg incubation*
- *Juvenile fish stranding and trapping*
- *Ramping rates*
- *Distribution and abundance of benthic macro-invertebrates.*

FERC Study Plan Determination (SPD) comments

In the SP AEA stated, "Development of a DSS-type process, and supporting software to efficiently process data analyses, will be initiated in collaboration with the TWG after the initial results of the various habitat modeling efforts are available in 2014 (Table 8.5-14). The intent is to prepare the DSS-type evaluation process by Q1 2015 to assist scenario evaluations in support of the License Application."

Methods for Objective 8:

Proposed

The ISR states that a DSS framework was initiated during 2013, and that the intention is to use an IRA "matrix method" as the basis for decision making. Stand-alone software for the DSS is no longer proposed. AEA intended to continue work on the DSS during 3rd quarter of 2014.

Implemented

Development of the DSS is contingent on data collection and analysis, and subsequent development of resource specific models that will be used to assess Project operations. Data collection was initiated in Q2 2013 and will continue during the second year of study. Model development activities are ongoing and will be completed during the next year of study prior to the USR. As a result, the ISR is limited to presenting potential methods and approaches for developing the DSS and conducting an integrated resource analysis (IRA). These approaches were initially provided in the SP (RSP Section 8.5.4.8), and were discussed briefly during the November 13-15, 2013 IFS TT Riverine Modelers Integration Meeting (RMIM). We expected that further discussion with the TWG would occur in 2014 and be presented as part of the POC, but this did not happen.

Variances for Objective 8:

No variances for Objective 8 were provided. However, the Service considers it a variance that no progress related to the DSS was made during 2014,2015, or 2016. The DSS is critically important to understanding if the Project is collecting appropriate information to determine Project effects on fish and wildlife resources.

Conformance with Objective 8

The Service is concerned about the lack of development progress of the DSS. The identification of an appropriate DSS is a Project component that should have been completed prior to the development of the initial SP. AEA has discussed and presented general concepts related to the development of a DSS to assess the Project effects on the Susitna River but are not identified in detail in the ISR or supporting documentation. This is critical information for determining the applicability of the methods and framework that will be used to integrate the numerous study results/outputs proposed to assess the Project effects on natural resources throughout the Susitna River.

Recommendations, modifications or new study request for second year study:

Recommendations

- In an aquatic habitat approach we want to end up with tallies of different macro, meso, and micro habitats weighted by “value” to various organisms for each proposed alternative. Emphasis should be on how the various modeling efforts can produce side-by-side comparisons of Project alternatives (including a no-Project alternative).
- DSS development and detailed understanding of data analysis, model interdependencies and outputs need to be provided in order to comment on the applicability of spatial and temporal model integration into a DSS to access project effects on aquatic resources.
- A separate study needs to be developed that will outline the proposed methods for the development and implementation of a DSS.

Request for new study (included separately in our filing as a stand alone study request)

- As part of the new Model Integration Study (under Objective 7) develop and implement a Project DSS prior to moving forward with additional field studies.

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Response to AEA's Post-March ISR 2016 meeting follow-up filing regarding the exchange of written communications between AEA and the Services

Finally, after review of AEA's document filed with FERC on April 29, 2016 titled "Additional Follow-Up on Action Items from March 2016 ISR Meetings: Study 8.5 (Fish and Aquatics Instream Flow Study) Response to Licensing Participant Comments on Modeling Approach Used to Develop Habitat Suitability Curves of Alaska Energy Authority" (available here: http://elibrary.ferc.gov/idmws/file_list.asp?accession_num=20160429-5507), we would like to address several points of misunderstanding. In this document AEA seems to understand that our criticism mainly involves small, perhaps pedantic complaints about notation. That is not what we were trying to convey. We have found two important areas of weakness in the ISR Part D, SIR, Appendix D of the Fish and Aquatics Instream Flow (8.5) report. One problem area is the description of methods and the description of the logic underpinning the study. The second problem area has to do with the reporting of the results, which we found to be incomplete and not consistent with the approved study plan.

Study 8.5 is a complex collection of interdependent studies intended to provide a basis for forecasting the way dam operations might affect flow, habitat, and ultimately aquatic wildlife—including the highly prized salmon resource. The effects of dam operation on fish will be predicted, at least in part, though habitat suitability curves. Fish and Aquatics Instream Flow Study (8.5), 2014-2015 Study Implementation Report, Appendix D (http://www.susitna-watanahydro.org/wp-content/uploads/2015/11/08.5_IFS_SIR_App_D_HSC.pdf) reports on a large number of curves developed for the purposes habitat suitability estimation. Although this report contains a considerable body of information, it does not contain adequate information to review the quality of the estimated curves, to review the adequacy of the model fit to the data, nor to review the validity of the model for predicting dam effect.

First, we address AEA's comments named as HSC-2 and HSC-3, as they relate to the description of the methods. Consider, as an example, the equation on the bottom of page 34 of the report in question (http://www.susitna-watanahydro.org/wp-content/uploads/2015/11/08.5_IFS_SIR_App_D_HSC.pdf):

> The draft final HSC model for Chinook salmon fry is:
>
> $$\log\left(\frac{p}{1-p}\right) = C_k + 1.80 * depth - 0.613 * depth^2 - 1.15 * vel + \gamma_{site} + \varepsilon,$$
>
> where:
> C_k is a constant depending on cover and turbidity:
> C_{CNT} = -1.02 for locations with cover and NTU≤30
> C_{NCNT} = -2.31 for locations with no cover and NTU≤30
> C_T = -2.69 for locations with no cover and NTU>30,
> p is the probability of Chinook salmon fry presence,
> γ is the random effect for site, and
> ε is random error (assumed normally distributed).

There are several notational problems with this as written. AEA seems to understand one of our points (that they failed to distinguish parameters from parameter estimates). We agree that the proposed notational changes listed under HSC_2 in AEA's response will fix some problems. Still, that leaves the much larger problem unaddressed. Note that this essentially unexplained quantity p is an out-of-place parameter that is not consistent with the logic behind the regression analysis.

In other words, the left-hand side of the equation contains a function of a *true unknowable parameter* (this is the point that AEA misunderstood in their response HSC-3). The equation seems to be saying this unknowable parameter is a function of data and some random quantities. Usually regression analysis involves some kind of function of observed data (not a parameter) on the left-hand side of the equation (called the dependent variable) expressed as a function of some other observed data (called the independent variables) together with a random quantity. Mixed effects models take this same basic form, only they are somewhat more complex. Note, again, the equation above has a parameter—not data—in the function on the left-hand side. How could that true probability be known with certainty in even a few cases? Clearly AEA did not regress the various independent variables on the true probability of Chinook Salmon presence—that would be impossible. They must have used some transformed data as the dependent variable in the regression. However, they have simply skipped one or more steps involved in completely and clearly writing down exactly what they actually did, perhaps thinking that these steps are obvious to anyone as familiar with this study as they are. It is not clear from the report what, exactly, was used as the dependent variable. This is not a small notational problem. The current description is not sufficient, and it does not meet modern standards for scientific reporting. The remedy we are asking for is a report with a clear and complete description of the methods that were used.

The Council of Scientific Editors[5] offers a simple and clear statement about the standard for scientific reporting of methods: "…it must include sufficient detail to allow another researcher to repeat the experiment." We could offer many other citations to statements about modern scientific reporting. The American Fisheries Society makes a very similar point[6]: "Descriptions of the methods employed in the study should be detailed enough to enable readers to repeat it. Previously published descriptions may be cited in lieu of presenting complete new ones provided that the sources are readily available... If more than one method was used or a particular method entails a series of major steps, present each method or step in a separate subsection. Appropriate tables and figures can reduce the need for detailed verbal descriptions of methods." In other words, to meet modern standards for scientific reporting we should have been able to find in one place (1) a complete description of where each variable in the regression equation came from and full and complete statement of how it was calculated (in this case, this is especially true of the dependent variable), (2) a complete and technically correct description of the method used to estimate the parameters (e.g., ordinarily least squares vs. generalized linear model using likelihood, etc., and other information necessary to be able to repeat the analysis), (3) technically correct equations demonstrating the models (separate from reporting on model parameters), and (4) any other information necessary to understand the methods in sufficient detail to repeat the analysis (note that this addresses AEA's comment HSC-1).

In AEA's response HSC-4, we found this statement: "AEA has shown select portions of this model to several colleagues with extensive knowledge of mixed effects and logistic modeling with only favorable reviews. If the greatest concern with the model is related to formula notation, then it should be easy to agree on a solution, as AEA has proposed above." We maintain that that the correct test is not whether AEA has had favorable reviews from friends and close colleagues—especially if these colleagues have had the ability to discuss the methods and ask questions in person. We maintain that the correct test is whether or not an independent scientist—not as familiar with the study as AEA scientists—can understand and agree with the written description of the logic and the methods from a stand-alone report (this relates to AEA's comments HSC-5, and we maintain that the reports must be self-contained). The second test is whether such an

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[5] Council of Science Editors. 2006. Scientific Style and Format, 7th ed. Rockefeller University Press. Reston, VA. (see top of page 4.)

[6] http://fisheries.org/docs/pub_tafs.pdf

independent scientist can find that the statistical estimates are justified by the data collected as part of the study.

The second important point we were trying to make is that the results were not reported in sufficient detail to be able to judge the quality of the regressions. The equations, such as the example shown above, seem to be the only presentation of the numerical results of the regression analysis, and this presentation is quite incomplete and insufficient. The accompanying statistical information that was presented centered on the *Akaike information criterion, or AIC value (we agree that this is a very important quantity for review) and information on multicolinearity (which is also important). What was not provided was important material to judge the statistical significance of the overall model, the statistical significance of the model parameters, the overall quality of the model fit, and information on model validation.*

The 2013 Final Study Plan for Study 8.5 (http://www.susitna-watanahydro.org/wp-content/uploads/2013/09/SuWa-FSP-2013-Section-08.05-IFS.pdf) provides a somewhat vague statement about habitat suitability curve reporting, but it is clear that some measure of sampling error was expected (see Objective 5, below):

> The fish community in the Susitna River is dominated by anadromous and non-anadromous salmonids, although numerous non-salmonid species are also present (Table 8.5-15). Development of HSC will involve the following steps: (1) selection of target species and life stages, (2) development of draft HSC curves using existing information, (3) collection of site specific HSC data, (4) development of habitat utilization frequency histograms/preference curves from the collected data, *(5) determination of the variability/uncertainty around the HSC curves* (emphasis added), and (6) finalization of the HSC curves in collaboration with the TWG.

The Final Study Plan also contains some questionable statements of fact that are offered without citation, support, or reference:

> For data sets with less than the target number of observations ($n \geq 100$), bootstrap analysis will be used to assess the variability and confidence intervals around each of the data sets used to develop the HSC curves. Bootstrapping is a data-based simulation method for assigning measures of accuracy to statistical estimates and can be used to produce inferences such as confidence intervals (Efron and Tibshirani 1993). This *method is especially useful when the sample size is insufficient for straightforward statistical inference* (note that the highlighted statement is made without citation or support, and it may not be correct). *Bootstrapping provides a way to account for the distortions that may be caused by a specific sample that may not be fully representative of a population* (this highlighted statement is certainly questionable, and again, offered without support).

Irrespective of the correctness of any of these statements about the bootstrap technique, it is clear that the intent was for any reported habitat suitability curves to be reported with a measure of sampling error, an analysis of the sensitivity of assumptions, or some other specific measure of the quality of any parameter estimates. Later in the Final Study Plan (page 8-61), when describing work products, it is even more clear that habitat suitability curves were to be reported with measures of sampling error: "The HSC/HSI Development Study component will include the following work products:… Results of bootstrap analysis used to assess variability and confidence intervals around each of the HSC curves developed from site-specific data." Moreover, the Final Study Plan is clear (page 8-61) that the statements about confidence intervals also relate to preliminary and initial reporting of the habitat suitability curves: "These work products and other results of the HSC/HSI analyses will be compiled and presented in initial and updated study reports."

We could not find these measures of sampling error, and the estimates themselves were not clearly labeled as such. The estimates that were presented were not conventionally displayed, such as in clearly marked tables. The only presentation we could find of parameter estimates were as numbers in equations where what appeared to be unknown parameters and parameter estimates were mixed together, as we previously explained.

Considering AEA's comment HSC-6, we note that Zuur et al. (2009), the reference cited and the reference R2 directed us to for a description of the use of mixed effects models, provides conventional advice to test for statistical significance of these mixed effects models (see Chapter 5 and other places in the book). Also, Zurr et al. describes how to test that individual parameters were statistically significant. This reference also shows how to develop estimates of sampling error (e.g., confidence intervals or standard errors) for the individual parameter estimates. Zuur et al. also offers minimal suggestions, especially in Chapter 5, for model validation. Indeed, Zuur et al. seems to be a sufficient reference to address most of the reporting deficiencies we have tried to describe.

In summary, the presentations of habitat suitability curves associated with Study 8.5 are incomplete, technically incorrect, and impossible to review except to say that both the method descriptions and the statistical results are incomplete or appear to be incorrect. Deficiencies in both methods and results must be addressed in the reporting of Study 8.5, it to provide understanding of estimated habitat suitability curves intended to predict fish dynamics as a part of reliably modeling dam effects.

8.6 Riparian Instream Flow

Summary of Proposed Modifications and New Studies

Based on the June 2014 and March 2016 ISR meetings, and review of AEA's relevant study 8.6 materials provided for review, the USFWS provides the following information.

USFWS PROPOSED MODIFICATIONS:

- USFWS has not proposed modifications to this study.

AEA's PROPOSED MODIFICATIONS:

- AEA's Power point indicated that during the April 2014 RIFS TWG meeting it was discussed that further evapotranspiration (ET) measurement were not warranted given that the Susitna Valley region is not a precipitation limited region. Therefore, a second year of sap-flow and stomatal conductance ET measurement will not be conducted. ET modeling will use the results of 2013-2014 measurements (ISR Part D, Section 7.2, page 9 and SIR Section 7.6.1, page 15).

REVIEW BY STUDY OBJECTIVE

Comments are based on the 2014 Initial Study Report for the Riparian Instream Flow Study (ISR 8.6); a subsequent Study Implementation Report (SIR 8.6 2015) including a supplemental Part D (2015); and several Technical Memoranda (principally Geo-Watersheds Scientific and R2 Resource Consultants, Inc. 2014).

Objective 1: Literature Review of Dam Effects on Downstream Vegetation.

Study methods are appropriate, and merging the review with the Fluvial Geomorphology Study (6.6) review into a single technical memorandum (R2 Resource Consultants, Inc. and Tetra Tech, Inc. 2014) resulted in a better product.

Objective 2: Focus Area Selection−Riparian Process Domain (RPD) Delineation.

Study methods are appropriate, and including satellite study sites to capture the variability in floodplain vegetation not found in the focus areas improves the level of information gathered for each RPD.

There remains some confusion about what constitutes pseudo-replication. One of Hurlbert's (1984) main points has to do with at what level replication was conducted and how the results are used to make predictions based on inferential statistics. Thus, "…the number of adequate sample sites necessary to perform robust statistical analyses, is addressed in the hierarchical riparian process domain sampling design …" (ISR 8.6, Part A – Page 5, last paragraph) is only true if a sufficient number of focus areas per RPD are sampled to attain the desired power of the statistic. One to three focus areas per RPD (i.e., ISR 8.6, Appendix A, Figure 1) are unlikely to be sufficient for "robust statistical analyses."

The innovative way RPDs were delineated, and the focus areas selected to represent the RPDs, are appropriate. We caution, however, against claiming statistical rigor for scaling-up the results to RPDs. Results need to be scaled up to RPDs, but our level of confidence in the scaled-up results will need to be supported by means other than inferential statistics based on the current study design.

For ISR 8.6, Appendix A, we suggest normalizing the results by Project River Mile. As acknowledged in Appendix A, RPD 3 has the most herbaceous vegetation based on the total transect length per RPD (e.g., Figure 2), but this is also the longest riparian process domain in the Middle River so it might be expected to have the largest total areas. In contrast, if the vegetation area were normalized by river mile, then the relative distribution of vegetation within RPDs would be more apparent. A final iteration of RPD delineation will be necessary to incorporate variation in ice processes and additional Lower River area, as acknowledged in SIR 8.6 Part D (2015).

We continue to question the adequacy of the focus areas representing herbaceous vegetation for the RPDs, since the analyses used to justify selecting the focus areas (ISR 8.6, Section 5.2 refers to Appendix A) continues to lump all herbaceous communities into one community type (herbaceous), while a number of woody communities with much less representation in the RPDs were used to justify the representativeness of the focus area.

<u>Objective 3</u>: Seed Dispersal and Seedling Establishment.

The methods for study Objective 3 have two subelements: (1) synchrony of seed dispersal, hydrology, and local Susitna River valley climate; and (2) seedling establishment and recruitment. The methodology for synchrony of seed dispersal is appropriate, although it would be desirable to sample more *Salix spp* at PRM 88 (i.e., ISR 8.6, Table 5.3-1) if additional specimens are available at that site.

The methodology for seedling establishment and recruitment is reasonable. Changing the FSP definition of balsam poplar and willow seedlings from plants with stems less than one-meter high to plants less than one year old, because it was difficult to differentiate between clonal and sexual recruitment without destructive sampling, was a good decision. Although not in the FSP, we recommend that AEA develop estimates of overwinter mortality of the seedlings because it is likely that winter mortality is very high in the presence of ice.

It will be very important to continue to distinguish between seedling and asexual reproduction. Seedling cohorts need to be summarized not just by elevation, but hydraulic position (e.g. inundating discharge) in order to link seedling establishment with flooding characteristics, using flow records. It is also critical that seedling patterns be characterized by distances along transects, in order to discern positions of unique cohorts. Only in this way can any secondary recruitment be identified.

Finally, USFWS recommends that winter mortality also be estimated, in order to get a sense of what locations are likely to result in ultimate pole and tree recruitment, and to help identify the importance of asexual reproduction in recruiting mature stands. Dendrochronology will continue to be a key tool in making these distinctions, along with recording ages of individuals by transect distance.

Objective 4: River Ice Effects on Floodplain Vegetation.

Objective 4 components are innovative, effective, and well developed. The ice scar mapping has continued through 2014 filling in sections of the Middle River and extending coverage into the Lower River. Preliminary results point to the importance of ice as a physical disturbance operating on a lateral extent that is large relative to open water flooding. Thus it may be important to characterize the frequency distribution of ice disturbance as a determinant of riparian succession and vegetation distribution. We suggest that although not critical as a requested study modification, that AEA explore how well multiple scarring events could be quantified by full “cookie” slabs (e.g., on downed or sacrificed trees). These cross-sections of the tree trunk can extend the historical frequency of scarring by revealing older ice scars that have completely grown over and are no longer detectable by external examination.

Objective 5: Floodplain Stratigraphy and Floodplain Development.

Work on this objective is being accomplished cooperatively with the Riparian Vegetation Study (11.6). Soil stratigraphy excavations are being conducted in association with Study 11.6 vegetation sampling locations, with a subset of the sediment cores being dated using radioisotopes. A substantial number of stratigraphic samples have been collected, including some collections from previously sampled vegetation plots in 2014. Some concerns have been raised about soil stratigraphy excavations occurring within permanent vegetation plots, but it seems reasonable to defer to the investigators to appropriately balance disturbance with slightly decoupling the soil and vegetation observations.

Less detail and progress has been reported for methods and measurement of erosion rates and integration of erosion with sediment accretion to produce synthetic analysis of floodplain turnover and development.

Objective 6: Riparian GW/SW Hydroregime and Plant Transpiration.

The methods for this study component are relatively sophisticated and some of the work is being done cooperatively with other studies (especially Groundwater, 7.5, and Riparian Vegetation, 11.6). Furthermore, several adjustments in the schedule, scope, and methods are in a grey area between modifications and variances. These are discussed by subelement of Objective 6 below and include: (1) introduction of new Rapid Vegetation Transect (RVT) sampling method for acquiring vegetation-groundwater paired sites for constructing vegetation-hydrology response curves; (2) moving groundwater wells outside of vegetation plots in some cases to avoid trampling; (3) likely less use of 2-D groundwater models and more use of observed and interpolated simple gradients and zones of river- or upland groundwater influence; and (4) less emphasis on evapotranspiration field work to parameterize the RIP-ET package for MODFLOW groundwater modeling. In general, USFWS concurs with these decisions. They were all discussed at TWG meetings to some extent. Suggestions for scaling back on evaporation-transpiration field work came as much from technical reviews as from the investigators. USFWS supports this decision based on the perspective that detailed variation in transpiration is not likely to be relatively important in the Susitna Valley region because it is not a precipitation limited region. The USFWS continues to have concerns about how well groundwater information will be able to drive vegetation distribution, especially with respect to scaling-up from focus areas and in predicting responses to Project alternatives that produce altered shallow aquifer water levels.

There are five subelements in Objective 6 work: (1) Stable Isotope Analyses, (2) Characterization of Rooting Depths, (3) GW/SW and Riparian Vegetation Modeling, (4) Plant Transpiration; and (5) Riparian Plant-Frequency Response Curves.

Stable Isotope Analyses (ISR Section 4.6.2.1): Investigating potential water sources for dominant woody and herbaceous species (i.e., precipitation, surface water from main and off channel areas, offsite groundwater sources) by stable isotope analysis is a sophisticated technique, although it may not directly produce a prediction of altered plant composition. To be most useful, plant xylem water should be collected during times of critical water stress (e.g., extended periods without precipitation and low groundwater levels), as well as times of abundance (e.g., periods of precipitation or high groundwater levels due to high river stage). These periods are not always easily defined in advance, but the June, July, and September sampling periods come close. Reporting the antecedent conditions for precipitation, river stage and groundwater for each sample period will be helpful in evaluating the potential to separate water sources for each sample period.

After the TWG meeting recommended by FERC's Study Plan Determination to discuss the sampling design for collecting plant xylem water, the comments were submitted to AEA and FERC (USFWS, Henszey 2013). Concern was expressed that the end-member mixing analysis (EMMA) proposed to estimate the different water sources used by plants requires n-1 independent tracers to uniquely identify n water sources (Phillips and Gregg 2001, Barthold et al. 2011). Currently there are four potential water sources (n = 4), and only two tracers (Hydrogen and Oxygen isotopes), so at least one additional tracer will be needed to meet the required minimum of three independent tracers to guarantee a unique solution. In addition, the two proposed stable isotope tracers may not be independent, since their isotopic fractionation processes scale each other. Work has proceeded using only two tracers. However, substantial insight into water sources may be obtained with only two tracers. Thus it is not critical to expand analysis to include additional tracers at this point. Analysis of the collected isotope data is needed to explore how much separation of sources in plant water can be obtained without analyzing for additional tracers.

Characterization of Rooting Depths (ISR Section 4.6.2.2): The root depth of dominant floodplain plants will be characterized by observing exposed roots along riverbanks, in trench excavations, and from soil core samples to determine root mass density. Observing exposed roots along riverbanks and in trench excavations is a generally accepted practice in the scientific community for describing root distribution dating back to at least Weaver (1915, 1919). There are methodological concerns about observations of root density (e.g., importance of non-suberized roots and details of washing roots from cores, Larenroth and Whitman 1971 and Sluiter et al. 2008).

The expanded methodology in ISR 8.6 for sampling soil-water content using reflectometers is good. If diurnal fluctuations in water content are observed (i.e., groundwater withdrawal by transpiration), and the amplitude of the fluctuations diminish with depth in the soil profile, these data may provide valuable insights into the effective rooting depth of floodplain plants.

A substantial amount of root depth data has been collected and more sampling is proposed. However, the utility of that data needs to be considered before embarking on substantially more field data collection. Some of the original motivation for collecting rooting depth data was its importance as a component of the RIP-ET (Baird and Maddock 2005) module for MODFLOW (Harbaugh 2005, Baird and Maddock 2005) groundwater modeling. It is currently unclear that this module will be needed or implemented in the Groundwater Study (7.5).

GW/SW and Riparian Vegetation Modeling (ISR Section 4.6.2.3): There are two parts of this work. The first is to develop the RIP-ET module of MODFLOW in collaboration with the Groundwater Study 7.5 using data on rooting depths, plant transpiration, groundwater levels, leaf area, and weather observations. A considerable amount of uncertainty has developed about how widely MODFLOW will be utilized and whether the RIP-ET component will be used as a part of MODFLOW applications. RIP-ET was developed for arid and semi-arid regions where rivers are often strongly “losing,” few trees and very low leaf areas are common away from the immediate vicinity of a river, precipitation is low, and potential evapotranspiration is high. Few of those conditions hold for the Susitna and vegetation-driven variation in ET may thus be considerably less important than in the locations where RIP-ET is most commonly used.

The second part of this work is the development of a data set of vegetation (collected in collaboration with Study 11.6) with concomitant surface water and groundwater conditions (produced by a combination of surface water and groundwater models, interpolation, and direct observation). The Rapid Vegetation Transect (RVT) vegetation sampling procedure was proposed in the 8.6 Study Implementation Report of 2015 to facilitate obtaining sufficient vegetation-hydrology replications. Additionally groundwater conditions at vegetation sampling locations will be obtained by a combination of direct well measurements, surface water observations of exposed groundwater, interpolation, and groundwater modeling. This seems likely to work for examining the current distribution of vegetation across sampled plots. It is less clear how well future conditions at other locations and under Project alternatives will be predicted with this approach to groundwater.

Plant Transpiration (ISR Section 4.6.2.4): Two methods are used to characterize plant transpiration: (1) continuous measurements of sap-flow velocity for woody species, and (2) periodic direct stomatal conductance from the leaves of herbaceous and small-shrub species. Both methods are sophisticated and should provide valuable insight into the transpiration process of floodplain plants along the Susitna River. The continuous sap-flow measurements for woody species will be especially valuable, since they should help to determine how these species respond to various water sources over the course of the growing season (e.g., precipitation events and water-table flux). The periodic direct stomatal conductance measurements will also provide valuable insight, but their value will likely be dependent upon collecting sufficient periodic data to observe diurnal and seasonal trends as well as response to critical events (e.g., water table extremes, and precipitation events).

Riparian Plant-Frequency Response Curves (ISR Section 4.6.3): This study component will develop quantitative relationships for dominant floodplain plant species and communities as determined by the GW/SW hydroregime. It will be valuable to include not only the deeper-rooted forest and shrub communities, but also the dominant shallower-rooted herbaceous communities. The shallower-rooted plant species and communities are likely to be more sensitive to regulated Project flows than the deeper-rooted species and communities.

There are numerous details of this analysis worthy of discussion, such as, what summary statistics of surface water and groundwater hydrology are appropriate, what resolution of groundwater levels is necessary, what forms of response curves should be considered (Henszey et al. 2004), how to deal with time since last disturbance and changes in hydraulic position from accretion, and how many observations of different vegetation and hydrology conditions are needed. Introduction of the RVT sampling protocol with less intensive use of observation wells should help obtain adequate sample size. The biggest concern is how to use vegetation-response curves that depend on predicting hydrology at unsampled locations (scaling up) or under new conditions (post-Project). Reasonable capabilities for doing this with open-water surface water are available. Parallel capabilities for ice-covered surface water and groundwater are less certain to be available.

Objective 7: Floodplain Vegetation Modeling Synthesis and Project Scaling.

The proposed approach is sophisticated and ambitious. It has potential for providing excellent information for comparing alternatives at multiple scales. However, it depends on results of several other studies and a number of predictive models that are not yet built. As noted above, the aspects most likely to be limiting in both scaling up from focus areas and in predicting Project impacts are (1) groundwater regimes, and (2) physical disturbance from ice.

SUMMARY COMMENTS

Study plan variances and conformance are identified in ISR and SIR 8.6. The most important modifications apply to future work and consist of (1) a reduced emphasis on transpiration measurement and modeling, and (2) modified vegetation-groundwater sampling for the purposes of quantifying vegetation-response curves. Although there are some potential limitations associated with both, they do seem generally reasonable and efficient. USFWS concurs with the reduction in transpiration measurements to (1) stomal conductance in 2013; and (2) sap flow in 2013 (partial) and 2014 (full). USFWS also concurs with the modification of paired vegetation-hydrology samples to include the Rapid Vegetation Transect approach and more use of groundwater transects, recognizing that there is some potential decrease in accuracy in order to achieve a reasonably large sample size.

Our two most important concerns and recommendations at this point are (1) using analysis and understanding based on work already completed to inform plans for the second phase of field work; and (2) how to use relations between vegetation and physical conditions of groundwater and ice scour.

The interruption in the original planned schedule due to funding issues offers the opportunity to adjust any new work based on careful analysis of results to date and increased understanding of how the system operates. With further analysis some objectives, such as the seedling establishment study, might reasonably be considered to be completed as originally planned. Additional vegetation-hydrology sampling is critical to establishing vegetation-response curves and thus for estimating potential Project effects. Increased understanding from the study to date suggests other work (frequency distribution of ice scar intensity) may call for more than originally planned effort, whereas less effort may be appropriate for other aspects (e.g., measurement of transpiration, implementation and calibration of RIP-ET, and maybe isotopic definition of water sources and measurement of rooting depths). The main point is that analysis should be the next step.

Depth to groundwater and the time since successional resets caused by ice scour may be very strong determinants of riparian vegetation along the Susitna River. Observations on existing ice scars and groundwater near or between wells will support a reasonable analysis of the relationships between these variables and current vegetation. However, using these relations to scale up from focus areas or to predict post-Project vegetation will require models to predict these physical variables. Some of these issues have been acknowledged and discussed with respect to groundwater in a recent Technical Memorandum (Geo-Watersheds Scientific and R2 Resource Consultants, Inc. 2014). However, there is considerable uncertainty about whether the ice processes and groundwater studies will be able to generate physical predictions well enough to support vegetation predictions.

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Studies 9.5 Fish Distribution and Abundance in the Upper Susitna River

Summary of Proposed Study Modifications and New Study

The 2013 and 2014 Study of Fish Distribution and Abundance in the Upper Susitna River was initiated to describe the current fish assemblage above the proposed Watana Dam (River Mile 184), including the spatial and temporal distribution, and relative abundance, by species and life stage. The intent is to provide a baseline description of fish assemblages in studied areas. This baseline, together with a number of other studies, is intended to be used to identify and evaluate potential project-induced effects on fish assemblages. An analysis of these data is intended to support recommendations for the protection, mitigation, and enhancement measures associated with the dam project.

The objectives of the Upper River Fish Distribution and Abundance (FDA) Study identified in the Federal Energy Regulatory Commission (FERC) study plan determination (April 1, 2013) include:

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 fish, 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 by:
    a. documenting the timing of downstream movement and catch using outmigrant traps;
    b. describing seasonal movements using biotelemetry (PIT and radio-tags); and
    c. describing 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.
6. Document the seasonal distribution, relative abundance, and habitat associations of invasive species (Northern Pike).
7. Collect tissue samples to support Study 9.14 (Baseline fish genetics).

Results from the Upper River studies have been compiled in two reports (ISR 9.5 2014 and SIR 9.5 2015). Three fundamental elements are still needed to fully understand, evaluate, and apply Study 9.5 results. First, AEA must describe the basic process of how the results of the study will be used to estimate project effects on fish populations, and provide statements about what is an acceptable level of accuracy and precision. Second, data collected in all sampling activities need to be made accessible and fully documented. And third, the data should be appropriately summarized and interpreted and statistical methods used in this process should be fully documented. Without these fundamental components, the study completion and documentation remains incomplete.

Although sampling was conducted over a three-year period (2012-2014), only one years sampling program was partially completed and results somewhat compromised by unknown interannual effects. USFWS recommends a minimum of two years of data collection be completed and results evaluated to determine if study objectives, including stated levels of precision, have been met. USFWS and NMFS have consistently recommended five years of study to understand interannual variation in physical and biological parameters. Analysis of the two years of research may well result in recommendations for additional years of studies.

Many study components of Study 9.5 remain incomplete or not attempted at all. These include a mark-recapture study to estimate rotary trap efficiency that was not conducted; association of movement patterns in relation to water conditions (discharge, temperature, and turbidity) that was not summarized; collection of tissue samples for mercury and other baseline metals that was below goal (and only mercury concentrations were measured); accurate location of spawning grounds and capture of holding Humpback and Round Whitefish and Burbot to assess gonadal condition that was not done; collection of Dolly Varden and Humpback Whitefish otoliths was far under sample goals and no documentation of analysis of these otoliths was provided; and only opportunistic fish stranding and trapping data were collected and not analyzed. The impact of these omissions has yet to be evaluated. The following list summarizes the most important comments and proposed study modifications.

Modification 1: The efficiency of each sampling gear type should be evaluated and compared so counts among sampling methods can be made comparable, interactions between sampling methods can be understood, and future sampling activities can be made more efficient. If such comparisons prove to be difficult or highly variable, then sampling gear should limited to the most effective gear types and deployment of this gear remain consistent.

The use of multiple sampling methods to measure fish abundance and distribution across a diversity of habitat types remains problematic. Different sampling gears have resulted in different, non-comparable measures of abundance. The effect of one sampling method on abundance estimates obtained in subsequent sampling activities is unknown. The same sampling gear-type is not used consistently (e.g. different electrofishing times or different densities of minnow traps). The use of block nets seems to be inconsistent.

The generally accepted scientific practice is to apply consistent methods and effort among sampling units to properly compare relative abundance by species and age class among habitat classification types. Studies 9.5 and 9.6 have collected a vast amount of abundance data. USFWS recommends that these data be evaluated to identify the most efficient and repeatable sampling protocol and this protocol remain consistent for all abundance measurements.

Modification 2: Develop a complete operational plan for relative abundance sampling that adheres to the statistical methodology used to designate sampling sites and provides estimates with acceptable precision. Expand the geographic range of sampling to include mainstem and tributaries upstream of the reservoir inundation zone. Implement this plan with no variances.

Sample site selection in 2013 was deemed to be deficient, with a number of tributaries being inaccessible and only one side channel, one side slough and three tributary mouth/plumes being sampled in the mainstem. Sampling of accessible tributary sites was incomplete, with only 36% of the selected stream length being sampled. The diversity of mainstem sample sites was much greater in 2014, although the number of sites remained below study plan goals (FSP 9.5 2014 and IP 2014). The Black River sampling plan in 2014 was proposed as a prototype for sampling other tributaries. The 2014 Black River sampling did adhere to the sample design. Proposed future sampling goals for other tributaries tended to be larger than 2013 but less than the study plan goals.

The tributary and mainstem river habitat upstream of the reservoir inundation zone were not sampled. These areas likely provide spawning, migration, and rearing habitat for a number of fish species including salmon. Construction of a dam, creation of a 70 mile long reservoir and zone of zero water velocity, and sediment deposition and channel morphology alteration at the head of the reservoir may adversely affect migration, growth, reproduction, and survival of fish species in these areas.

Although the data collected during Upper River abundance sampling activities are incomplete, ambiguous, and limited, they may provide a basis for designing a sampling program that would provide levels of precision necessary to achieve study objectives. Accurate and verified mapping of the Upper River drainage also provides another source of information that improves sample design over earlier study plans. In this planning process, USFWS recommends that main channel, split main, and multiple split macrohabitats be classified as a single main channel macrohabitat and tributary mouth sampling should be conducted as other macrohabitat sampling and not limited to clearwater plumes. The mainstem Susitna River and drainages that enter into the Susitna River above the inundation zone should be included in the selection of habitats to be sampled. The streams include the Tyone River, Maclaren River and Clearwater Creek. Scale aging for juvenile salmon is a proven method for allocating fish to different age groups and should be employed for these fish. Scale aging, fin ray aging, or other simple and non-destructive means to age other species of fish should be investigated. Fish should be weighed to the nearest 0.1 gram and lengths measured for all captured fish.

Modification 3: Develop a complete and rigorous early life history sampling program that better integrates the intergravel monitoring component of the early life history studies and focuses on the location and timing of Chinook Salmon emergence. This sampling program should also be integrated with the abundance and distribution sampling program to provide an understanding of the early spring distribution of fish species and life stages.

The early life history sampling objective was added late in the planning process. Sampling was conducted in early and late June in 2013. Sampling was not done in 2014. Because sampling was limited to select tributaries and not comparable to the more extensive summer and fall sampling of both mainstem and tributary habitats, the overwintering distribution and movements between tributary and mainstem habitats remains poorly understood. Only five juvenile Chinook Salmon were found in these June samples, providing little information on the timing of emergence and movement of these fish. With the exception of Arctic grayling and stickleback, large numbers of zero catches were observed for other fish species.

A spring sampling program that is comparable to the summer and fall sampling program should be considered in the operational planning of a relative abundance sampling program (Modification 2). These data would help determine if resident fish overwinter in tributaries or the mainstem. Additional early life history sampling in areas of known Chinook Salmon spawning and redd construction would help identify the timing and water conditions of emerging Chinook Salmon and provide information on migration to rearing habitat. The 2014 early life history sampling in the Middle River proved to be very systematic and effective, capturing over 18,000 juvenile salmon (SIR 9.6 2015). The design of this sampling program could provide a good model for design of the Upper River early life history sampling.

Modification 4: Continue and expand downstream migrant trap operations for two years. Evaluate the ability of these traps to describe the timing of fish migrating past these sites.

Rotary screw traps were operated at two tributary sites in 2013 and a mainstem and tributary site, with fyke net sampling at another tributary site, in 2014. Under a schedule of two days of trap operation, followed by three nonoperational days, poor performance under some stream conditions, and seasonal limits imposed by icing, Upper River rotary screw traps were marginally successful in accurately describing downstream migration of some fish species and effectively unsuccessful for other species. The small number of fish caught in Upper River traps (especially Chinook Salmon, which averaged less than 10 fish per trap over the entire season), the generally uniform catches throughout the season, sometimes increasing during the last days of operation in the fall, and the inability to operate in early spring when fish may initiate downstream migration all indicate that the sampling was unsuccessful.

Understanding the magnitude and timing of downstream migration pass the dam site is crucial to assessing potential project related impacts and evaluating passage alternatives. Understanding migration between tributaries and mainstem river habitats is also important in understanding dam effects on fish behavior. The performance of rotary screw traps, to date, has been poor and provided little information on migration for most species, especially Chinook Salmon. Modifications to trap operations need to be discussed, implemented, and evaluated to determine if data needs are being met. These modifications may include expanding operations to seven days a week, assessing the efficiency of traps, relocating traps to areas immediately downstream from tributary mouths, relocating traps to waters more favorable to trap operations, and the use of alternative capture methods.

Modification 5: Evaluate the effectiveness and value of the PIT tagging program.

The value of the 2013 and 2014 PIT tagging and detection program to describe fish movements is questionable. PIT array antennas were not installed in sequential spatial intervals at antenna sites, eliminating the ability to both discriminate upstream or downstream movement and assess the detection efficiency. Very small numbers of tagged fish were captured outside the areas where they were tagged. No Chinook Salmon tagged in the Upper River were recaptured Interpretation of results from the few fish that are recaptured are problematic since tagging effort is not representatively distributed over habitat types or behavior characteristics.

A detailed evaluation of the results of PIT tagging activities and discussion among involved researchers may provide insights into ways to improve and expand the existing sampling and tagging program, to redirect tagging objective to more attainable results (e.g. intensive study of a limited section of river), or to abandon the PIT tagging program and direct resources to other sampling activities.

Modification 6: Continue the planning and implementation of radio-tagging studies. Evaluate results from the two years of tagging and almost three years of locating tagged fish and assess if tagging goals are appropriate and achieve stated objectives. Conduct targeted searches to identify specific holding or spawning locations.

Radio-tagging did provide a good description of fish movements for the few fish that did survive. However, the study is very much crippled by the variances. Radio-tagging goals were only achieved for four species in the Upper River and two species in the Middle and Lower River. Low survival in the months after tagging further reduced tagging numbers. For example, in January, 2015, a total of 91 radio-tagged fish (out of 249 applied radio-tags) of all species were located in the Upper River and 24 radio-tagged fish (out of 179 applied radio-tags) located in the Middle and Lower River. Manual tracking and directed searches to identify habitat type of spawning or holding fish was not conducted.

Radio-tagging studies were employed to analyze the seasonal distribution and movement of fish throughout the range of potential habitats. These data are crucial in developing an understanding of effects of change from riverine to reservoir lacustrine habitats on fish distribution, abundance, migration, and spawning in the impoundment zone. Understanding the effects of fluctuating reservoir surface deviations on fish access and movement between reservoir and tributary is also important. Unfortunately, little information was presented on movement and holding patterns. Only the movements of selected Arctic Grayling and Longnose Sucker were presented in ISR 9.5 (2014) and no spawning locations were identified for any species. Detailed analysis of the current radio-tagging data should provide at least some general ideas on movement and distribution and direction for subsequent radio-tagging studies. Future radio-tagging activities need to include precise location and identification of habitat associated with holding and spawning activities.

Study 9.5 summary

In summary, an ambitious set of objectives and accompanying studies were proposed in support of Studies 9.5 generating vast amounts of data, which are extensive in both quantity and complexity. Very little data have undergone analysis and none of the study objectives have been completed. Some elements of these studies remain incomplete, due to sampling goals not being met or some studies simply not being conducted. Other studies proved to be impractical or inconclusive and require reevaluation of study feasibility (PIT tagging, Upper River rotary trap sampling, and Upper River early life history studies). However these data, when analyses are completed, can provide a resource for determining what is feasible, determining the expected levels of accuracy in future sampling, and determining optimum allocation of sampling effort for future studies. Of course, to realize these benefits require that the data that was previously collected be made available, be complete, and be fully documented.

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9.6 Fish Distribution and Abundance in the Middle and Lower Susitna River

Summary of Proposed Study Modifications and New Studies

The 2013 and 2014 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River was initiated to describe the current fish assemblage below the proposed Watana Dam (River Mile 184), including the spatial and temporal distribution, and relative abundance, by species and life stage. The intent is to provide a baseline characterization of fish assemblages in studied areas. This baseline, together with a number of other studies, is intended to be used to identify and evaluate potential Project-induced effects on fish assemblages. An analysis of these data is intended to support recommendations for the protection, mitigation, and enhancement measures associated with the dam. Study 9.6 complements Study 9.5, Study of Fish Distribution and Abundance in the Upper River. Many of the objectives, sampling methods, and means to summarize data are similar, resulting in comparable comments and study modifications.

Results from the Middle and Lower River studies have been compiled in two reports (ISR 9.6 2014 and SIR 9.6 2015). Although the data collected in these studies is extensive, three fundamental elements are still needed to fully understand, evaluate, and apply Study 9.6 results. First, AEA must describe the basic process of how the results of the study will be used to estimate Project effects on fish populations, and provide statements about what is an acceptable level of accuracy and precision. Second, data collected in all sampling activities need to be made accessible and fully documented. And third, the data should be appropriately summarized and interpreted and statistical methods used in this process should be fully documented. Because these fundamental components are missing, the study completion and documentation remain incomplete.

Although sampling was conducted over a three-year period (2012-2014), only a one year's sampling program was partially completed and results compromised by unknown interannual effects. Anomalous weather and low adult salmon returns in 2012 likely make 2013 abundance and distribution of juvenile salmon and other fish species non-representative of average conditions in the Susitna River. USFWS recommends a minimum of two years of data collection be completed and results evaluated to determine if study objectives, including stated levels of precision, have been met. USFWS and NMFS have consistently recommended five years of study to understand interannual variation in physical and biological parameters. Analysis of the two complete years of research may well result in recommendations for additional years of studies.

Many study components of Study 9.6 remain incomplete or not attempted at all. These include a mark-recapture study to estimate rotary trap efficiency that was not conducted; association of movement patterns in relation to water conditions (discharge, temperature, and turbidity) that was not summarized; diurnal behavior is poorly documented and only studies in the winter months of February, March, and April; accurate location of spawning grounds and capture of holding Humpback and Round Whitefish and Burbot to assess gonadal condition that was not done; and only opportunistic fish stranding and trapping data were collected and not analyzed. The impact of these omissions has yet to be evaluated. The following list summarizes the most important comments and proposed study modifications.

Modification 1: The efficiency of each sampling gear type should be evaluated and compared so counts among sampling methods can be made comparable, interactions between sampling methods can be understood, and future sampling activities can be made more efficient. If such comparisons prove to be difficult or highly variable, then sampling gear should limited to the most effective gear types and deployment of this gear remain consistent.

The use of multiple sampling methods to measure fish abundance and distribution across a diversity of habitat types remains problematic. Different sampling gears have resulted in different, non-comparable measures of abundance. The effect of one sampling method on abundance estimates obtained in subsequent sampling activities is unknown. The same sampling gear-type is not used consistently (e.g. different electrofishing times or different densities of minnow traps). The use of block nets seems to be inconsistent.

The generally accepted scientific practice is to apply consistent methods and effort among sampling units to properly compare relative abundance by species and age class among habitat classification types. Studies 9.5 and 9.6 have collected a vast amount of abundance data. USFWS recommends that these data be evaluated to identify the most efficient and repeatable sampling protocol and this protocol remain consistent for all abundance measurements.

Modification 2: Develop a complete operational plan for relative abundance sampling that adheres to the statistical methodology used to designate sampling sites and provides estimates with acceptable precision. Implement this plan with no variances.

The number of sites sampled in 2013 was deemed to be inadequate, with a number of tributaries and Middle River mainstem sites being inaccessible or reclassified to other habitat types. In the Middle River, 162 of 207 sites were sampled. Off-channel sites were poorly sampled in the Lower River with only 4 side channel, 2 upland slough, and 3 side slough habitats sampled in 2013. Classification of habitat type and sample design was inconsistent between Middle and Lower River studies. The intention of the 2014 abundance and distribution sampling was to return to the unsampled 2013 sample sites and complete the first year of sampling for the Middle River. No abundance and distribution sampling was conducted in the Lower River.

Although the data collected during Upper River abundance sampling activities are incomplete, ambiguous, and limited, they may provide a basis for designing a sampling program that would provide levels of precision necessary to achieve study objectives. Accurate and verified mapping of the Middle and Lower River drainages also provides another source of information that improves sample design over earlier study plans. In this planning process, USFWS recommends that main channel, split main, and multiple split macrohabitats be classified as a single main channel macrohabitat and tributary mouth sampling should be conducted as other macrohabitat sampling and not be limited to clearwater plumes. Sampling should also occur at the mouths of side sloughs and upland sloughs. Classification of sloughs should be based on stream bank morphology and not clarity of water. Early life history sampling should be extended to sampling sites identified for summer and fall abundance and distribution sampling in the spring, immediately after ice breakup, to understand fish distribution during this potentially critical time of year (see Modification 3). Scale aging for juvenile salmon is a proven method for allocating fish to different age groups and should be employed for these fish. Scale aging, fin ray aging, or other simple and non-destructive means to age other species of fish should be investigated. Fish should be weighed to the nearest 0.1 gm and lengths measured for all captured fish.

Beaver pond habitat may prove to be an important habitat for juvenile salmon rearing and overwintering (Malison et al, 2014; Collen and Gibson 2011). Beaver ponds are currently a mesohabitat level category, meaning that this habitat is sampled if it occurs in a macrohabitat selected for sampling and is located in the first 200 m of stream length to be sampled. Several beaver pond habitats were sampled in 2013 and winter of 2014. Analysis of data from these samples and discussion among Susitna River researchers may recommend that beaver pond habitat be classified as a macrohabitat. This would ensure that a targeted number of beaver pond habitats would be sampled and compared to other habitat types.

Modification 3: Continue the development of a complete and rigorous early life history sampling program that better integrates the intergravel monitoring component of the early life history studies. This sampling program should also be integrated with the distribution and abundance (FDA) sampling program to provide an understanding of the early spring distribution of fish species and life stages. Include a modification to species identification that better identifies and estimates the salmon species composition of emergent and rearing juvenile salmon (see Modification 4).

Sampling was conducted before ice breakup and in early and late June in 2013 and in three sampling periods from May 19 through June 25 in 2014. About two thousand juvenile salmon were counted in 2013 and over 18,000 juvenile salmon counted in 2014. The Intergravel Monitoring component of the Early Life History studies was not incorporated into emergence and migration of juvenile salmon. In fact, it appears that the winter intergravel monitoring in spring of 2013 was terminated in April, 2013, just prior to the ELH sampling in May and June. Intergravel monitoring in 2014 seemed to be directed more towards fish distribution in the winter studies, not emergence of salmon in April and May. Because sampling was limited to select sites, these sites were located only in the Middle River in 2014, transect lengths were smaller than abundance and distribution sampling, and sampling gear was limited to fyke nets, early life history samples are not comparable to the more extensive summer and fall sampling of both mainstem and tributary habitats. The overwintering distribution and movements between tributary and mainstem habitats remains poorly understood.

A spring sampling program that is comparable to the summer and fall sampling program should be considered in the operational planning of a relative abundance sampling program (Modification 2). The 2014 early life history sampling in the Middle River proved to be very systematic and effective, capturing over 18,000 juvenile salmon (SIR 9.6 2015). The design of this sampling program could provide a good model for extending early life history sampling to Lower River sites.

Modification 4: *Develop a protocol for accurately and correctly identifying all juvenile salmon to species. If numbers of individual fish preclude genetically identifying each specimen, then implement a sampling program that provides acceptable estimates of species composition of samples.*

Accuracy in species identification needs to be improved. In 2013, 28% of Coho Salmon were misidentified as Chinook Salmon (SIR 9.6, 2015). Based on length frequencies of juveniles identified as Chinook Salmon, this level of misidentification may be much greater. Species misidentified also occurred between other species of salmon. Modification in species identification protocol in 2014 substantially improved identification of Chinook and Coho salmon in FDA samples. However, over 80% of the salmon captured in Early Life History studies were designated as mixed Chum/Sockeye salmon or as mixed salmon. High or unknown error rates in identifying salmon to species or allocating a group of juvenile salmon to a mixed species category is unacceptable.

Genetic identification should be conducted on as many individuals as possible to estimate rates of misidentification for all species of juvenile salmon. Subsampling early life history catches would provide a more specific species allocation of catches. Mixed-species designation drastically limits any potential usefulness of the resulting data, and should be avoided.

Modification 5: Continue and expand downstream migrant trap operations for two years. Evaluate the ability of these traps to describe the timing of fish migrating past these sites.

Rotary screw traps were operated at four sites in 2013 and no traps were operated in the Middle and Lower River in 2014. The four traps were more successful in capturing downstream migrating fish than Upper River traps, especially for juvenile salmon. The traps average annual catch was 2,884 fish, of which 66% were juvenile salmon. Problems did occur with debris loads and flood events, resulting in several sampling periods where traps were not operational. Juvenile salmon were caught immediately on installation of all four traps, indicating that downstream migration of juveniles was already underway in mid-June, and timing statistics do not include early downstream migrants.

The rotary screw traps in the Middle River did perform well in documenting the downstream migration of fish in summer and fall. Understanding the magnitude and timing of downstream migration from tributaries to mainstem habitats and from in-river to marine environments is important for assessing potential Project related impacts. Modifications to trap operations which could improve trap performance include expanding operations to seven days a week, assessing the efficiency of traps, beginning trap operations earlier in the season, relocating traps to waters more favorable to trap operations, and the use of alternative capture methods.

Modification 6: Evaluate the effectiveness and value of the PIT tagging program.

The value of the 2013 and 2014 PIT tagging and detection program to describe fish movements is questionable. PIT array antennas were not installed in sequential spatial intervals at antenna sites, eliminating the ability to both discriminate upstream or downstream movement and assess the detection efficiency. Very small numbers of tagged fish were captured outside the areas where they were tagged. Interpretation of results from the few fish that are recaptured are problematic since tagging effort is not representatively distributed over habitat types or behavior characteristics.

A detailed evaluation of the results of PIT tagging activities and discussion among involved researchers may provide insights into ways to improve and expand the existing sampling and tagging program, to redirect tagging objective to more attainable results (e.g., intensive study of a limited section of river), or to abandon the PIT tagging program and direct resources to other sampling activities.

Modification 7: Continue the planning and implementation of radio-tagging studies. Evaluate results from the two years of tagging and almost three years of locating tagged fish and assess if tagging goals are appropriate and achieve stated objectives. Conduct targeted searches to identify specific holding or spawning locations.

Radio-tagging provided a good description of fish movements for the few fish that did survive. However, the study is very much crippled by the variances. Radio-tagging goals were only achieved for four species in the Upper River and two species in the Middle and Lower River. Low survival in the months after tagging further reduced tagging numbers. For example, in January, 2015, a total of 91 radio-tagged fish (out of 249 applied radio-tags) of all species were located in the Upper River and 24 radio-tagged fish (out of 179 applied radio-tags) located in the Middle and Lower River. The release of radio-tagged fish was not distributed throughout the Susitna River drainage, but concentrated in a few limited areas, limiting results to just those populations. Manual tracking and directed searches to identify habitat type of spawning or holding fish was not conducted.

Radio-tagging studies were employed to analyze the seasonal distribution and movement of fish throughout the range of potential habitats. These data are crucial in developing an understanding of effects of changes in river flow due to dam operations on fish distribution, abundance, migration, and spawning in the Middle and Lower River. Generally qualitative information was provided for movements in the Susitna River drainage and potential foraging locations were identified. Often this was limited to the movement history of a few radio-tags. No spawning locations were identified for any species. Detailed analysis of the current radio-tagging data should provide at least some general ideas on movement and distribution and direction for subsequent radio-tagging studies. Future radio-tagging activities need to include precise location and identification of habitat associated with holding and spawning activities. Radio-tagging efforts should be allocated proportionally throughout the Susitna River drainage to study the movements of all populations of resident fish.

Modification 8: Develop an operational plan for winter sampling that increases the geographic range and diversity of habitats sampled and includes measuring physical attributes of the sites.

The ad hoc selection of sample site during winter sampling (e.g., selecting open water areas) and the small range in sampled area of the river (37 river miles of Middle River habitat, compared to 200 total river miles) limits the ability to make interpretations of or draw conclusions from winter sampling results. For example, warmer water may create open leads which are easier to sample, and may also be more attractive to juvenile salmonids. The use of video for sampling should be limited or paired with other sampling methods since 85% of observed fish were either undifferentiated salmon or unidentified species. Four species of emergent fry salmon were captured in the March and April of 2014 sampling periods, but no Pink Salmon were recovered in any winter samples. Juvenile Pink Salmon were also scarce in 2013 samples. Pink Salmon fry were found in 2014 Early Life History studies. The scarcity of Pink Salmon fry in many of the samples should be of concern and a subject for directed sampling efforts.

Modification 9: Develop a more complete sampling and radio-tagging program for Northern Pike populations.

Tagging of Northern Pike was limited to 5 radio-tags being applied in the same general location (Yentna-Deshka zone). Four of these tags were still active in 2014 and two still active in 2015. There was no focused effort to census waters outside of the abundance and distribution study area or to present results other than to state that the radio-tagged fish remained within one river mile of the tagging location in 2013. Far more effort and resources need to be allocated to this part of the study in order to meet the objective.

The sampling plan should identify sampling locations and methods that can target Northern Pike populations. Radio-tagging goals need to be developed that adequately describe the movement of these fish. Studies from the Sport Fish Division of Alaska Department of Fish and Game and possibly other agencies should be referenced to obtain a better understanding of the abundance, distribution, and movement of this fish species.

Study 9.6 summary

In summary, an ambitious set of objectives and accompanying studies were proposed in support of Studies 9.6 generating vast amounts of data, which are extensive in both quantity and complexity. Very little data have undergone analysis and none of the study objectives have been completed. Some elements of these studies remain incomplete, due to sampling goals not being met or some studies simply not being conducted. Other studies proved to be impractical or inconclusive and require reevaluation of study feasibility (PIT tagging and Northern Pike studies). However these data, when analyses are completed, can provide a resource for determining what is feasible, determining the expected levels of accuracy in future sampling, and determining optimum allocation of sampling effort for future studies. To realize these benefits however, requires that the data that was previously collected be made available, be complete, and be fully documented.

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9.7 Salmon Escapement

Summary of Proposed Study Modifications and New Studies

The salmon escapement study (Study 9.7) was launched to characterize the distribution, abundance, habitat use, and migratory behavior of all species of adult anadromous salmon across mainstem river habitats and select tributaries above the Three Rivers Confluence. The study was also to specifically estimate the distribution, abundance, and migratory behavior of adult Chinook Salmon throughout the entire Susitna River drainage and the Coho Salmon distribution and abundance in the Susitna River above the confluence of the Yentna River. Unfortunately, this study had several variances and setbacks, most notably the failure of the Indian River weir in 2014 due to high water. Still, a large number of migrating salmon were successfully radio tagged, and a large number survived and were tracked to a final destination.

We agree that most—but not all—of the study objectives of this study were met and that the study was well planned and mostly well conducted. Even so, this study has been insufficient to accurately characterize the typical magnitude and spatial distribution of Chinook Salmon in the Upper River. The escapement study was conducted during years of low abundance and years with age-class distribution shifted to younger age classes[1]. As age class is strongly related to size, and size may be related to a fish's ability to pass to the upper reaches of the Susitna River and breed, the observed numbers of radio-tags probably fails to represent the spatial distribution and magnitude of large-sized Chinook Salmon that spawn in the very upper reaches of the Susitna River, past Devils Canyon, in a typical year. This study should not be considered adequate to reliably characterize the overall spatial distribution, size distribution, and magnitude of Chinook Salmon escapement in a typical year.

The magnitude of the Chinook Salmon escapement estimates were likely not only underestimates of what might be considered present in a typical year, but these studies likely underestimated the magnitude of the escapement in the Upper River for the low-abundance years of the study. This hypothesis is supported by the observation of a relatively large number juvenile Chinook Salmon documented within the Upper River—relatively large with respect to the estimated adult Chinook Salmon escapement. Also, in an earlier analysis of preliminary data, Upper River Catch Per Unit Effort (CPUE) averages for juvenile Chinook Salmon were similar in magnitude to estimates of CPUE for Middle and Lower River sites (ISR 9.5, Draft Feb 2014)." If this pattern is repeated as more data is analyzed, it probably indicated that a larger percentage of the Chinook Salmon run is migrating to the Upper River than the radio tagging program indicated. It

[1] Lewis, B., W.S. Grant, R.E. Brenner, and T. Hamazaki. 2015. Changes in Size and Age of Chinook Salmon *Oncorhynchus tshawytscha* Returning to Alaska. PloS one, 10(6), p.e0130184.

should not be surprising or unexpected that the radio tagging process would diminish the ability of Chinook Salmon to survive and finish the migration, even in a well-conducted study. The USFWS is especially concerned that the fish and aquatic studies, which were conducted during historically low Chinook Salmon returns, will result in the under-appreciation of the importance of Upper River habitats to Chinook Salmon production in Cook Inlet.

Additionally, due to variances, the study did not adequately document mainstem salmon spawning locations by macrohabitat nor did it provide information on physical habitat characteristics at spawning locations. Airplane and helicopter surveys that identified mainstem-spawning locations were not followed up by boat and foot surveys, as described in the study plan. We do not have good information on the number of mainstem off-channel habitats used for salmon spawning. We also do not know if different macrohabitat types provide preferred spawning habitat for any particular salmon species. The adult escapement study, through ground and boat surveys, did not provide information on the characteristics of mainstem salmon spawning habitat at the macro- and mesohabitat level. This information is necessary to determine if the two Middle River focus areas, where spawning surveys were conducted, are representative of side channels, sloughs, and tributary mouths that provide spawning habitat for Pacific salmon in the Middle and Lower River.

Modification 1: There should be some additional radio tagging in the middle river and with tags tracked to specific spawning locations.

This additional radio tagging will permit the identification of exact locations of mainstem salmon spawning locations by macrohabitat, and provide information on physical habitat characteristics at spawning locations (information that will be needed for other studies). When general locations are identified by airplane or helicopter surveys, the specific locations will need to be identified by boat and foot surveys, as originally intended for this study. The mainstem off-channel habitats used for salmon spawning and preferences of macrohabitat type for each particular salmon species must be recorded. The additional tagging should also provide information on the characteristics of mainstem salmon spawning habitat at the macro- and mesohabitat level. This information is necessary to determine if the two Middle River focus areas, where spawning surveys were conducted, are representative of the hundreds of side channels, sloughs, and tributary mouths in the Middle and Lower River.

Modification 2: Develop a complete operational plan for an additional year of radio tagging and tag recoveries. Implement this plan with no variances.

Rather than proposing very specific tag numbers and tag recovery effort measures, we propose that the various trade offs be carefully weighed against each other, and that the most cost-effect set of decisions be fully described in an operational plan. This plan should describe the specific sampling goals and lay out measurable objectives. These operational plans should be developed cooperatively with NOAA and USFWS and other knowledgeable stakeholders.

9.8 River Productivity

Summary of Proposed Study Modifications and New Studies

Introduction

The River Productivity Study was intended to provide baseline information on river productivity and the means to estimate changes in river production, in response to operational scenarios of the proposed Susitna-Watana project (Project). Understanding how differences in food availability, food quality, temperature, and velocity affect juvenile salmon growth among macrohabitats will provide necessary information for evaluation of the current environment and probable Project effects. This information is necessary for the US Fish and Wildlife Service (USFWS) to develop mitigation measures intended to protect, mitigate or enhance affected resources.

Deviations from the FERC-approved study plan may have prevented the collection of information needed by the USFWS to assess Project impacts. The objectives of the River Productivity study do not appear to have been met through implementation of the "first" study year's field methods (2013 and 2014). Reviews identified inconsistencies between the study plan (RSP) and the implementation plan (3/1/2013), including inconsistent sampling methods or sampling effort among sampling locations. These inconsistencies may compromise responsiveness of data to the RSP and complicate analyses. The study effort was also not coordinated with other interrelated studies as well as it could have been, in terms of sampling locations. In response to these concerns, the USFWS has provided study modifications intended to improve the responsiveness of this study to the FERC-determination, in order to meet the objectives of the RSP. Integration of this study with interrelated studies may also benefit from a new study for Model Integration. A New Study request for Model Integration is included as an enclosure.

The nine objectives of the River Productivity Study identified in the Federal Energy Regulatory Commission (FERC) study plan determination (April 1, 2013) are:

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 Lower 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 Lower 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 Lower 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.

USFWS requests the following study modifications to the River Productivity study, as it was implemented. These modifications, should improve adherence to the FERC-approved study plan and the likelihood of meeting the approved study's goals and objectives:

Modification 1-1: Provide a description of the key words and databases used for literature searches so the completeness of this review can be ascertained.

Modification 2-1: Repeat benthic macroinvertebrate, benthic organic matter, and periphytic algal sampling at all tributary mouth sampling locations to complete the study according to the study plan, using appropriate sampling methods for water depths and velocities. Implement accepted scientific practices for macroinvertebrate and algal sampling scientific practices. Sample a minimum of 6 additional tributary mouths in the Middle River, below Devils Canyon. As implemented, sampling did not adhere to the approved study plan.

Modification 2-2: Complete periphytic algal sampling at upland slough locations to complete the study, according to the approved study plan.

- Repeat sampling of benthic macroinvertebrates, macroinvertebrate drift, benthic organic matter, and periphytic algae at upland slough sampling locations per the study plan, using appropriate sampling methods for water depths and velocities, and implementing accepted macroinvertebrate and algal sampling scientific practices.
- Sample a minimum of five replicate upland slough habitats per the study plan. Avoid incorrect classification and inclusion of sites that did not fit the upland slough definition, namely the aquatic habitat near Montana Creek.
- Co-locate upland slough sites selected for the River Productivity study be co-located with upland sloughs sampled for the FDA study.
- Sample additional upland sloughs in the Middle River below Devils Canyon.

Modification 2-3 and 2-4: Select side slough and side channel sampling units and sampling locations according to the approved study plan. Sampling units must be selected to represent the river, in accordance with the hierarchical habitat model adopted for this project. Sample locations should also be selected in accordance with the approved study plan.

Modification 2-5: Select representative main channel sampling units within each focus area at a minimum of 6 locations. Within these units, sampling locations must be distributed throughout the 500 m sampling unit, as determined in the approved study plan.

Modification 2-6: Collect macroinvertebrate samples at locations wetted under most flow conditions and collect samples in accordance with the approved study plan. According to the RSP, samples were to represent the river in accordance with the hierarchical habitat model adopted for the Project. Sampling locations must adequately represent the macro and mesohabitats defined by the Projects habitat model.

Modification 2-7: Include collections of invertebrates and algal samples from sites dominated by finer grained substrates (not just cobbles), so that the samples are representative of the substrates at each location, per the approved study plan.

Modification 2-8: Collect algal samples from multiple depths (0-1, 1-2, 2-3 feet) within each macrohabitat, proportional to the depths present and such that all sites are inundated for 30 day prior to sampling, following the study plan.

Modification 2-9: Collect benthic macroinvertebrate and algal samples during the spring, summer, and fall sampling periods for a minimum of two years as described in the approved study plan.

Modification 2-10: Repeat the invertebrate emergence study in a subsequent year to obtain adequate replication among all macrohabitats.

Modification Objective 3-1: Measure invertebrate drift upstream and downstream from tributary mouths during the second year of sampling, as provided for in the approved study.

Modification 3-2: Conduct drift sampling every 4 hours in one or more of each representative macrohabitat to determine diel variation in drift during each sampling event.

Modification 3-3: Repeat tows in slow water habitats using a mesh sized for zooplankton collection, in order to estimate the contribution of zooplankton as a food resource in these habitats.

Modification 4-1: Conduct reference sampling in the Talkeetna River sufficient to provide replicate measures of all five of the major macrohabitats.

Modification 5-1: Use bioenergetics modeling to evaluate the pre- and post-Project influence of temperature, water velocity, food availability and food quality on juvenile Coho and Chinook salmon at five or more replicate Middle River main channel or side channel, tributary mouth, side slough, and upland slough macrohabitats.

- Refine study objectives using bioenergetics modeling to evaluate the pre- and post-project influence of temperature, water velocity, food availability and food quality on juvenile Coho and Chinook salmon at five or more replicate Middle River main channel or side channel, tributary mouth, side slough, and upland slough macrohabitats.
- Macrohabitats should be located within Middle River focus areas, below Devils Canyon, to take advantage of 2D hydraulic modeling and to overlap with the distribution of juvenile salmon. However, not all macrohabitats within a focus area need to be sampled, as long as there are five or more replicates of each macrohabitat type. These macrohabitats are most likely to support rearing juvenile Coho and Chinook salmon, and vary in temperature, water velocities, and macroinvertebrate species.
- Conduct the study between July and early September. Sampling during this time period will reduce effort and allow time for age-0 juvenile salmon to move from spawning to

summer rearing locations, and for most age-1+ Chinook Salmon to emigrate from the Middle River. Fish sampling must be conducted to provide a measure of relative abundance on each sampling date and at each sampling site.

- Cold brand all Chinook and Coho salmon captured on each sampling event with unique marks for sampling location, and individuals to determine average growth within a site between sampling events and individual growth for recaptured fish. Measure a the fork length of fish and the first 50 of each species at each sampling location an each sampling event, weighed to the nearest 0.1 g. Invertebrate drift sampling should occur every other week throughout this time period.
- Coordinate this study with other studies to determine the number and locations of additional water temperature monitoring locations within each sampling site to provide accurate and representative values. This modification will be best accomplished within a new study for Model Integration. A New Study request for Model Integration is included as an enclosure.
- All sample locations should be distributed to adequately represent each macrohabitat within each focus area, according to the Projects hierarchical habitat model.

Modification 7-1: Collect and analyze diets from a minimum of 8 fish with food in their stomachs, for each fish species and life stage, as required in the study plan (Objective 7).

This does not appear to have been completed in order to meet Objective 7.

Modification 8-1: Expand the geographic scope of the River Productivity Study to the Lower River.

The USFWS and NMFS (Services) raised concerns that macroinvertebrate sampling, using a Hess sampler, would result in samples collected at shallow depths in previously dewatered sample sites. To prevent these sampling problems, we recommended different sampling methods. During the 2013 sampling, about 50% of the invertebrate sampling locations had been dewatered within 30 days prior to sample collection.

We recommended that algal samples be collected at multiple depths to ensure evaluation the effects of light on primary production. FERC’s study determination (April 1, 2013) incorporated this recommendation. However, algal samples were collected in front of the Hess sampler as originally proposed by AEA and all of the samples were collected in water depths less than 1.5 feet.

We raised the concern that the Hess sampler, by design, would result in a predominance of riffle sampling, even though this mesohabitat is rare within the Middle River. All samples were indeed collected from riffles representing less than 1% of available main channel habitats.

We recommended sampling algae in off-channel habitats from the dominant substrate, however, per the Initial Study Report (ISR), samples were collected from cobbles even in habitats where they were rare.

We recommended that drift samples be collected upstream and downstream from tributary mouths. This recommendation was supported by FERC but was not implemented.

We recommended that growth rates within macrohabitats be obtained from tagged fish, to ensure that rearing occurred in that location. This recommendation was supported by FERC, but was not implemented by AEA.

We commented that the RSP and IP did not provide locations for stable isotope sample collection. FERC required consultation with the Services to select sites for stable isotope sampling; however, this consultation did not occur.

We requested, and FERC required, testing for relationships between measures of benthic and drifting invertebrates and rearing juvenile salmon. However, there were only two focus areas where this hypothesis could be tested, fish and macroinvertebrate sampling occurred in different locations, and the data were therefore not comparable.

Since the River Productivity study was not conducted in all focus areas, sampling locations did not need to be restricted to focus areas. Conducting the study only in focus areas resulted in sampling that did not provide adequate replication in macrohabitats. Important habitats were not sampled, fish sample sizes were extremely low for the bioenergetics study, and the stable isotope study was not conduced at locations that support salmon spawning or where most rearing juvenile salmon were located. The focus area concept was developed for the Instream Flow Study to provide areas to represent each geomorphic reach. Focus areas were developed as sites where intensive data were to be collected and allowed for 2D hydraulic and geomorphic modelling. The River Productivity study does not provide detailed information for any of the focus areas, is not representing all geomorphic reaches, and has no sampling sites within those focus areas most important for adult and juvenile salmon (FA138 and FA128).

In a second year of study, USFWS requests that the River Productivity study be conducted in five or six replicates of each macrohabitat type within the Middle River, regardless of whether they occur within or outside of a focus area. Emphasis should be placed on site selection within focus areas, to the extent that this fits with the primary objective of selecting optimal sites and providing adequate replication of macrohabitats. We further recommend that an operational plan for the study be developed with considerations presented in the state's (Alaska Department of Fish and Game) fisheries research Operational Planning guidance document (Regnart and Swanton 2012).

Bioenergetics modeling is a critical study element addressing differences and factors that limit juvenile salmon distribution and growth among macrohabitats. It will provide additional information on the current environment not provided through the Fish Distribution and Abundance and Instream Flow studies. Study results will provide information necessary to evaluate Project effects, beyond the habitat models predicting salmon presence or absence due to differences in physical habitat criteria. It appears AEA has not fully met the study objectives in the following primary ways: (1) Study site selection did not adhere to the Project's hierarchical habitat model (2) site selection did not adequately replicate side slough and upland slough habitats, (3) juvenile salmon were not tagged, as provided for in the plan, and sample sizes were too small to provide accurate or representative measures of growth, (4) sample sizes of stomach contents were too small to accurately describe juvenile salmon diets, and (5) water temperature data were not representative of site conditions.

STUDY MODIFICATIONS AND SUPPORTING DOCUMENTATION

Objective 1: *Synthesize literature on the impacts of hydropower development and operations (including temperature and turbidity) on benthic macroinvertebrates and algal communities.*

Modification 1-1: Provide a description of the key words and data bases used for literature searches in order for review participants and FERC to determine the completeness of this review.

AEA produced a literature review to synthesize three topics: macroinvertebrate and algal community information in Alaska, general influences of environmental variables on benthic communities, and potential effects of hydropower operations on benthic communities. The review included 500 reports and papers. This synthesis provided a good but incomplete summary of relevant literature. AEA's review was missing 27 of the 53 published papers that USFWS found conducting a similar limited search. While the synthesis presented in the ISR is useful and informative, it did not include some of the more salient scientific papers and reports that would have made the synthesis more complete. No details were provided on the methodology of the literature search. USFWS is requests that prior to the second year of study, AEA provide a list of the key words and data bases and any other methods used to develop the literature review. This information is needed to evaluate opportunities for additional inclusion of literature into the review.

Objective 2: *Characterize the pre-Project benthic macroinvertebrate and algal communities with regard to species composition and abundance in the Middle and Upper Susitna River*

Modification 2-1: Repeat benthic macroinvertebrate, benthic organic matter, and periphytic algal sampling at all tributary mouth sampling locations to complete the study according to the study plan, using appropriate sampling methods for water depths and velocities. Implement accepted scientific practices for macroinvertebrate and algal sampling scientific practices. Sample a minimum of 6 additional tributary mouths in the Middle River, below Devils Canyon. Complete periphytic algal sampling at upland slough locations to complete the study, according to the approved study plan. As implemented, sampling did not adhere to the approved study plan.

The number of tributary mouths sampled seemed insufficient to evaluate the value of these macrohabitats for rearing juvenile salmon and resident fish species. At each mouth, samples were taken from near, or at, the same location, bringing into question whether or not samples are representative. Samples may not be representative of this habitat type, in terms of the range of available hydraulics and substrates present in tributary mouths. Only two tributary mouths sampled were below Devils Canyon that overlapped the distribution of juvenile salmon (Indian River and Montana Creek) and only one of these was in the Middle River. This is insufficient replication to use ANOVA to test for significant differences among macrohabitat types, as proposed, or to test for relationships between fish distribution and abundance and macroinvertebrate density as recommended by FERC for IFS Study 8.5. In addition to spatial representation, samples were also isolated to particular flow conditions. We recommend tht samples be taken at a range of flows and seasons to be more representative of baseline conditions.

At all tributary mouth sampling units, sampling locations, for the five replicate samples, were collected in tributary deltas. None of the samples were collected within the portion of the main channel influenced by tributary flow (Figure A1 and A2). Tributary mouths are characterized by AEA as clearwater areas where tributaries flow into the mainstem. The macrohabitats can be further subdivided into tributary deltas and clearwater[1] plumes. Sampling units for the FDA Study 9.6 were further defined by FERC to include the tributary delta and 200 m downstream in the main-stem channel. Physical and water quality characteristics differ between the tributary delta (which is characterized by unstable substrate and shallow water depths) and the tributary-influenced main-stem (characterized by shallower slopes and greater depths). Juvenile salmon and resident fish may be more abundant within the main-stem influenced portion of this macrohabitat due to greater water depths, cover, and possibly higher productivity than other main-stem sites. Organic matter may deposit in these portions of the macrohabitat, and algal abundance may be higher due to reduced scour and more stable substrate. The exclusion of tributary-influenced mainstem habitats may lead to an underestimation of the importance of these habitats.

Within tributary deltas, replicate samples within sampling units were collected within very close proximity to each other (< 10m apart), rather than from representative locations, as required in the study plan. The Final River Productivity Implementation Plan (IP) states that benthic samples will be collected from five "suitable locations, spacing them as equidistantly as possible, to be representative of the site." Therefore, for a 200 m tributary mouth, sampling locations should have been selected about every 40 m. The IP further states, "If five unique and separate locations are not available, it will be necessary to collect more than one sample within the same location. If this is the case, space the sample locations out as far as possible. For example, if conditions require two samples in one riffle area, sample at the downstream end and then the upstream end. As a general rule, samples should not be taken within 10 m of each other. Selected locations at each site should be sampled in a downstream-to-upstream direction." It is clear from the sampling locations presented in Figures A1 through A3 [the distribution of sampling sites in AEA's Study Implementation Report (SIR) largely expand on GPS points in the ISR figures], that this methodology was not implemented per the study plan. If samples were collected every 10 m then sampling would be distributed at a minimum over 40 m; however, samples were all collected within the tributary delta and within close proximity to each other. Collecting all samples from the same location will reduce the variability in sampled depths, velocities, and substrates within a macrohabitat, and limit AEA's ability to identify accurate habitat suitability criteria and develop curves or models for macroinvertebrates (Objective 6).

USFWS RSP comments recommended a minimum of six replicate sampling units for each macrohabitat type. The FERC study determination (April 1, 2013) estimated, based on habitat classification in the RSP and IP, that the study would provide approximately five replicates of each macrohabitat type. It is necessary for our evaluation of the effects of the proposed project to determine if tributary mouth habitat is important for summer rearing and overwintering of

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[1] "Clearwater" has not been defined, but is assumed to refer to an area of reduced main-stem turbidity due to tributary discharge.

juvenile salmon, and if so, whether this is due to differences in food availability. The FDA study was designed to measure the relative abundance of juvenile salmon in tributary mouth habitat and the River Productivity study was designed measure the density of benthic invertebrates and drift. The Instream Flow study was to evaluate the importance of invertebrates for modelling fish abundance. However, the productivity study did not collect benthic or drift samples downstream from tributary discharge points. Only two tributary mouths were sampled downstream from Devils Canyon where juvenile salmon are more abundant (Indian River and Montana Creek), and FDA sampling was only conducted at Indian River (see AEA ISR 9.6 Appendix A). Therefore there is only one tributary mouth location were both fish and invertebrates were supposed to be sampled and invertebrates were not collected at representative locations within the clearwater plume. The clearwater plumes were also not sampled as extensively as the FERC study plan determined. Because of these study implementation variances, it is unlikely the study objectives can be met unless the study is modified to address deficiencies.

Productivity sampling in all Focus Areas will provide necessary replicate measures of tributary mouth habitat downstream from Devils Canyon: Portage Creek, an important Chinook and Coho salmon spawning tributary, is located in FA 151; an unnamed small tributary flows into FA 144; Indian River is in FA 141; Gold Creek is just upstream from FA 138 and Skull Creek are in FA 128; a small unnamed tributary flows into FA 115; Gash Creek is in FA 114, and Whiskers Creek (if classified correctly) is in FA 104. Sampling within all Focus Areas would meet the intent of the RSP and IP, if detailed information were provided to allow assessment of whether or not there was adequate replication of Middle River tributary mouths.

Modification 2-2:

- Repeat sampling of benthic macroinvertebrates, macroinvertebrate drift, benthic organic matter, and periphytic algae at upland slough sampling locations per the study plan, using appropriate sampling methods for water depths and velocities, and implementing accepted macroinvertebrate and algal sampling scientific practices.
- Sample a minimum of five replicate upland slough habitats according to the study plan. Avoid incorrect classification and inclusion of sites that did not fit the upland slough definition, namely the aquatic habitat near Montana Creek.
- Co-locate upland slough sites selected for the River Productivity study with upland sloughs sampled for the FDA study to meet study objectives.
- Sample additional upland sloughs in the Middle River below Devils Canyon to adequately assess the project area.

Only two upland sloughs were sampled for River Productivity for the entire Susitna River and sampling within the selected sampling units did not follow the approved plan. AEA reports that samples were collected from an upland slough near Montana Creek; however, this site did not fit the Project definition for an upland slough. This channel is an old Montana Creek distributary channel (Figure A4). Water was diverted from this channel in the 1960’s during construction of the Parks Highway. The channel backs up behind a railroad culvert to give the appearance of a slough but this site does not function, physically or ecologically, as an upland slough and is not representative of this habitat. The data from this site are rather incomparable to data collected from true upland sloughs. An alternate upland slough site is available just upstream of Montana Creek and could be sampled to provide a valid comparison in subsequent study years (Figure A5).

Benthic and algal samples were collected from an upland slough sampling unit in FA 104, however all sample replicates were collected from the same location (Figure A6). The IP states that samples will be distributed equally over the 200 m sampling unit. Therefore, sampling was not conducted according to the approved plan. Sampling locations within the FA 141 upland slough sampling unit appear to be inappropriately selected, based on limitations imposed by the Hess sampler. The SIR (Table 4.8-1) stated that both Hess and Ponar samplers were used to collect samples. No drift was sampled and it is not possible to determine which substrate was sampled to collect algae. The upland slough backwater is dominated by fine substrate and deep water. As such, sampling does not appear representative of this habitat and instead seems to have been conducted around the limitations imposed by the Hess sampler. In addition, replicate samples were all collected within close proximity to each other, particularly during spring and summer. Therefore, sampling was not conduced according to the study plan specifications, regarding representativeness. Benthic, algal, and drift samples were to be distributed evenly throughout the 200 m sampling unit and appropriate methods should be used for the substrate types and water velocity.

The FA141 upland slough River Productivity sampling unit was also not co-located with fish sampling from the FDA study (see AEA ISR 9.6 Appendix A). FDA sampling occurred in the large upland slough beaver complex on the right bank upstream from Indian River while River Productivity sampling occurred in an upland slough on the left bank. No Coho Salmon >50 mm were captured in this slough by the River Productivity Study (see SIR table 4.7-1, 2, 3 and FDA_CD_Fishcapturetag).

Upland slough habitat was available in FA 173 but was not sampled (Figure A7). FERC recommended sampling all macrohabitats within all focus areas selected for River Productivity sampling. River Productivity sampling within the upland slough in FA 173 should have been conducted per the study plan in subsequent study.

Current and historic studies indicate that upland sloughs are of the most productive macrohabitats for rearing Coho and Chinook salmon. AEA ISR 9.6 reported juvenile Chinook Salmon as being most abundant in the upland sloughs of FA 115 and FA 141. However, River Productivity sampling did not occur in either of these sloughs. Upland sloughs, located on the lateral margins of the main-stem channel, will be the macrohabitats most affected by water storage and flow fluctuations from operation of the proposed Project. River Productivity sampling from two upland sloughs is insufficient to document the macroinvertebrate and algal communities within these macrohabitats, particularly as no juvenile Coho Salmon were captured in the upland slough in FA 144.

In addition to sampling conducted in FA 104 and FA 141, we request the upland sloughs in FA 115 (Slough 6A), FA 138 upland sloughs, and FA 144 upland slough (right bank) be sampled for benthic invertebrates, invertebrate drift and periphytic algae using appropriate sampling methods as provided for in the study plan. This would provide five replicate upland slough sampling units within the Middle River below Devils Canyon. Additional upland slough sampling appears necessary to meet study objectives.

Modification 2-3. Side slough sampling units and sampling locations within side slough sampling units must be selected according to the study plan. Additional Middle River side slough sampling units should be selected and sampled below Devils Canyon.

The FERC study determination (April 1, 2013) recommended that AEA select all macrohabitats represented within the Middle River and Lower River for River Productivity sampling. AEA moved the Lower River Trapper Creek sampling area to the Montana Creek area but did not sample available slough habitat there (Figure A7). Within side slough sampling units, all five replicate samples were collected from the same location (Figure A8). This sampling did not implement the study plan; accepted scientific practice is to distribute sampling locations randomly or systematically through the sampling unit, at a length of 20x the width of the channel.

Study results from FA 104 were collected within Whiskers Creek and presented as being representative of side slough macrohabitat. However, all summer and fall samples were collected within Whiskers Creek, which is a tributary and not a side slough macrohabitat (Figure A8 upper panel). This site is also not a tributary mouth, as tributary mouths must discharge into main channel or side channel habitat (see definitions in AEA 9.9). In addition, all five spring and summer replicates were collected from the same location and were not distributed throughout the sampling unit, as described within the study plan.

River Productivity sampling was conducted in only two side sloughs that were used to represent the entire Susitna River and only one of these side sloughs (FA 104) was downstream from Devils Canyon. In addition, the short side slough at FA 104 is very dissimilar from adjacent side sloughs in FA128 and FA138. The adult escapement and FDA studies have identified side sloughs as the macrohabitat that provides main-stem spawning habitat for chum, sockeye, and coho salmon and rearing and overwintering habitat for Chinook, Coho, and Sockeye salmon. These lateral habitats likely will be affected by proposed river regulation during the spring and winter load-following releases. The importance of these relatively shallow and clear water habitats may be due to greater primary and secondary production, augmented by marine sources of nitrogen and phosphorus. However, River Productivity sampling was only conducted in one side slough for the entire Susitna River downstream from Devils Canyon (two in total including one in FA 173), and salmon spawning has not been documented in this side slough (FA 104).

USFWS recommends that River Productivity sampling be conducted at a minimum of 6 Middle River side slough macrohabitats below Devils Canyon. In addition to FA 104, USFWS recommends that sampling side sloughs in FA 114 (misclassified by AEA as a side channel), FA 128 and FA 138, both important spawning channels, the side slough just downstream from Indian River in FA 141 (Figure A11), and the side slough at the upstream end of FA 144. This is consistent with the FERC determination (April 1, 2013) that estimated five replicates for each macrohabitat, based on their review of AEAs revised study and implementation plans.

Within side sloughs and all River Productivity sampling units, sampling locations sampling reaches should be established that are consistent with FDA sampling reaches at 20x the width of the channel in length. Each sampling location, within these sampling units, should be separated by at least one or more channel widths.

Modification 2-4. Select and sampling side channel sampling units that are representative of this macrohabitat type, ensuring that sampling is distributed throughout the 500 m sampling unit as provided for in the study plan.

Sampling was not conducted at sampling units that were representative of side channel habitats, and sample locations within these units were not selected according to the study plan. Instead samples were collected within close proximity to each other. Figure A9 shows the FA 184 sampling units and sampling locations selected by AEA. The side channel and main channel sampling units and all sampling locations were collected from the head of a single island. Samples collected from this site clearly do not represent main channel or side channel habitat and will preclude detection of differences among macrohabitat types.

Site selection also suffered from misclassification. Figure A9 shows the side channel sampled in FA 173. Based on AEA's classification methods, this channel is a side slough, not a side channel. Figure A10 shows the side channel site selected for FA 141, which is an ephemeral channel on the downstream end of an island that is frequently dewatered. This is a flood channel. Figure A11 shows available side channel habitat, just downstream from the Indian River that seems to be more representative of side channel habitat.

Figure A12 shows the channel site selected in FA 104 that is just downstream from an upland slough. The figure depicts the channel at flow levels used for habitat characterization (10,000 to 12,000 cfs) and it appears to clearly be within clearwater upland slough habitat. It appears that the only true side channel sampled was RP-81-4, but at this site all samples were collected from approximately the same location (AEA ISR Appendix B Figure B-4). Therefore, it is not clear to the whether macroinvertebrate or chlorophyll-a data were collected in such a way that side channels, though quite common in the Middle River, were adequately represented.

Within each side channel sampling unit, all sampling locations were selected in close proximity to each other, instead of distributing the locations systematically as provided for in the approved plan. Side channel sampling sites for the FDA study are 500 m long and the accepted scientific practice is sampling units of 20 times channel width (i.e., Moulton et al. 2002). The Final River Productivity IP states that benthic sample will be collected from five "suitable locations, spacing them as equidistantly as possible, to be representative of the site. If five unique and separate locations are not available, it will be necessary to collect more than one sample within the same location. If this is the case, space the sample locations out as far as possible. For example, if conditions require two samples in one riffle area, sampling at the downstream end and then the upstream end would provide greater representation. As a general rule, samples should not be taken within 10 m of each other. Selected locations at each site should be sampled in a downstream-to-upstream direction." For a 500 m sampling unit sampling locations could have been separated by 100 m. However at a minimum, according to the implementation plan, samples should not have been collected from the same riffle and should have been at least 10 m apart. Review of Figures A10 through A14 illustrates that all samples were collected on the same point bar (FA 184 and FA 141) or riffle (FA 104).

Benthic invertebrate, benthic organic matter, benthic algal sampling would benefit from adherence to AEA's IP. In future efforts, side channel sampling units should be selected such that they are representative, pursuant to the Project hierarchical habitat model. A minimum of 6 side channel sites should be sampled downstream from Devils Canyon. USFWS recommends including side channel habitat in FA 144 and FA 141, side channel habitat below Montana Creek (identified in Figure A13), side channel habitat in FA 138, side channel habitat in FA 138, side channel habitat in FA 115 or 114, and side channel habitat in FA 104.

Modification 2-5. Benthic invertebrate, organic matter, and benthic algal samples collected in main channel sampling units do not appear to address study objectives. Select main channel sampling units that are representative of this macrohabitat type, sampling locations within the main channel sampling units that are distributed throughout the 500 m sampling unit, according to the study plan.

A main channel sampling unit should be selected within each focus area to provide a minimum of six replicate samples. Sample locations should be distributed throughout each 500 m main channel sampling unit, as stated in the study plan, and must not be collected from the same channel feature.

AEA did not select main channel sampling units that were clearly in main channel macrohabitat types and all samples within these sampling units were collected in close proximity to each other. Figure A9, shows FA 184 main channel sampling locations, and figures A13 through A14 show main channel sampling locations for FA 173, FA 104, and Montana Creek. Main channel sampling units were not selected to be representative, sampling locations were not distributed throughout the sampling unit as provided for in the approved plan, and sampling units were often dewatered within 30 days prior to sample collection. These variances from the study plan likely prevented AEA from meeting study objectives.

Main channel sampling locations in FA-184 were on the same point bar as samples collected to represent a side channel (Figure A9). A side channel location was also used to represent a main channel in FA-104 and in FA- 81, in spring. In FA-141 AEA did not sample main channel habitat even though this macrohabitat type was present within the FA. Main channel habitat is the dominant macrohabitat type, but only one sampling unit was sampled that was clearly located within main channel habitat.

AEA also did not distribute sampling locations within main channel sampling units as provided for in the study plan. Similar to other sampling units, all sampling locations were within close proximity to each other.

Modification 2-6. Collect macroinvertebrate samples at locations wetted under most flow conditions and collect samples in accordance with the approved study plan. According to the RSP, samples were to represent the river in accordance with the hierarchical habitat model adopted for the Project. Sampling locations must adequately represent the macro and mesohabitats defined by the Projects habitat model. To sample these habitats, other sampling techniques, including dome samplers and SCUBA may be necessary. We recommend that Hess samplers not be used exclusively.

The Services expressed concern during study plan development and provided formal comments on the appropriateness of the Hess sampler to collect macroinvertebrates in large rivers. These concerns were put forth in the proposed and revised study plans. Hess samplers prevent sampling at depths greater than approximately 1.5 feet. Hess sampler use is also not the accepted scientific practice for macroinvertebrate sampling in large rivers because of this depth restriction. Use of a Hess sampler restricts representative sampling and increases the likelihood of taking samples in areas that were recently dewatered. In the end, this limitation can prevent representing the range of depths and substrates needed to evaluate habitat criteria and develop Habitat Suitability Criteria/Habitat Suitability Indices. In their study determination (April 1, 2013) FERC stated that, "AEA should select the most appropriate sampler according to the bottom substrate, water velocity, and other conditions (see Klemm et al. 1990), but should endeavor to use the same sampler in all macrohabitats of this type to ensure consistency among samples. Additionally, AEA should sample benthic algae on cobble substrates at multiple depths up to 3 feet (e.g., depth categories of 0–1 foot, 1–2 feet, and 2–3 feet) at each macrohabitat site (main channel, tributary confluences, side channels, and sloughs), to the extent feasible given the limits of field safety."

ISR results from the 2013 sampling validate concerns over the use of the Hess sampler. Most of the sampling sites were not inundated 30 days prior to sampling. Only riffles were sampled, which (based on results in Study 9.9, river Productivity) accounts for < 5% of main-stem and side channel habitat (Table 4. Middle River Technical Memorandum). Our review of the depths for Hess samples (ISR_9_8_RiverPro_Hessdepthstage), shows that all of the samples were collected in water depth < 1.5 ft, and 75% of the samples were collected in water depths of 0.7 ft or less. Since algal samples were collected in front of each Hess sample, benthic macroinvertebrate and algal samples were not collected from multiple depths up to 3 feet as FERC required.

Sampling methods were also not consistent among macrohabitat types, as was required by FERC. For example, figure A6 shows sampling locations in an upland slough sampling unit where sampling was moved to the upper portion of the slough to accommodate a Hess sampler, even though a dredge or grab sampler was used in other upland sloughs.

The use of a Hess sampler also likely explains why samples were collected from tributary deltas and not tributary mouths as required. As in other situations like where AEA sampled the head of islands, sampling was restricted to shallow water areas that were not necessarily representative of the macrohabitat. Tributary deltas are shallower and allow for use of a Hess sampler; however, tributary mouth habitat, including the downstream plume, is often deep and would require a sampler designed for these habitats (Figure A1 through A3). The habitat sampled in FA 141, as a side channel, appears to have been selected due to shallower water depth conducive to the use of a Hess sampler; however, this resulted in samples being collected from habitat that is frequently dewatered and not representative of Susitna River side channels (Figure A10). The locations selected to represent side channels and main channels were also located on island point bars in FAs 81, 104, and 141. Again, these are shallow water habitats allowing use of the Hess sampler, but they are often dewatered prior, or shortly following sampling events.

Modification 2-7. Collect invertebrate and algal samples from sites dominated by a range of finer grained substrates, so that samples are representative of the dominant habitat, according to the study plan.

Algal samples collected in 2013 were from cobbles substrates in sampling units that were dominated by fine substrates. These samples are likely not representative and may not comprehensively allow a full evaluation of food resources among macrohabitats. FERC's approved sampling plan required testing for differences in algal abundance (as indicated by concentrations of chlorophyll-a and AFDM) among macrohabitat types. Backwater habitat at the mouths of upland sloughs, side sloughs, and tributary mouths are often dominated by fine sediments. Water velocities and water depths vary between sites with cobble and fine substrates, and cobbles provide a more stable algal substrate. Since water velocity influences nutrient availability, algal sloughing and light availability varies with water depth, particularly in brown-water upland slough habitats. It is reasonable to hypothesize that algal abundance will be different between these two substrate types. Chlorophyll-a can easily be extracted from fine sediment samples, however it is sampled (i.e., petri dish, cores). Fine sediment samples can easily be dried and organics burned to determine AFDM. FERC's recommendations for sample collection were feasible and should be implemented to adequately represent the aquatic habitats under study.

Modification 2-8. Collect algal samples from multiple depths (0-1, 1-2, 2-3 feet) within each macrohabitat, proportional to the depths present, and such that all sites are inundated for 30 days prior to sampling per the study plan.

The FERC study determination (April 1, 2013) required that algal samples be collected from multiple depths in order to determine a relationship between light availability and primary production. Primary production was also to be evaluated as a local criterion for consideration in the development of Habitat Suitability Criteria/Habitat Suitability Index models. Though feasible, samples collected in water up to three feet were not collected. Most of the sampling locations were also not inundated for 30 days prior to sampling, as required (primarily in main channel and side channel habitats). This has a large effect on algal chlorophyll-a concentrations in these habitats. In future studies, algal samples should be collected from multiple depths, as provided for in the approved study plan, to avoid selection of locations that have not been dewatered during the previous 30 days.

Modification 2-9. Collect benthic macroinvertebrate and algal samples during the spring, summer, and fall sampling periods for a minimum of two years, as described in the study plan.

Spring sampling should occur prior to June 1, and fall sampling should occur in October.

Spring and fall sampling represent time periods when glacial melt is low, resulting in low stage heights and low turbidity, potentially mimicking post-Project conditions. It has been reasonably hypothesized that primary production is high during these periods of greater light availability. During late fall, decreases in light are accompanied by increases in nutrient availability from decaying salmon carcasses, resulting in visual increases in algal abundance (Figure A15). Creating a 42 mile-long reservoir on the Susitna River is likely to result in reduced turbidity in the Middle Susitna River that may result in an increase in primary productivity. Therefore, it is important to conduct benthic invertebrate and algal sampling during spring and fall time periods of low turbidity to assess these conditions.

The AEA River Productivity IP stated that invertebrates, algal, and drift samples would be collected in the spring (April – early June), summer (late June through August), and fall (September through October) (IP page 47). Sampling was not conducted in all seasons, as determined in the approved plan. AEA conducted their spring sampling between June 19th and July 18th 2013, which would have been representative of summer. Summer samples were collected August 12- 29, 2013. Fall samples were collected September 22-October 3, 2013. Spring breakup occurred very late in 2013, one indication of anomalous environmental conditions. Samples collected late, from the middle of June through the middle of July are not representative of spring conditions and were not conducted prior to increases in summer turbidity. Fall samples were collected early, during late September when turbidity was still high. For example, October 9, 2012 main-stem turbidity was measured by NMFS at ~36 NTU in a side channel of the Susitna River; by October 27, 2015 turbidity was near 1 NTU at the same location (Figure A15). We suggest that AEA's sampling did not measure potential increases in primary productivity during early spring and fall, according to the study plan.

Modification 2-10.

The macroinvertebrate emergence study should be repeated to obtain adequate replication among all microhabitats, avoiding dewatered sample locations. At a minimum, there should be five replicate sampling locations distributed within each 200 to 500 m macrohabitat sampling unit. Sampling should be conducted within sampling units representing each of the five macrohabitat types (main channel, side channel, side slough upland slough, and tributary mouth). Samples need to be collected in the spring, prior to breakup, to coincide with the emergence of juvenile salmon as provided for in the approved plan.

Emergence traps were not deployed in the spring, prior to breakup, and traps were not emptied every two weeks, as required by the study plan. It is questionable whether useful data were obtained from many of the sites, due to poor representation of samples and lack of replication. Many of the emergence traps deployed in 2013 were found out of the water or damaged, when traps were checked (AEA SIR Table 4.3-2) making the trapping effort unknown. Though it is known that traps were dewatered, AEA calculated emergence results assuming the traps were wet throughout the sample period. Because the traps may have been dewatered for significant periods of time (as long as two weeks), this assumption is not valid and can be expected to bias results. Furthermore, the habitats sampled would have been of questionable value, even when flooded. We question whether emergents from these traps should have been processed as representative samples and whether or not the results should have been reported because traps that remained intact were deployed for far longer than the two week trapping period specified in the implementation plan (middle of June to early August). These variances from the approved study plan methodology resulted in non-standard data collection. It is questionable whether or not these existing samples can be used to evaluate differences in emergence timing or insect production among sites or macrohabitats, relative to water temperatures or flow variability.

We are concerned that only one emergence trap was installed at each macrohabitat, traps were not placed randomly within each macrohabitat, and that results from one trap may or may not be representative of the macrohabitat under investigation. Similar to benthic sampling, replicate samples need to be collected within each macrohabitat to provide a mean value representative of the sampling unit. This is of particular importance as trap locations may not be selected randomly, and one or more traps may become dewatered or damaged between collection intervals. Water temperature was also highly variable within and among sampling units (AEA SIR). Water temperature variation typically results in differences in emergence timing and production. Multiple traps would provide a precaution to access this variability, and may provide some data in the event that one or more traps are damaged between visits.

Objective 3: *Estimate drift of benthic macroinvertebrates in selected habitats within the Middle and Lower Susitna River to assess food availability to juvenile and resident fishes.*

Modification 3-1. In future studies, invertebrate drift should be measured up and downstream from tributary mouths, as required in the approved study plan. If invertebrate drift is measured in the tributary, tributary discharge also must be considered, to allow for adequate estimation of the relative contribution of a tributary to main-stem food availability.

FERC in their study determination (April 1, 2013) stated that:

> "macroinvertebrate drift sampling upstream and downstream of tributaries would provide information needed to assess the relative contribution of tributaries and the main-stem Susitna River to fish food resources" (section 5.9(b)(4)). This information would inform the assessment of fish food availability, which is among AEA's stated study objectives, and can be used to evaluate the potential effects of project-related changes in macroinvertebrate drift on fish food resources in the Susitna River (section 5.9(b)(5) and (7)). We anticipate that bracketing the tributary mouths for drift sampling would require little or no additional effort relative to AEA's proposed drift sampling methods, and as such any associated costs would be minimal (section 5.9(b)(7)). We recommend conducting macroinvertebrate drift sampling upstream and immediately downstream of tributary mouths to collect information needed to assess the relative contribution of tributaries and the main-stem Susitna River to fish food resources."

Mainstem and side channel drift samples were not collected downstream of tributary. The sampling locations presented in AEA Figures 4.2-1, 4.2-3, 4.2-4 and 4.2-5 (ISR Part A Page 55-61) show that tributary sampling did not occur both up and downstream at any station's tributaries (Tsusena Creek, Indian River, Whiskers Creek, or Montana Creek). Instead, tributary sampling occurred within the tributary itself, not in the mainstem, downstream. The concentration of drift, downstream from tributaries, within or below the mixing zone, will represent the combination of main channel and tributary sources. Sampling below tributaries will account, to varying degree, for differences in tributary and main-stem drift concentration and discharge. With samples collected in tributaries, AEA also needed to measure tributary discharge, to calculate a drift value (flux) used to compare with main-stem values and to assess tributary influence on food availability. A high concentration of invertebrates in the drift may have little contribution to mainstem food availability under low tributary discharge flux rates (discharge x concentration). However, tributary discharge was not considered or reported when tributaries were sampled. As such, the contribution to mainstem food availability cannot be calculated.

Modification 3-2. Drift sampling should be conducted every four hours in one or more of each representative macrohabitat, to determine diel variation in drift during each sampling event.

During the first year of study, macroinvertebrate drift was collected concurrently with benthic and algal sampling. This resulted in drift samples being collected during different times of the day, from morning to early evening. However, according to Hauer and Lamberti (2006) drift density and the size of drifting organisms can very over a 24 hour period. The peak timing of drift may also vary seasonally due to the large differences in day length, especially in this subarctic location. The evaluation of differences in invertebrates drifting in the water column or zooplankton can be obscured by variability caused by diel differences in drift abundance. Similarly, differences in drift density and composition could alter bioenergetic modeling predictions of consumption.

The IP stated that diel drift did not need to be accounted for due to the dominance of Chironomids, citing a study that found disruption in Chironomid drift patterns in northern latitudes. However, results from 2013 show that while Chironomids may have the highest relative abundance, they rarely account for more than 60% of drift samples in numbers, and are likely far less in biomass (SIR Table 5.2-1). Spring and autumn sampling also occur during times of distinct photoperiods.

Many invertebrate species exhibit high rates of downstream drift associated with diel periodicity. Many are night-active, for which light intensity is the phase-setting mechanism, but chemical triggers from predators can also influence this (see McIntosh et al 2002). Some are day-active, for whom water temperature may be the phase-setter (Waters 1969). Diel patterns consist of one or more peaks, occurring at various times of the 24-hour period, depending on the species (Sagar and Glova 1988).

Magnitude of drift is often a function of water temperature, current velocity, stage of life cycle, population density, and growth rates. Disturbances, either natural (e.g., flood) or anthropogenic (e.g., pulsed flows) can also have a significant effects on stream drift (Lake 2000).

In turn, feeding activity in stream fishes is greatly tied to energy efficiency with a hierarchy of fish species selecting optimum foraging sites, typically associated with drift feeding stations. Feeding rate and location, within the 24-hr period can change dramatically, depending on water temperature, light availability, drift rates, and competition. Sampling only within daylight periods is likely to miss key aspects of drift relevant to identifying and describing drift in relationship to fish diets. Perry and Perry (1986) found dramatic changes in invertebrate drift during and following flow manipulation, related to rate of flow change and time of day. Therefore, the exclusion of drift samples throughout the 24-hr period, as it relates to season, may preclude an adequate characterization of baseline conditions and the means to compare these conditions to disturbed (regulated) conditions.

Diet selection and feeding patterns are also influential and highlight the importance of sampling throughout the 24-hr period. Sagar and Glova (1988) studied the diel feeding periodicity, daily ration and prey selection of juvenile Chinook salmon, in relation to the available prey. Maximum food intake (dry weight) occurred about dawn, when mayflies were the major prey, but the greatest number of freshly eaten prey occurred during the afternoon, when Chironomids and terrestrial dipterans predominated. Feeding activity at night was low, with smaller mayflies comprising up to 50% of prey. During the day young salmon fed selectively on Chironomids and larger mayflies, while Trichopterans and terrestrial taxa were under-represented in the diet. Food consumption over the 24-h period averaged 8.3% of the fish dry body weight. Prey abundance in the drift explained about 50% of the composition of the diet. Although the fish selected larger mayflies, size apparently was not a main criterion for diet selection, because Chironomids were more frequently selected. Previous dietary experience of the fish and the diel pattern of prey abundance appear to best explain the selective feeding of juvenile Chinook Salmon. Johnson and Johnson (1981) observed clear segregation in the feeding times of Coho Salmon and Steelhead Trout, suggesting a mechanism to avoid competition.

Considering the clear periodicity observed in numerous studies of stream salmonid and other fish species' diets, USFWS recommends this study be modified so that the variability in drift over a 24-hour period is evaluated in one of each of the five macrohabitat types during spring, summer, and fall sampling.

Modification 3-3. Study methods should be modified to use finer mesh when conducting tows in slow water habitats, in order to estimate the contribution of zooplankton as a food resource in these habitats.

USFWS recommends this study modification based on AEA's initial results that identified zooplankton as a major component in the stomach contents of fish species. Based on the first study year, zooplankton also appear be a significant food source in stillwater habitats of upland sloughs, side sloughs, and main-stem macrohabitats (SIR Table 5.2-1). Tow samples collected in low velocity habitats should use a fine mesh net of 50 µm or less, consistent with the EPA National Lake Assessment methodology (EPA 2012). This would allow for the collection and identification of macrozooplankton.

We recommend that the enumeration and biomass estimates of macrozooplankton use the EPA (2012) methodology.

Objective 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.*

Modification 4-1. Modify the study so that reference sampling in the Talkeetna River provides replicate measures of all five major macrohabitats (main channel, side channel, side slough, upland slough, and tributary mouth).

During 2013, AEA collected benthic, drift, algal and organic matter samples from a side channel, side slough, and upland slough habitat. It is currently unknown whether potential Project effects will have a greater effect on one or more of the Susitna River macrohabitats. Tributary mouths, side sloughs, and upland sloughs may be most affected by water storage, whereas main channels and side channels may be most affected by changes in organic matter transport, turbidity, and water temperatures. Since Susitna River sampling is designed to characterize conditions in all five major macrohabitats, this same sampling design should be implemented in the Talkeetna River in order to provide a measure of the reference condition.

Objective 5: *Conduct trophic analysis to describe the food web relationships within the current riverine community within the Middle and Lower Susitna River.*

Modification 5-1: We request the following modifications to the Growth Rate and Growth Rate Potential Modeling study:

- Refine study objectives using bioenergetics modeling to evaluate the pre- and post-project influence of temperature, water velocity, food availability and food quality on juvenile Coho and Chinook salmon at five or more replicate Middle River main channel or side channel, tributary mouth, side slough, and upland slough macrohabitats.
- Macrohabitats should be located within Middle River focus areas, below Devils Canyon, to take advantage of 2D hydraulic modeling and to overlap with the distribution of juvenile salmon. However, not all macrohabitats within a focus area need to be sampled, as long as there are five or more replicates of each macrohabitat type. These macrohabitats are most likely to support rearing juvenile Coho and Chinook salmon, and vary in temperature, water velocities, and macroinvertebrate species.
- Conduct the study between July and early September. Sampling during this time period will reduce effort and allow time for age-0 juvenile salmon to move from spawning to summer rearing locations, and for most age1+ Chinook Salmon to emigrate from the Middle River. Fish sampling must be conducted to provide a measure of relative abundance on each sampling date and at each sampling site.
- Cold-brand all Chinook and Coho salmon captured on each sampling event with unique marks for sampling location, and individuals to determine average growth within a site between sampling events and individual growth for recaptured fish. Measure a the fork length of fish and the first 50 of each species at each sampling location an each sampling event, weighed to the nearest 0.1 g. Invertebrate drift sampling should occur every other week throughout this time period.
- Coordinate this study with other studies to determine the number and locations of additional water temperature monitoring locations within each sampling site to provide accurate and representative values. This modification will be best accomplished within a new study for Model Integration. A New Study request for Model Integration is included as an enclosure.

Sampling locations for juvenile salmon and other target fish species were not representative of the macrohabitat sampled and did not provide adequate replication. The study plan required sampling of four or five replicates of each macrohabitat type. This replication was particularly important for side sloughs, upland sloughs, and tributary mouth habitats that are likely more variable in drift and water temperature than main channel and side channels. The study was instead implemented at a total of only three sites that AEA classified as upland sloughs. However, the site near Montana Creek was not an upland slough, and no Coho Salmon were captured at the upland slough in FA 141. Therefore, the study only reflected Coho Salmon growth in the FA 104 upland slough. Similarly, only one side slough was sampled at FA 104, even though side slough habitat was present near Montana Creek (RM 81) and Indian River (FA 141). Any measures of Coho or Chinook salmon growth, or consumption rates of Coho or Chinook salmon are only representative of a single side slough, and the side slough in FA 104 cannot be considered representative of Middle River side sloughs.

Statistical comparison of differences in growth among macrohabitats are essentially testing for differences between the side slough and the upland slough in FA-104, and were conducted with small sample sizes. Macroinvertebrate drift, water temperature, and fish sampling was not conducted in the two tributary mouths (Montana Creek and Indian River) but instead in tributary deltas that are not preferred habitat for juvenile salmon. Sampling of FA 104 tributary mouth/side slough (RP 104-1) did not occur in either of these habitats (tributary mouths discharging into side channels or main channels), but was conducted in a tributary. USFWS recommends repetition of this study at five or more of each of the macrohabitats, pursuant to the Project hierarchical habitat structure.

Growth was not measured from the change in length or weight of marked fish within each habitat, as required in the approved study plan. AEA states that this was not conducted because this method could not track individual fish and it wasn't possible to determine if fish left the tagging site, reared in another location, and then returned. This conclusion is not supported by the literature. Merz (2002) used subcutaneous dye marks to identify individual *O. mykiss* for as long as 985 days, tracking some movement and residency. The study was also able to estimate growth of individual fish. Not using subcutaneous dye marking affected success of meeting study objectives. As a study variance, AEA proposed to determine growth from recaptured PIT tagged fish. USFWS does not believe this proposed study variance will meet the objective because (1) only fish > 55 mm can be PIT tagged, (2) PIT tagged fish also could leave and return to a macrohabitat, undetected, (3) PIT tagged fish for estimating growth for length at age (as proposed in the RSP) will provide measures for fish that may not represent the population, particularly as larger fish are selected for PIT tags, (4) cold branding can be applied to a larger number of fish at a much lower cost, and (5) combined locations and colors of tagging can be used to mark individual fish. To date, AEA has not recaptured enough PIT tagged fish to determine growth within each replicate macrohabitat.

Since juvenile salmon were not marked, it is not clear if growth occurred within the habitat under investigation. Ultimately, the change in the mean weight at age was used to estimate growth. Growth based on changes in the mean weight of target fish species of open populations did not account for any loss, recruitment, immigration, or emigration. Apparent growth, as a change in the mean weight can be due to the death of smaller juvenile fish. The death of smaller fish will result in an increase in mean weight but is not due to true growth. A reduction in relative abundance over time (truncation of the size frequency distribution) could indicate the loss of fish from the population. However, since abundance, or relative abundance, was not measured in each macrohabitat type, it is not clear whether the changes in length over time are due to growth, or the death of smaller fish. Similarly, immigration of larger fish or emigration of smaller fish would result in a change in the mean weight over time and would results in errors in growth measurements and all modelled parameters.

Intensive fish sampling is recommended to obtain measures of relative abundance, to determine if change in the mode of the size distribution could be due to the death or emigration of smaller fish (reduced relative abundance) or the immigration or recruitment of fry (increase in relative abundance). AEA did not clearly specify the level of effort applied to fish sampling at productivity sites. In 2013, an unknown number of fish traps were set for 90 minutes. This level of effort would have been short of that needed to make estimates. For juvenile Coho and Chinook salmon, USFWS recommends the use of baited minnow traps fished for 20 to 24 hours, at a density of one trap per every ten meters of shoreline. This would require 20 traps for all productivity sampling units in off-channel habitats.

USFWS does not believe the recommended changes to target fish species will meet the objective. The study should evaluate the bioenergetics of juvenile Coho and Chinook salmon. The Fish Distribution and Abundance study demonstrated that juvenile Chinook and Coho salmon are abundant in main and off-channel habitats of the Middle River.

Sample sizes of Chinook Salmon in 2013 and 2014 were too small to accurately represent Middle River Chinook Salmon or macrohabitats. In 2013, a total of four age-0 Chinook Salmon were captured and aged, and only five during the fall (AEA Figure 5.4-2). These samples sizes do not allow for an accurate measure of weight at age for Chinook Salmon in 2013. This also means that accurate diet could not be determined to calculate the energy derived from different prey items used to model consumption and growth efficiency. In 2014, only 3 age-0 Chinook Salmon juveniles were captured during the summer from the single Middle River side slough habitat and none in spring or fall (AEA Table 4.7-1 through 3). During 2014, a total of 10 Chinook Salmon were sampled during summer and 13 during fall from the two Middle River tributary mouths. For upland sloughs, the total number of Middle River juvenile Chinook Salmon sampled was 11 in summer and four in the fall. This means that spring to summer juvenile Chinook Salmon growth in side sloughs, which are common throughout the Middle River and provide important juvenile Chinook Salmon habitat (1980s study), is based on the length of only three fish from one side slough, and cannot be measured for the summer to fall time period. However, AEA Table 5.4-2 reports values for these habitats without recognizing or qualifying these limitations.

Diet composition was variable among fish species at a given site, over time, and, based on diet and stable isotope mixing models, among sites and macrohabitat types. Water temperature was variable within a site, and among macrohabitats. However, as shown in Table 5.4-2, a single value is reported for modeled consumption and growth efficiency for pooled habitat types. Using a single value for growth, but different values for water temperature and diet as reported, should result in different modeled values of consumption and growth efficiency for each site. If measured water temperature is different between side sloughs, upland sloughs, and tributary mouths, and diets differ among these habitats, but growth rates are the same, then it is not possible to have a single value for modeled consumption and growth efficiency that represents all three habitat types. In addition, maximum consumption rates (P_{max}) also vary with water temperature and would result in different values for growth efficiency among sampling sites. It may be that using site-specific values of diet composition results in unrealistic consumption and growth efficiency values, which would strongly suggest errors in growth estimates. If the model was run using only values of temperature and diet from a single site or average values, then results are not representative of multiple different macrohabitat types and not reported as though they do.

Water temperature and turbidity data reported by the River Productivity Study do not appear to be representative of the sampling sites. No quality assurance procedures were developed for water temperature or turbidity monitoring. As reported, water temperature loggers, in some macrohabitats, appear to have been placed in upwelling waters or buried in sediment. No details are provided in the study report on finding locations of representative well-mixed water temperatures for logger placement or seasonal maintenance of water temperature loggers. For some sampling sites multiple water temperature loggers may be necessary to document current conditions. Prior to the next year of study, AEA should develop a quality assurance plan to ensure that accurate and representative water temperature and turbidity data are collected.

Modification 5-2. In regards to the Growth Rate Potential Study, until a foraging model for age-0 Coho and Chinook salmon becomes available and applicable for all water velocities, the effort directed toward this study should be shifted to obtain more accurate field measures of juvenile salmon growth and water temperatures within all macrohabitats.

Growth rate potential is growth rate modeled from field measures of drift density, water velocity, and water temperature by combining a foraging and bioenergetics model. The foraging model estimates consumption rates from drift density and water velocity for water velocities > 0.95 ft/s. However, a foraging model is only available for age-1 Coho Salmon. These estimates of growth rate potential are not useful, given the limitation to a single species and age class and for water velocities over 1 ft/s.

Additionally field measures of growth should be applied, in order to measure the current environment and predict Project effects. If accurate growth rates are obtained from replicate habitat types, along with water temperature, water velocities, turbidity, and drift, then the model can be used to evaluate the relationship between water velocity, drift, turbidity and consumption.

Modification 5-3. The study should be modified to include four Middle River Focus Areas including Indian River (FA141), Gold Creek (FA 138), Skull Creek (FA-128), and Whiskers Creek (FA 104).

If only two focus areas are studied, which is not recommended, we recommend FA 128 and FA 104. This would provide some continuity with the 2013-2014 studies, but a site that supports spawning and rearing (e.g., FA 128).

Modification 5-4. We recommend a sample 10 g of macroinvertebrates, and 5 g of algae, terrestrial invertebrates, and benthic organic matter are obtained from a composite sample collected from 10 or more locations. These samples should be distributed systematically (20 m between sampling locations) or selected randomly within each focus area macrohabitat.

This modification is necessary to ensure that samples are representative of the macrohabitat under investigation.

There appears to be a lack of detail in the River Productivity IP regarding the focus areas and locations within focus areas (specific macrohabitats). There was also a lack of detail regarding the number of salmon carcasses, algae samples, invertebrate samples, and target fish species that would be sampled at each sampling location. These details are needed to assess whether or not the objectives of this study were met. The Services are concerned that the Indian River focus area was near the upper extent of the spawning distribution of anadromous fish, and therefore, was less likely to contain delta C ratios indicating marine nutrient sources. In addition, the Indian River FA supports most of the salmon spawning, and the tributary is at the downstream end of the focus area. This being the case, sampling locations upstream of the Indian River would be less likely to contain marine nutrients. Carbon and nitrogen uptake from decomposing salmon carcasses would occur primarily within Indian River, and downstream of Indian River in the mainstem Susitna River. Marine sources of carbon and nitrogen upstream from Indian River could only come from spawning locations upstream (Portage and Slough 21) or from fish migrating upstream out of Indian River, into the Susitna River. The Services recommended a number of additional potential sites within the Middle Susitna River that support salmon spawning and were more likely to contain the target fish species (Coho and Chinook salmon, and Rainbow Trout). FERC required consultation with NMFS and USFWS prior to selecting sampling locations, but the Services were not consulted and the study was conducted in the Indian River Focus area. AEA added additional sampling locations, but the new sampling locations were not those recommended.

USFWS does not agree with the implemented study modification of selecting focus areas and sites without consultation as required by FERC. USFWS agrees with AEA’s study modification to increase the number of sampling locations, but does not agree with the locations selected. According to AEA, additional sampling locations were selected to represent a potential gradient of marine derived nutrients. One additional site was selected at FA 184, at the proposed dam site above Devils Canyon, and the second site at RP-81 in the Lower River segment. As stated previously, USFWS believes that Indian River (FA 141) already represents a site that would likely have low ratios of marine to terrestrial carbon in target fish species. The FA 184 site is upstream of most salmon spawning habitat, and was not expected to support enough juvenile Coho or Chinook salmon to meet study objectives. This was substantiated through the implementation of this study in 2013. FA 184 is not representative of any substantial portion of the Middle River. The Lower River site at Montana Creek site may contain higher or lower ratios of marine nutrients, as it is influenced by inputs from the Talkeetna and Chulitna Rivers. These influences may either concentrate or dilute marine carbon and nitrogen exported from the Middle River. We request that AEA consult with the Services, prior to conducting any additional sampling.

The IP states that samples would be collected from salmon carcasses, target fish species, aquatic insects, terrestrial insects, algae, benthic organic matter, and transported organic matter and analyzed for carbon and nitrogen isotopes. The ISR does not state the number of target fish species that were sampled, or where they were collected. Nor does it state the sampling locations and numbers of samples for any of the insects, algae, or organic matter. Only 260 samples were collected from a potential 1,920 in 2013. This level of sampling appears inadequate to meet stated objectives and determinations.

AEA stated in the IP that if stable isotope sampling goals were not achieved, then a portion of the sampling effort would be reallocated in order to reach objective goals. AEA did not reach the sampling number goals in 2013 and there is no description in the ISR or SIR of how sampling effort was or will be reallocated in order to achieve them in the next year of study.

Objective 7: *Characterize the invertebrate compositions in the diets of the representative fish species in relationship to their source (benthic or drift component).*

Modification 7-1. Diets from a minimum of 8 fish, for each species and life stage, with food in their stomachs should be analyzed according to the approved study plan.

AEA attempted fish sampling at every site; however, it was not always within one week of the benthic and drift samples, as required in the approved plan. At some sites, the River Productivity study deployed minnow traps for a maximum of 90 minutes in effort to collect target fish for stomach samples. AEA reported very few captured fish at Focus Areas 173 and 184. The total effort resulted in only 260 total stomach samples collected in 2013, out of a potential of 1,920. ISR Table 4.9-2 shows that some macrohabitats were not sampled in either the Fish Distribution and Abundance Study or the River Productivity study, leaving many data gaps for this objective.

Modification 7-2. Expand the geographic scope of the River Productivity study to the entire Lower River.

The Lower Susitna River is defined as the approximate 102-mile section of river between the Three Rivers Confluence and Cook Inlet. Potential project impacts to biological productivity in the Lower River should be considered. Drift of algae and macroinvertebrates from the Susitna River play important roles in energy flow and food webs, ultimately affecting growth and productivity of various aquatic species seasonally occupying the Lower River and Cook Inlet. Such species include all five ecologically, culturally, and economically valuable species of Pacific salmon as well as Eulachon and Cook Inlet marine mammals. Understanding the expected changes in nutrients, algae, and invertebrates in the Lower Susitna would directly inform our understanding of the secondary effects on fish distribution, run timing, and relative abundance if the proposed project is constructed and operated. This information is necessary for USFWS to develop measures that will protect, mitigate and possibly enhance fish and wildlife resources affected by Project construction and operations.

The existing nine River Productivity Study objectives must be geographically expanded to assess the full extent of changes that are likely to occur in the Lower River, as a result of the proposed project. Methodology must be consistent with the modifications for the objectives described above and the additional biological information gathered in this study must be provided with an equivalent level of detail in the River Productivity study in Middle and Upper reaches. AEA is encouraged to consult with licensing participants, to determine optimum sampling locations and sample timing.

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Appendix A. USFWS figures for Study 9.8 River Productivity Comments

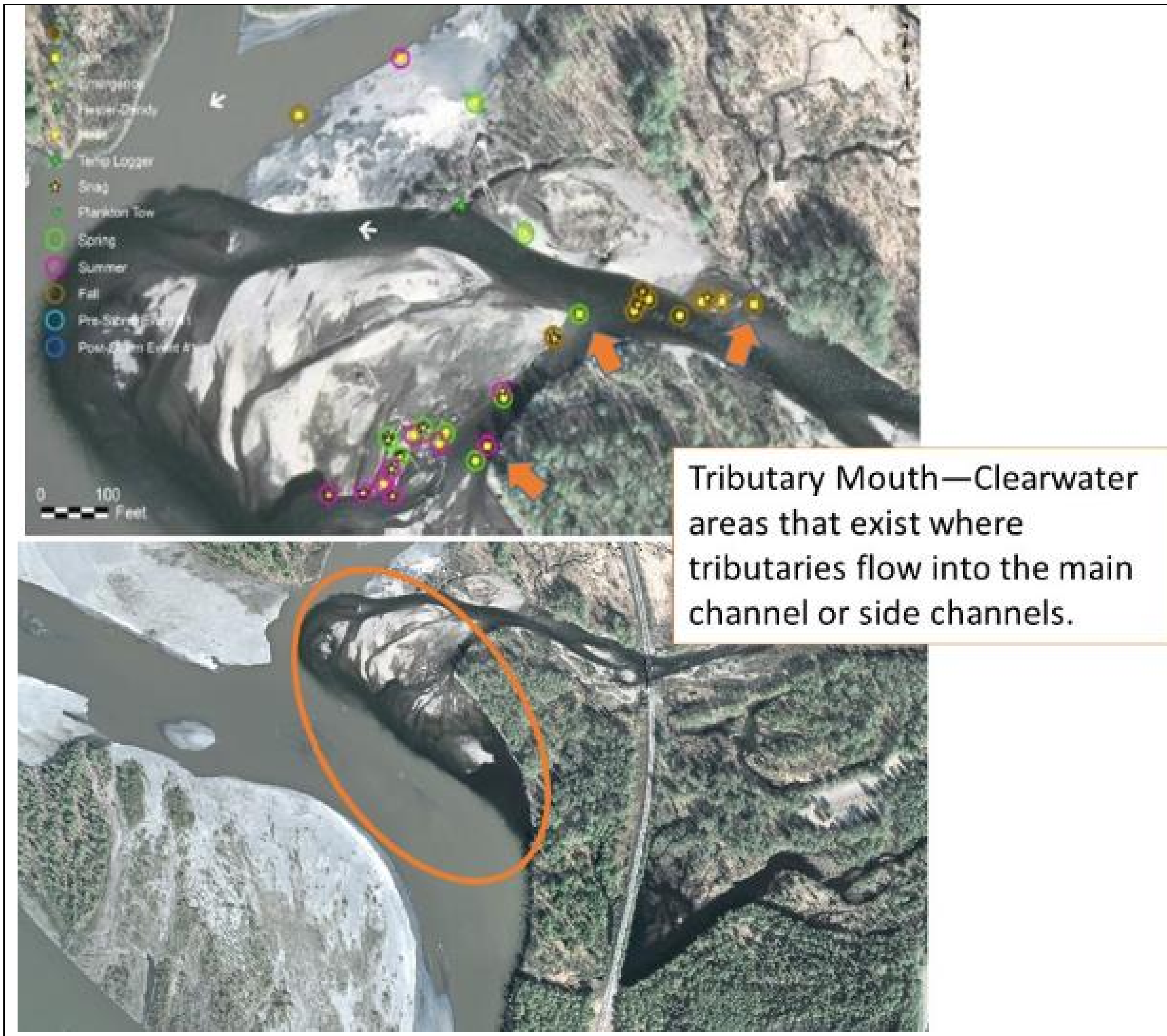

Figure A1. Benthic invertebrate, algal, and drift sampling locations in Montana Creek (upper) and aerial photograph of the Montana Creek with tributary mouth habitat outlined. Arrows point out drift sampling locations. Sampling locations are not representative of tributary mouth habitat since all samples were collected in the tributary delta and no samples were collected in the clearwater area where the tributary flows into the main channel. Drift samples (yellow squares and arrows) were not collected in the main-stem below the tributary mouth as required by FERC.

Figure A2. Benthic invertebrate, algal, and drift sampling location in Indian River (upper) and aerial photograph of the Indian River with tributary mouth habitat outlined. Arrows point out drift sampling locations. All samples were collected in the shallow high velocity tributary and are not representative of tributary mouth habitat. Drift samples were not collected in the clearwater area that flows into the main chanel as provided for in the aproved plan. This is the only Middle River tributary mouth sampled that adequately overlaps with the distribution of juvenile anadromous salmon.

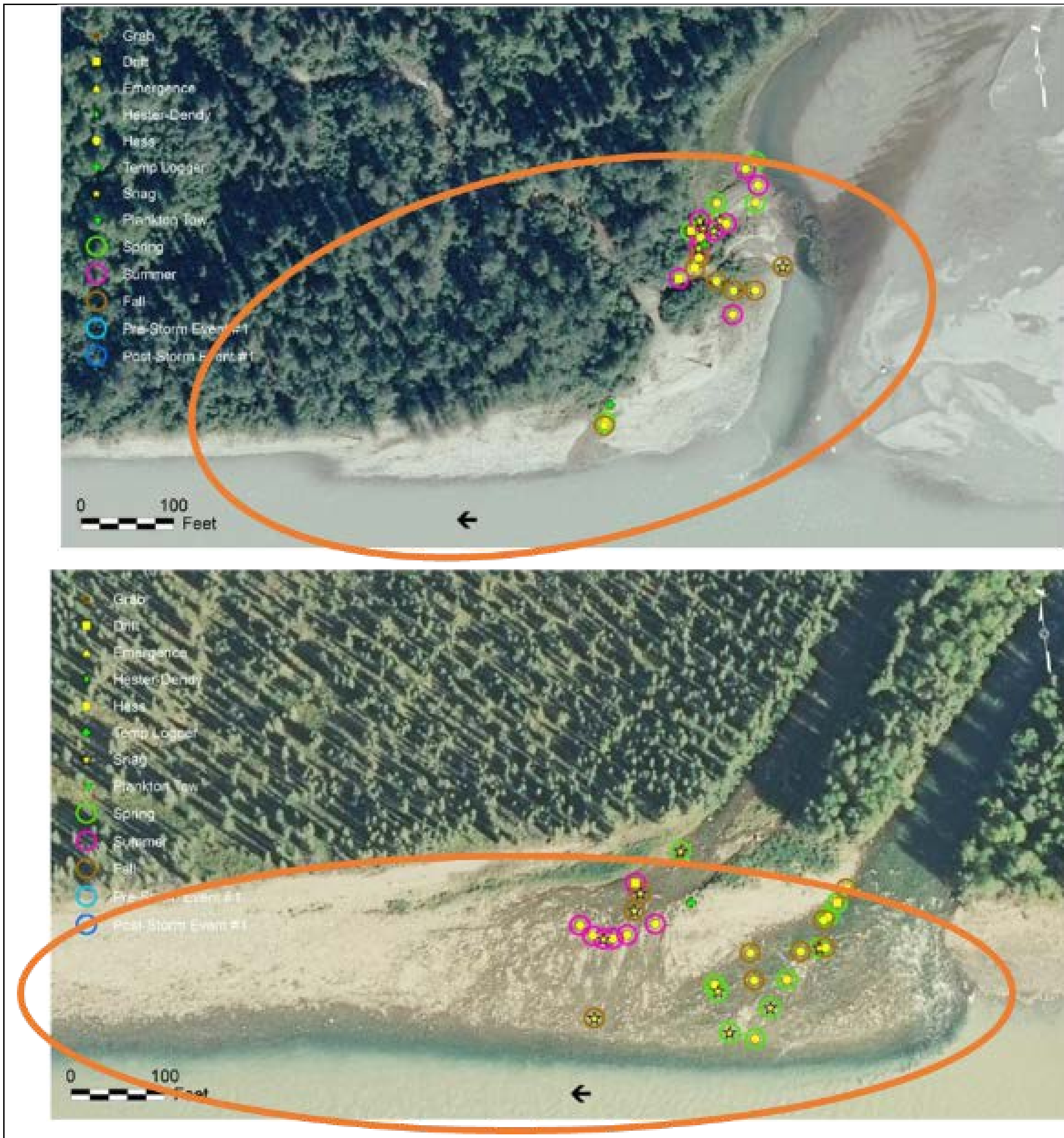

Figure A3. Benthic invertebrate, algal, and drift sampling location in FA 171 and FA 184. All samples were collected in the shallow high velocity tributary and are not representative of tributary mouth habitat. Drift samples were not collected in the main channel above and below tributary mouths as recommended by FERC. Sampling locations were likely dewatered 30 days prior to spring sample collection. All replicates sampled are collected from the same immediate location.

Figure A4. Benthic invertebrate, algal, and drift sampling location in Montana Creek site classified as an upland slough (top photograph); however, aerial photograph of this location (oval in middle photograph) shows that this is a distributary of Montana Creek and not a Susitna River overflow channel. Data from this site should be discarded. This is one of only three sites selected to represent upland sloughs. Lower photograph shows true upland slough habitat near Montana Creek that the Services requests be sampled for this study .

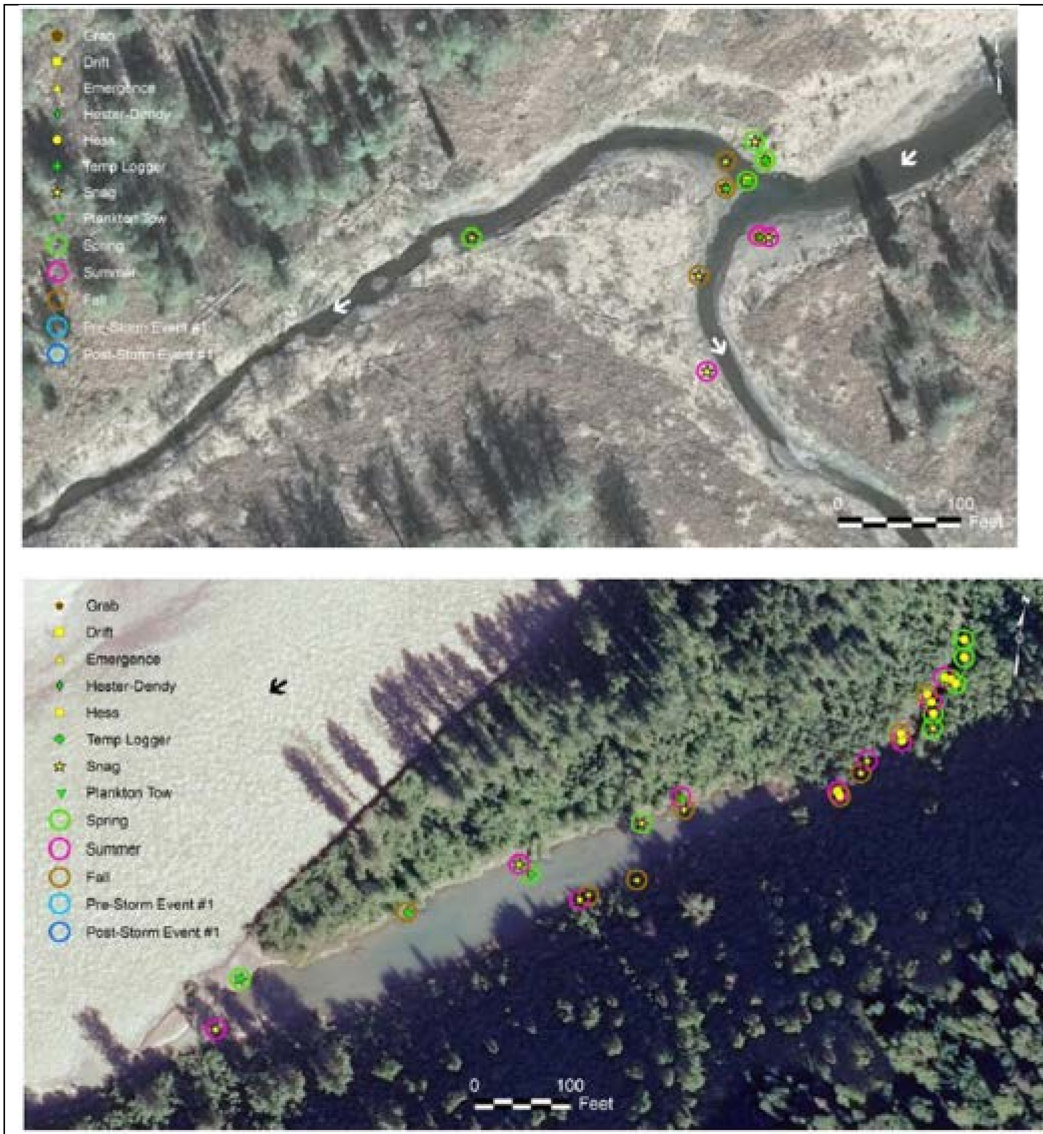

Figure A5. Sampling locations in the FA 104 Focus Area upland slough (upper photograph). All benthic grab and drift samples were collected from the same location within this macrohabitat. This sampling is not consistent with the approved plan. Lower photograph shows the upland slough in FA 144. Samples in this FA 144 slough were not collected in the dominant backwater habitat but were concentrated in riffle habitat at the upstream end, to facilitate use of a Hess sampler.

Figure A6. Orignal ISR classification of FA 173 (top), most recent classification (middle) and aerial photograph of FA 173 (bottom). FERC determination recommended sampling all macrohabitats within River Productivity focus areas. Lower right is an upland slough habitat that was not sampled by AEA. Arrow in upper middle of photograph side slough habitat (clear water and disconnected) that was sampled and misidentified as side channel habitat.

Figure A7. Aerial photograph of Montana Creek showing side slough macrohabitat that was not sampled. The study plan required sampling all macrohabitats within every focus area or Lower River sampling reaches.

Figure A8. AEA FA 104 habitats sampled by the River Productivity study and reported as side slough. The location shown in the upper photograph clearly shows that most of the samples were collected within Whiskers Creek which is a tributary, not a side slough. The FA 104 side slough (lower photograph) is the singe River Productivity sampling site of this macrohabitat type that overlaps with the distribution of rearing juvenile salmon and one of only two side slough sites on the entire Susitna River sampled by AEA.

Figure A9. AEA River Productivity sampling locations in FA 184 (top). All of these samples collected from the same point bar are supposed to represent two different unique macrohabitats, main channel and side channel. All of the sample replicates are collected within feet of each other, which is not the accepted scientific practice and will not provide replicate measures of different habitat conditions necessary to develop habitat suitability models, one of the study objectives. Sampling site in FA 177 was reported as side channel; however, it is clearly side slough habitat. Samples are all taken from approximately the same location.

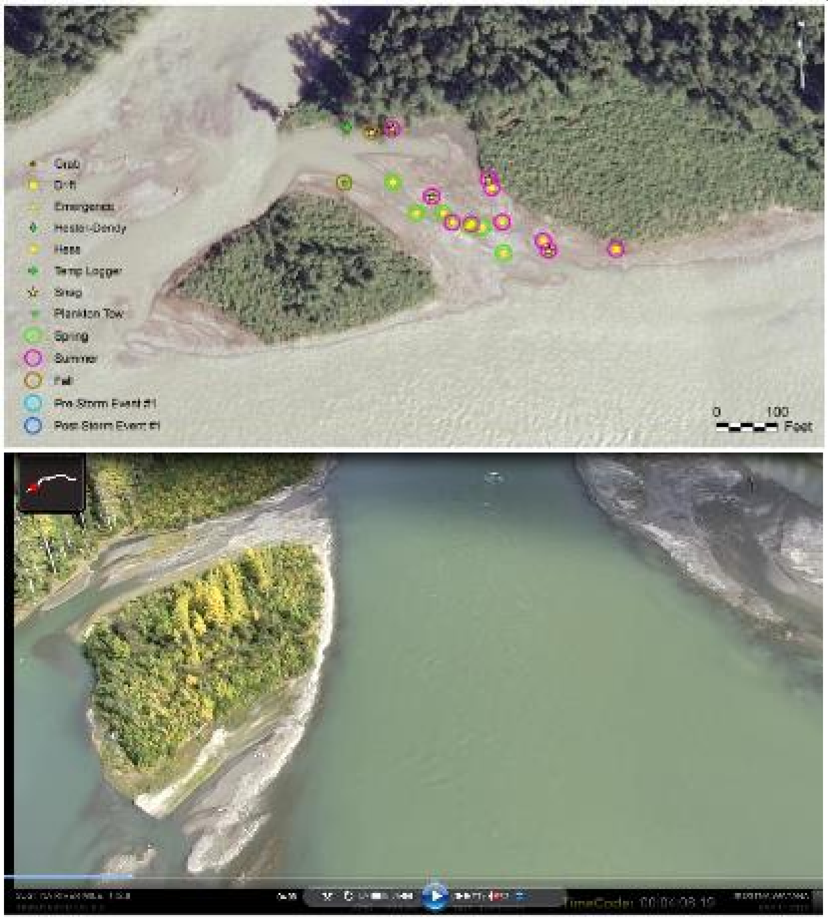

Figure A10. Upper photograph showing habitat within Indian River Focus Area (FA 141) selected by AEA to represent side channel habitat. The classification of this habitat does not meet the definition for side channel habitat and the site is frequency dewatered as shown in the lower photograph which was taken from AEA's habitat characterization aerial video. This location is upstream from the mouth of Indian River and was not sampled by the FDA Study 9.6. This location is one of two Middle River side channel sites downstream from Devils Canyon.

Figure A11. Side slough and side channel habitat just downstream from the mouth of Indian River and Focus Area 141. Only one side slough was sampled for the River Productivity study downstream of Devils Canyon. AEA did not sample this side slough habitat downstream from the major Middle River Chinook and Coho salmon spawning tributary since it did not fall into the boundaries of the Focus Area. AEA did not sample this side channel habitat, instead sampled as small ephemeral channel at the downstream end of an island (see Figure A10).

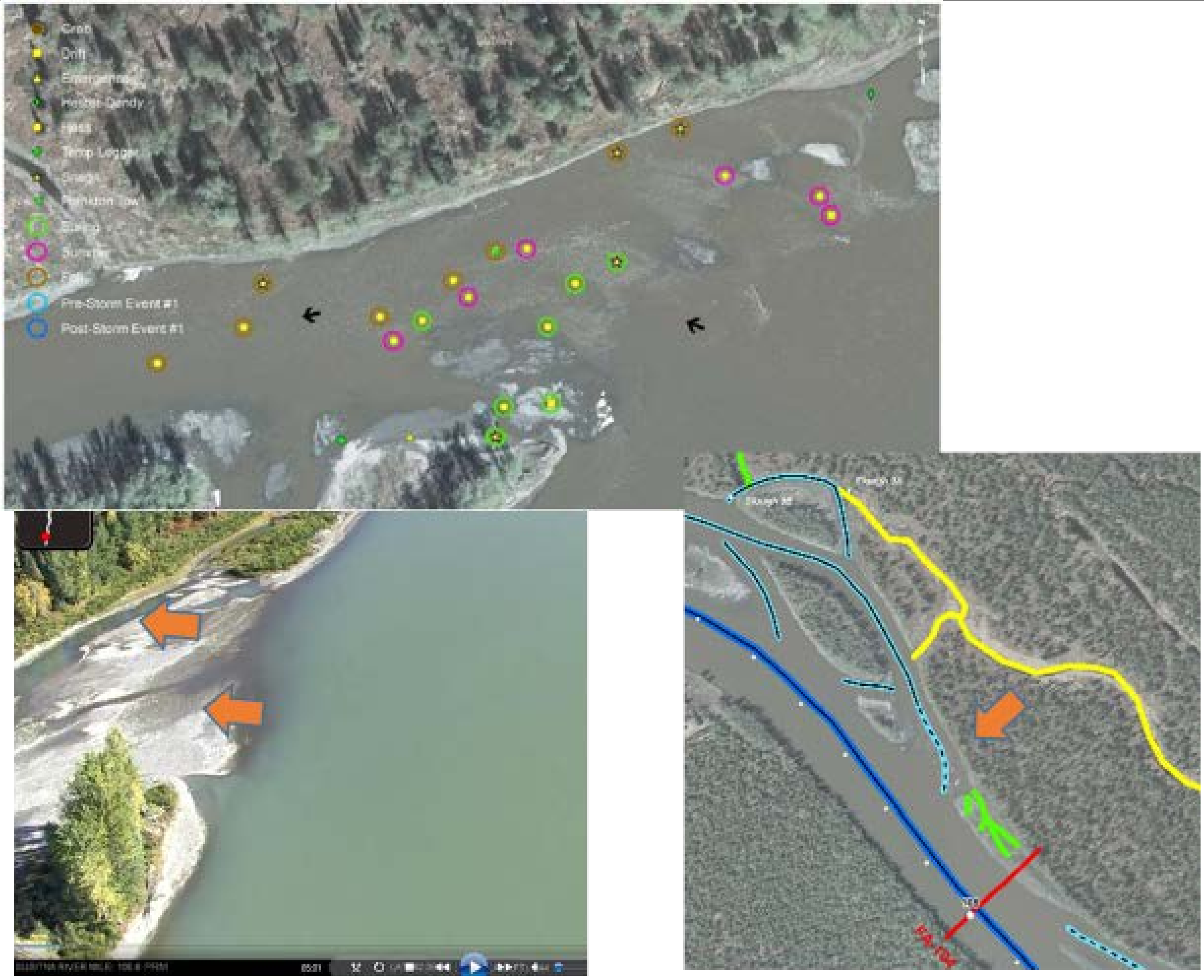

Figure A12. Location selected in Focus Area 104 by AEA to represent side channel habitat (top photograph). Even though side channel habitat is extensive in this Focus Area (right), a sampling site was selected that is often dewatered. During low flows clear water from the side slough extends downstream overlapping productivity sampling sites. This location is not representative of side channel habitat and should not have been selected by AEA for productivity sampling.

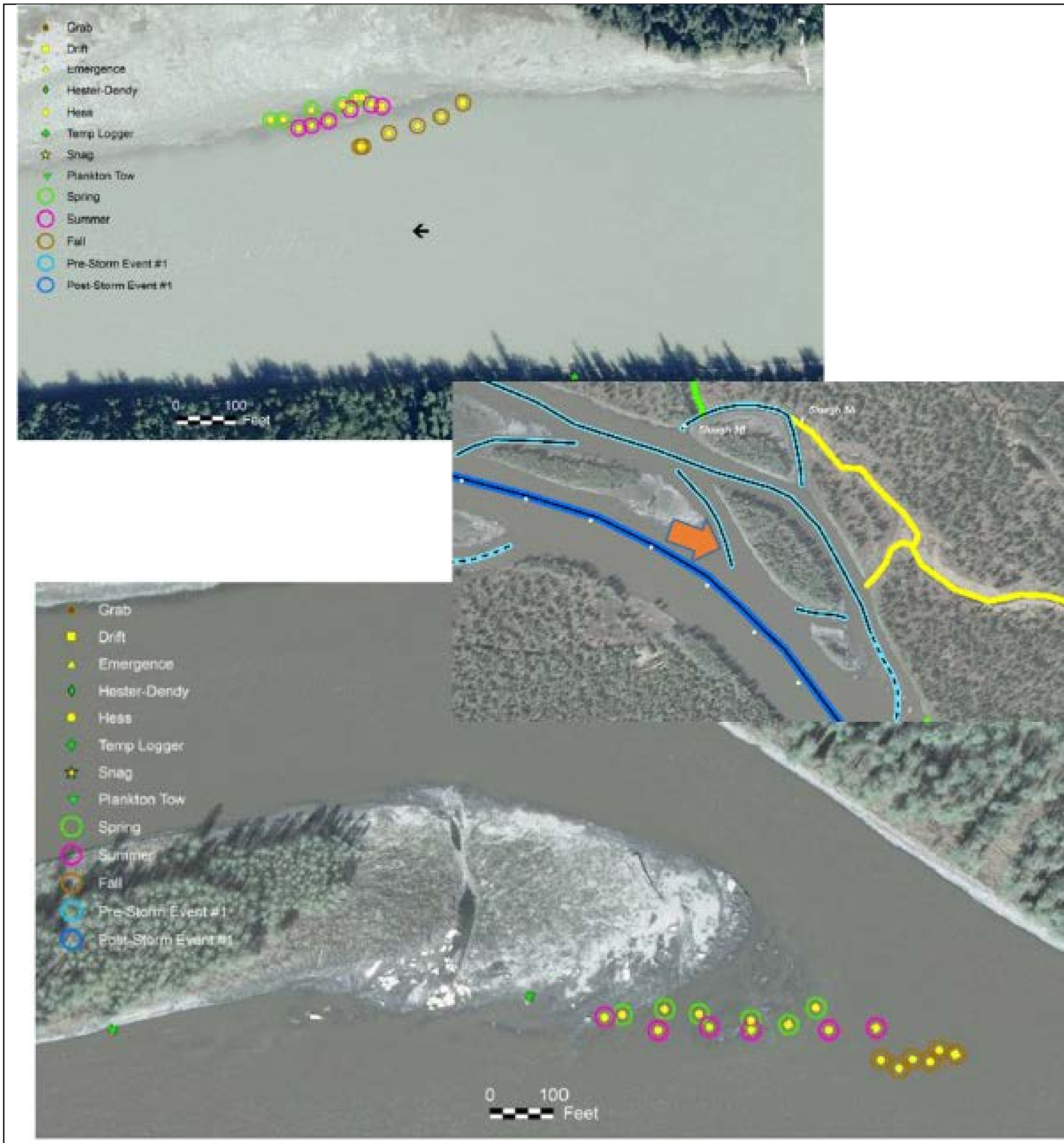

Figure A13. Benthic sampling locations in FA-173 main channel productivity sampling unit (top). All sampling locations are in close proximity to each other and are not distributed throughout the sampling unit as provided for in the approved plan. Sampling locations are in shallow water that was likely dewatered within 30 days prior to sample collection. Benthic sampling locations in FA-104 main channel sampling unit (bottom photograph). Inset is AEA habitat classification from Study 9.8. Based on classification many sampling locations are within side channel and not main channel macrohabitat. All sampling locations on each sampling date are not distributed throughout the sampling unit as provided for in the approved plan.

Figure A14. AEA productivity sampling locations in RM 81 (Montana Creek) sampling unit selected to represent main channel habitat. “Spring” samples (June 29 and 30) were collected from side channel habitat (see aerial photograph insert). During each sampling event, all five replicates were collected from the same location and not distributed throughout the sampling unit as provided for in the approved sampling plan. Side channel habitat was not sampled on all sampling dates even though it is present in the study area.

Figure A15. Extensive biofilm on gravel and cobble substrates in side channel habitat on October 26, 2015, with low turbidity and numerous salmon carcasses. Fall productivity sampling was completed prior to fall reductions in main channel and side channel turbidity.

Reference

Regnart, J. and C. O. Swanton. 2012. Operational planning–policies and procedures for ADF&G fisheries research and data collection projects. Alaska Department of Fish and Game, Special Publication No. 12-13, Anchorage.

9.9 Characterization and Mapping of Aquatic Habitats

Summary of Proposed Modifications and New Studies

U. S. Fish and Wildlife Service's (USFWS) evaluation of potential effects of the proposed Susitna-Watana hydroelectric Project will largely depend upon successful identification of fish habitat relationships according to Alaska Energy Authority's (AEA) hierarchical habitat classification model, and their ability to develop realistic flow-habitat relationships, pursuant to this model. Clear, accurate, and repeatable classification of habitat, at relevant spatial scales, is essential to this evaluation. Throughout study plan development and at technical working group meetings (TWGs), USFWS stressed the importance of accurate and complete habitat classification to AEA and the Federal Energy Regulatory Commission (FERC).

AEA's Revised Study Plan (RSP) (December 2012), as modified by the FERC Study Plan Determination (SPD) (April 1, 2013), established a habitat model that was to be used to classify and quantify habitat in the Susitna River and its tributaries. This model was also to serve the basis to stratify surveys of the distribution and abundance of fish, river productivity, and microhabitat utilization and availability.

The objectives of the study, as provided in the FERC SPD (April 1, 2013), are summarized here as follows:

Objectives 1 and 2: Characterize and map **Upper River tributaries and lake habitats** to evaluate the loss or gain in fluvial habitat and to inform other studies.

Objectives 3 and 4: Characterize and map the **Upper River mainstem** to evaluate the loss or gain in fluvial habitat and to inform other studies (3); Characterize and map the **Middle River mainstem** to evaluate the loss or gain in fluvial habitat and to inform other studies (4).

Objective 5: Characterize and map the **Lower River mainstem** to evaluate the loss or gain in fluvial habitat and to inform other studies.

USFWS has attended and participated in numerous TWG meetings and Instream Flow (ISF) technical team meetings (TTM), and has provided detailed Interim and RSP comments to FERC with the intent to ensure that Susitna River habitats were consistently and accurately classified, and that the results were presented in a format that could be used by AEA, FERC, and other review participants. Though various media were available (LiDAR, aerial photos, and video) were available to AEA in 2012, USFWS is concerned that AEA's first "final" habitat maps were not released until the Initial Study Report (ISR) (June 2014), and again with the Study Completion Report (SCR) (October 2015). This was long after focus areas were selected, and fish distribution and abundance, river productivity, and microhabitat utilization and availability surveys were performed.

USFWS reviewed the ISR (June 2014) and SCR (October 2015) reports, attachments, and errata submitted by AEA and found that the field data collection for Upper River tributaries was conducted as proposed within the RSP. However, data analyses and data results were not presented as proposed within the RSP (December 2012), as modified by the FERC SPD (April 1, 2013). It is therefore unlikely that independent reviews can be made to determine if the study implemented in the Upper River tributaries will meet project objectives. Additionally, AEA did not provide geomorphic classification of the approximately 69 Middle River tributaries within the ISR, as required per the FERC SPD (April 1, 2013).

USFWS comparisons of AEA's habitat classification, based on 2012 aerial imagery and 2013 AEA field surveys, revealed numerous discrepancies at the macrohabitat level. The percent difference between macrohabitat (Level 3) classification shown in line maps and macrohabitat classification from field surveys averaged 43%, and ranged from 0%, for the single multiple split channel, to 57.9% for upland sloughs. AEA's ability to survey and assess fish habitat relationships, with sufficient discernment, rests upon their ability to consistently and accurately classify habitat.

USFWS reviewed AEA's 2012 aerial imagery and determined that AEA's habitat classification in the SCR (October 2015, Appendix A and B) is largely inaccurate, inconsistent, and incomplete. This can be summarized as follows:

- Some tributary mouths were identified by AEA on the line maps and others were not; AEA line maps identified 34 Middle River tributary mouths, while USFWS identified 69, according to AEA's hierarchical habitat model.
- The line mapping identified some clear water plumes but other clear water plumes were not identified on the final maps (12 shown on AEA ISR line maps compared to the 69 USFWS counted).
- The upland slough classification was incorrectly applied to tributaries and disconnected oxbow lakes; upland sloughs were misclassified as side sloughs, and side sloughs were often misclassified as side channels. These macrohabitats consistently display significantly different physical habitat characteristics and patterns of fish habitat utilization.
- Ephemeral cross-island (flood) channels were classified as separate macrohabitats that did not comply with the study definitions.

Inconsistent and inaccurate classification has resulted in errors in fish distribution and abundance and productivity sampling location selections. Microhabitat utilization and availability were surveyed with no regard to the Project hierarchical habitat model. This degree of error and departure from the FERC determination will prevent AEA from developing and predicting realistic and accurate flow-habitat relationships.

Our general observations of the ISR 9.9 Characterization and Mapping of Aquatic Habitats are:

1) Study results were presented in numerous documents that were not clearly linked to one another.
2) Middle and Upper River macrohabitat mapping was incomplete with conflicting classifications amongst documents and those within tables.
3) Results and analyses in Upper River Technical Memoranda mix classification levels and do not follow the approved Level 3 and Level 4 habitat classification,
4) Ground surveyed subsamples were presented as representative of the entire tributary or mainstem from which the subsample was taken. Given the survey protocol, this was unrealistic.
5) Results from ground surveys were not used to resolve line-mapping errors.
6) Geomorphic classification of Middle River tributaries was not provided.
7) In comparison to aerial line surveys, initial ground surveys showed an underestimate of off-channel level 4 habitats.
8) Off-channel mesohabitat mapping, including measures of woody debris, undercut banks, and other habitats has not been completed, and
9) Study results were not presented in a manner that clearly describes the length, and/or area of each level within the hierarchical habitat model.

Given these issues, study results do not currently meet the stated study objectives. As the basis for all other studies, this study must be completed prior to any additional sampling. Therefore, USFWS is recommending that AEA complete the habitat classification, according to their hierarchical habitat model and present the study results as outlined in the approved sampling plan. If necessary, a technical team, with agency support, should be developed to accurately and consistently complete the habitat classification as outlined in the approved plan.

USFWS recommends the following Study Modifications:

1. Provide a single Upper River habitat classification in a single document (Objectives 1 and 2).

2. Produce tables summarizing the coordinates and slope of each reach, with the confinement, width, substrate, and other characteristics of the channel (Objectives 1 and 2).

3. Present the relative distribution of habitats below the inundation zone, and the classification of habitats within the varial zone and above maximum pool elevation (Objectives 1 and 2).

4. Provide the geomorphic classification for all Middle River tributaries as noted in the FERC study determination (Objectives 1 and 2).

5. Review the aerial video for the Middle and Upper River and accurately and consistently classify the Level 3 macrohabitats and Level 4 mesohabitats for the main channel and visible off-channel habitats (Objectives 3 and 4).

6. Prevent misclassification of ephemeral bar and island dissection (flood) channels as side channels, side sloughs, or upland sloughs. Also prevent the use of flood channels to address study objectives (Objectives 3 and 4). These flood channels are ephemeral because they have not been incised to a depth in which they interact with the water table.

7. Clearly define and accurately apply the mesohabitat classification to Susitna River habitats (Objectives 3 and 4).

8. Provide results of the mainstem classification in tables showing lengths of each line on line maps for all Susitna River macrohabitats (main channel and off-channel), as provided for in the approved plan (Objectives 3 and 4).

9. Provide maps and tables showing Upper River and Middle River macrohabitat area as proposed n the FERC-approved plan (Objectives 3 and 4).

10. For both the Upper and Middle Rivers: complete ground surveys of 5 to 10 mainstem and off-channel mesohabitats, classify mesohabitats in off-channels, and provide Tier III habitat characteristics. AEA should also complete the 100% survey and classification of mesohabitats for all macrohabitats in focus areas, including the percentage composition of mesohabitats within and for each macrohabitat (Objectives 3 and 4). As implemented, AEA did not use mesohabitat classifications to structure surveys of microhabitat or fish distribution data. The forfeited the intent of using habitat mapping to collected representative data and make valid comparisons. We stress the importance of developing an operational plan following recommendations included in the state's (Alaska Department of Fish and Game) fisheries research Operational Planning guidance document (Regnart and Swanton 2012).

11. Show beaver pond complexes and backwater mesohabitats on classification maps for the entire Middle River (Objectives 3 and 4). These are physically unique habitats supporting unique patterns of fish habitat utilization.

Study Modifications and Supporting Documentation

Objective 1 and 2: Characterize and map Upper River tributaries and lake habitats to evaluate the loss or gain in fluvial habitat and to inform other studies.

Modification 1: *USFWS recommends that the Upper River habitat classification be provided in a single document. This recommendation is necessary to ensure that all information provided is current and includes any study modifications or additional analyses recommended through TWG meetings or by FERC.*

The ISR (June 2014) or SCR (October 2015) does not contain Upper River tributary classification results, but refers to other technical memoranda or appendices to other study plans. These technical memoranda were completed prior to study plan approval. Since the classification of Upper River tributaries was largely completed in 2012, it would have been most helpful if the ISR or SCR contained all of the Upper River study results within a single document and with incorporated changes in habitat classification levels, as described in the FERC SPD (April 1, 2013).

Modification 2: *Study results should be provided in a table for each stream that show the starting elevation and ending elevation of each geomorphic reach, reach slope, confinement, channel width, substrate, and other habitat variables. Information on each geomorphic reach will provide USFWS with the ability to determine if habitat and fish distributions are similar among geomorphic reaches, with the same physical characteristics within a stream and among streams.*

Reach characteristics are needed to determine the total number and locations of reaches with distinct morphological differences. That is, does each tributary contain three distinct geomorphic reaches, common among all Upper River tributaries, or do some tributaries have unique geomorphic reaches? These are determinations that should have been made prior to structuring surveys of microhabitat and other data that were dependent upon the characterization and mapping of habitat.

Modification 3: *Study results for Upper River tributaries should be presented to show the relative distribution of habitats below the inundation zone, and classified habitats within the varial zone and above maximum pool elevation.*

USFWS recommends that the Upper River tributary classification include tributary habitats at all classification levels that will be directly altered by the proposed Project. This request was made by USFWS during TWG meetings. It is important to understand the geomorphic reaches and tributary mesohabitats that will be lost due to their location within the zone of inundation, and to be able to compare this with tributary habitats projected to be above maximum pool elevation, under all operational scenarios. These results, along with fish habitat associations for each tributary from Study 9.5, will be used to estimate project effects to the fish community, assuming ecologically relevant fish habitat models will be constructed.

Modification 4: *USFWS recommends that AEA provide the geomorphic classification for all Middle River tributaries, as provided for in the FERC study plan determination (April 1, 2013).*

AEA did not incorporate recommendations from the FERC determination. FERC stated, "*We recommend modifying the study plan to have AEA classify Middle River tributary reaches within the zone of hydrologic influence into geomorphic reaches based on tributary basin drainage area and stream gradient to provide a general understanding of the relative potential value to fish and aquatic resources, and report on these attributes in the initial and updated study reports*."

AEA did not provide a geomorphic classification for Middle River tributaries within Study 9.9 ISR (June 2014) or SCR (October 2015). This information is necessary to determine if all tributaries and tributary mouths support the same fish community or if the fish community varies by the tributary geomorphic classification (e.g. low sloped wetland stream, lake-stream complexes, or moderate sloped streams). Tributary classification will be used to determine if fish distribution and productivity sampling adequately represented tributary types present within the Middle River.

Objective 3 and 4 (rephrased for greater specificity). Characterize and map the Upper River mainstem from the proposed Watana dam site to the Oshetna River to evaluate the loss or gain in fluvial habitat and to inform other studies; Characterize and map the Middle River to evaluate the gain or loss in fluvial habitat and to inform other studies.

Modification 5: *USFWS recommends that FERC require AEA to review the aerial videography for the Middle and Upper River and accurately and consistently classify the Level 3 macrohabitats and Level 4 mesohabitats for the main channel and visible off-channel habitats, using the classification definitions or criteria provided for in the SPD (April 1, 2013). Ground surveys need to be conducted at survey flows to classify those macrohabitats that cannot be definitively identified from aerial videography.*

Detailed habitat mapping of the Susitna River, according to AEA's hierarchical habitat model, is an essential foundation to the environmental assessment of this project. The hierarchical habitat model was to structure surveys of all data and their analysis. Though the USFWS put forward extensive efforts to work with AEA and FERC, we find the study results presented in ISR (June 2014) and SCR (October 2015) for Study 9.9 to be inaccurate and incomplete. This may prevent AEA from meeting their study objectives.

AEA developed a habitat mapping strategy that would use aerial video (September 2012), LiDAR, and aerial photographs to classify Level 3 macrohabitats and Level 4 mesohabitats for main and side channels and visible off channel habitats. The classification was to be conducted to inform other studies and to document existing conditions. The RSP (December 2012) described ground-truthing as a method to verify habitat classification from aerial imagery, to conduct mesohabitat classifications in focus areas, and to provide Tier III survey data. Ground-truthing was to be conducted at flows similar to those when aerial imagery was obtained, but it was not. AEA also did not implement the classification put forth in the SPD.

AEA also used ground surveys to modify macrohabitat classifications that were specified in the SPD. In recent ISR meetings, AEA stated that 6 macrohabitat classifications were changed following ground-truthing. It is important to note that this did not simply mean there were only six locations where the classification from ground-truthing was different from the classification from aerial imagery. Next, the RSP (December 2012) and SCR (October 2015) do not provide a protocol for modifying classifications when there are differences between aerial imagery and ground-truthing results. The discrepancies are meaningful and should not simply be edited away. The habitat classification should only have been modified if systematic errors, that could have been applied to the entire Middle and Upper River, were identified. With these points in mind, we draw attention to AEA's altered classification of a side channel in FA 104 to a side slough and a side channel in FA 113 to a side slough based on ground-truthing results. This raises the following questions: one, how many other side channels or side sloughs, which were not ground-truthed, were also classified incorrectly from aerial imagery; and two, if errors resulted in reclassification, why wasn't the classification changed for other side channels or side sloughs not ground surveyed? These changes and resulting questions leave uncertainty about the results of this study.

The mouth of Whiskers Creek in FA 104 provides a good example of the inconsistency in habitat classification and the efficacy of the results in meeting project objectives. The habitat classification maps released in November of 2014 (after the first study year) (ISR Attachment L 2014) identified the mouth of Whiskers Creek as a side slough, with no backwater or clearwater plume mesohabitat (Figure C1). The 2013 ground survey classified the mouth of Whiskers Creek as a main channel pool with a main channel clear water plume (ISR Appendix D). The most recent maps provided with the SCR in 2015 (SCR Appendix B) classify this habitat as a side slough with backwater mesohabitat and a side channel clearwater plume. Furthermore, this most recent classification cannot be used to retroactively inform early surveys that that were structured around the earlier classifications. It is also important to note that this confusion was within a focus area where the most detailed studies are to be conducted. As a result, the River Productivity study inconsistently referred to samples collected at this location as both tributary mouth and side slough (see Study 9.8 SCR).

The confusion noted in the Whiskers Creek example could be due, in part, to two main factors. At the macrohabitat level (Level 3), AEA did not update their study methodology to clarify how to classify habitats where two different classifications merge (i.e. slough and tributary). AEA also did not provide a method to differentiate between pools and backwaters at the mouths of side channels, sloughs, or tributaries at the mesohabitat level (Level 4).. USFWS has always identified the habitat downstream of Whiskers Creek confluence as a tributary mouth(due to the dominance of flow from Whiskers Creek) that contains backwater and a clearwater plume (Figure C2).

Due to the large differences between AEA's final classification and ground surveys, USFWS reviewed AEA's aerial imagery to see why these differences occurred. To perform this inquiry, USFWS used AEA's classifications to develop a dichotomous macrohabitat classification key (Appendix A). A systematic, repeatable approach is essential to performing valid and useful habitat classifications. Using this dichotomous key, we compared the surveyed macrohabitat classifications for the Middle River (ISR Appendix D, June 2014) with final macrohabitat classification in revised Appendix A (ISR Appendix L, June 2014).

The results of USFWS comparison of consistency between AEA's macrohabitat classification from aerial imagery and ground surveys are summarized in Table 1 and Appendix B. Of the 95 macrohabitats identified, 41 (43.2%) were classified differently by ground surveys (ISR Appendix D) compared to the final line maps (ISR revised Appendix A or L. There were 10 channels classified by ground surveys that were unclassified on the aerial videography; therefore, an estimated 10% of the Middle and Upper River macrohabitats are unclassified. Differences in habitat classifications ranged from 17% for main channels to 58% for upland sloughs. USFWS review identified numerous errors in the AEA line map classification including inaccuracies, inconsistency, and incompleteness.

Table 1. Total number of Middle River habitats classified by ground surveys (ISR Appendix D), the number of macrohabitat classifications that were different than those shown on AEA final line maps (ISR Appendix L), and the percent difference (Different/Total x 100).

	Total	Different	% Different
All Macrohabitats	95	41	43.2
Main Channel	17	3	17.6
Multiple Split	1	0	0.0
Side Channel	34	10	29.4
Split Main	18	3	16.7
Side Slough	13	4	30.8
Upland Slough	19	11	57.9
Unclassified	10	10	100.0

Tributary Mouths

Tributary mouths are defined by AEA as "clearwater areas that exist where tributaries flow into the main channel or side channels". This definition includes both the tributary delta or backwater, and the clearwater plume caused by tributary discharge. One objective of habitat characterization is to inform other studies (e.g. Fish Distribution and Abundance study 9.6). The FERC determination for study 9.5 recommended that tributary mouth macrohabitat sampling extend 200 m downstream from where tributaries enter the main channel or side channel. Therefore, the habitat characterization study should have identified all tributary mouth macrohabitats as tributaries that contain a clearwater plume mesohabitat. However, tributary mouths were consistently misclassified.

For example, Chase Creek (SCR October 2015, Appendix A Map 51) is shown with a clearwater plume as main channel mesohabitat but not as a tributary mouth macrohabitat. This resulted from AEA's failure to define habitats in accordance with their approved plan. If clearwater plumes are a mesohabitat of tributary mouths, then only those tributary mouths with clearwater plumes need to be classified. If clearwater plumes are a mesohabitat of main channels or side channels, then all 69 Middle River tributaries flowing into the Susitna River need to be identified as tributary mouths.

In the SCR (October 2015), Appendix A Map 50 in Focus Area 113, the tributary 113.7 has a classified tributary mouth. Nearby Slash Creek and Gash Creek, however, are not identified as tributary mouths, even though clearwater plumes are visible at the mouths of both of these streams. Tributary 115.4 (Map 50 of 55) in FA 115 is identified as a tributary mouth with no clearwater plume mesohabitat. Lane Creek has a main channel clearwater plume mesohabitat and is identified as a tributary mouth (Map 49 of 55); however, the clearwater plume and tributary mouth at unnamed tributary 117.4 were not classified, even though a plume is clearly visible on the aerial imagery (Figure C3). McKenzie Creek and Little Portage Creek are not tributary mouths according to AEA (Map 47 of 55). However, they are both clearly tributaries and tributary plumes are visible on aerial imagery (Figure C4). The tributary at 124.4 (Curry) is identified as a tributary (SCR October 2015, Map 46 of 50) but the tributary clearwater plume is not classified, though clearly visible (Figure C5). If a tributary clearwater plume is not necessary for tributary mouth classification, then it is not clear why this is a tributary mouth while other tributary confluences were not classified. These same errors and inconsistencies continue throughout the river. Therefore it’s not possible for the results of this classification, as shown in the SCR, to inform other studies on the number of tributary mouths available for sampling.

The RSP clearly defines tributary mouths as locations where tributaries discharge into the main channel or side channel of the Susitna River, creating a downstream clearwater plume. USFWS recommends that AEA revisit the aerial imagery and accurately and consistently classify these Middle River tributary mouth macro and mesohabitats. Accurate and consistent habitat classifications should have been used to structure other surveys surveys and will certainly be necessary prior to any additional field sampling.

Side Channels and Split Main Channels

AEA’s departure from their classification let to inconsistent classification of side and split main channels. AEA classified side channels as those connected to the main channel but containing much less flow (~10%) Split channels were defined as bifurcations where a dominant or subdominant channel could not be readily identified. This left it inevitable that a large number of channels, those receiving greater than ~10% of the flow to remain unclassified. AEA further defined side channels as a channel separated from the main channel by an island whose length is greater than or equal to channel width and split channels as being separated by islands without permanent vegetation (permanent vegetation is not defined but is presumed to mean woody vegetation).

Evaluation of side and split channel classification in Focus Areas (FA) illustrates several issues with AEA’s classification: In FA 104 the right channel was classified as a side channel (SCR October 2015, Appendix A Map 54 of 55). The channel is subdominant and may contain approximately 10% or more of total flow. The channel is separated from the main channel by an island with a length > channel width (if the cross-island channels are ignored). In FA 115, however, the left channel (flowing in front of Slash and Gash Creek, Map 50 of 55) is classified as a split main channel. This was inconsistent because this channel is also subdominant (not navigable under most flows), and is separated from the main channel by a long island. In addition, the island is clearly vegetated. Split channel classification is applied to one channel and side channel classification to another; however, both channels meet the classification description for side channel. This is an example of where AEA’s classification was not accurately or consistently applied in areas where distinct physical characteristics have been identified. In addition, the cross-island channels in FA 115 are classified as split channels when they are clearly subdominant, whereas the cross-island channels if FA 104 are classified as side channels.

These examples of misclassification are found throughout SCR Appendix A (October 2015), where the split main channel classification was applied to side channels. Following are more examples: Compare the split main channel classification of the channel at PRM 125.5 (Map 45 of 55), which is clearly a subdominant channel on aerial imagery (Figure C6), with the side channel classification in FA 128 (Map 44 of 45). Both of these channels are subdominant, and likely contain ~10% of total flows, but one is classified as a split main channel and the other a side channel. The channel flowing past Slough 11 in FA 138 (Map 40 of 45) is clearly a subdominant channel, and is separated from the main channel by a vegetated island, but is miss-classified as a split main channel. This is inconsistent with the definitions in the approved plan. There is no clear basis for the two channels at the top of Map 38 of 55 in FA 138 to be classified as split main channels instead of side channels. The channels are clearly subdominant, contain roughly <10% of the flow, and are separated by long vegetated islands, whereas the small cross-island channel, which has been classified as a side channel, does not comply with the side channel classification. An exposed gravel bar in FA 173 (Map 26 of 55), at PRM 174 is classified as side channel, but does not comply with the classification descriptions. These types of inconsistencies and inaccuracies are found throughout the SCR (October 2015).

Side Channels and Side Sloughs

AEA also inaccurately and inconsistently applied the side channel classification to side sloughs. AEA differentiated side channels from side sloughs based on the upstream connection to the main channel and water turbidity. This classification is flow dependent, since at high flows side sloughs can become connected to the main channel and can be dominated with turbid water. AEA defined flows of 10,000 to 12,000 cfs as those to be used for classification. In the most recent maps (SCR Appendix A, 2015), AEA changed side channel habitat in FA 104 (Slough 3b) and FA 113 (Oxbow I) to side slough habitat (ISR Appendix L, 2014 and SCR Appendix A Maps 54 and 50 of 55, 2015). Therefore, the upstream connection and water clarity at these two sites shown on aerial imagery can be used to compare to other side channel sites to see if they also should be side channel or side slough habitat.

The connectivity and clarity of Slough 3b and Oxbow I from aerial videography were shown in Figure C7 and C8. In this videography, the upstream ends of both sloughs are not overtopped and the water appears clear. Since the channels at PRM 119 (SCR Appendix A Map 45, 2015) are not overtopped and the water appears clear on videography (Figure C9), these sites also should be classified as side sloughs; however, they are classified by AEA as side channels. The channel in FA 128 (Slough 8A) is classified as a side channel; however, the upstream end is not overtopped on the videography and the water appears clear (Figure C10). It is unclear why channels in FA 104 and FA 113 are classified as side sloughs and the channel in FA 128 is classified as a side channel when they appear exactly the same on the 2012 aerial videography.

Another example is the side slough complex near at PRM 131 (Figure C11) that was incorrectly classified as a network of side channels. USFWS has noted many other such examples. Based on the approved classifications and classification of sites where AEA changed the classification from side channel to side sloughs in FA 104 and FA 113, these sites also should have been classified as side sloughs.

AEA also inconsistently classified habitats downstream from where two different macrohabitats join. For example, in FA 173, side channel habitat merges with side slough habitat and the habitat downstream continues as side slough. However, if the side channel habitat classification is based on an upstream connection within the main channel, then the entire habitat downstream must also be connected to the main channel at the upstream end, even after it combines with another habitat type. Whenever a side slough and side channel combine, based on the classification, it must continue downstream as a side channel. Habitat downstream from the confluence of a side slough and an upland slough must continue as a side slough, not as upland slough (Slough 1 Map 55). Whiskers Creek intersects with a side slough and downstream habitat is classified as a side slough, but Chase Creek intersects with an upland slough and downstream habitat is classified as a tributary. Downstream habitat in both situations is dominated by tributary flow.

One objective of the habitat characterization study is to consistently survey and measure changes in fluvial habitat. Classification using the same methods and videography used by AEA resulted in large differences in classification. Therefore, the “final” classification maps used by AEA (SCR Appendix A, 2015) will not meet the study objective. The second study objective was to inform other studies. Studies 9.5, 9.6, and 9.8 selected sampling units based on macrohabitat classification, however many habitats that should have been available for site selection were never classified. For example, the Winter Fish study sampled upland slough habitat, in the most studied FA on the Middle River (FA 128), but the upland slough is not shown on the classification maps (Slough A on Map 44 of 45 below Skull Creek). We also know that many sites sampled were misclassified. Therefore, the study did not meet the second objective and has led to errors in the Fish Distribution and Abundance (FDA) and River Productivity studies.

USFWS believes that most classification errors were due to inconsistent implementation of study methodology. Clear review of the aerial videography and consistent application of AEA’s hierarchical classification model should eliminate most errors. USFWS recommends that AEA reclassify all Middle and Upper River macrohabitats, according to their hierarchical habitat model, using the aerial imagery. Site visits should be conducted, under survey flow conditions, to confirm classification accuracy, when locations are not clearly visible. USFWS should be given an opportunity to review and comment on revised maps and final classification approved by FERC prior to any additional field sampling for FDA or river productivity.

Modification 6: *USFWS recommends that ephemeral flood channels (cross-island channels) not be classified as side channels, side sloughs, or upland sloughs. They should also not be used to address study objectives. These channels should have a distinct classification for FDA and River Productivity sampling or not be sampled.*

AEA's final line maps classify ephemeral bar-dissection (flood) channels as side channels, side sloughs, or upland sloughs, however short they are. These channels do not fit these defined habitats. For example, side channels, as defined by AEA, are connected to the mainstem with turbid water but carry a minor portion of the flow. They are also separated from the main channel by a vegetated island that is at least as large as the bank-full channel width. However, most of the islands created by flood channels do not meet this definition. Not only do these channels not meet AEA's classification, they arguably do not provide the same quantity and quality of fish habitat as similarly classified channels occupying the margins of the floodplain.

Juvenile salmon that are oriented toward the banks of large rivers are less likely to be found in cross-island channels. Juvenile salmon migrating downstream along the left or right river bank will enter the upstream or downstream ends of side channels and sloughs located on the river margins but will not encounter islands in the middle of the Susitna River unless they cross the main channel. Even if juveniles do encounter flood channels, the channel gradients are to too high to support rearing (the current is too swift to hold fish). The absence or low abundance of juvenile salmon in cross-island channels was documented in AEAs winter fish technical memorandum (see NMFS RSP Study 9.6 comments, March 18, 2013). The distribution of juvenile salmon will also influence the distribution and abundance of piscivorous resident fish. Therefore, these habitats are of limited value as habitat.

Due to these differences in physical characteristics and fish utilization, USFWS recommends that side slough, upland sough, and side channel classification not apply to cross-island flood channels and that these channels are not selected for FDA or river productivity sampling.

Modification 7: *USFWS recommends that AEA clearly define and accurately apply mesohabitat classifications to Susitna River habitats. If selection of FDA surveys, summaries, and analyses are to be conducted at the mesohabitat level, then AEA's mesohabitat classification must be completed for all main and off-channel habitats in the Middle and Upper segments of the Susitna River.*

AEA did not accurately and consistently classify main channel and off-channel mesohabitats. Specifically, remote line maps do not accurately classify or differentiate between runs, glides, or backwaters. Main channel habitats are classified as run/glide; however, these are two different habitat classification types (AEA Table 1.1-1). According to AEA's classification definitions, glides have slopes of 0 to 1% and therefore, will be most abundant in Susitna River mainstem channels. Runs have water surface slopes from 0.5 to 2% and are less likely to occur within Susitna River main or off-channels. AEA Table 5.1-14 differentiates glides from runs, but all slopes for both mesohabitats are less than 1and the table does not identify in which macrohabitat these mesohabitats occurred. Backwaters are areas where the water surface slope is 0% and are located where channels are governed by hydraulic controls. Under low mainstem flow conditions, backwater habitats may transform into glides. This being said, AEA has inconsistently and inaccurately applied these classifications to main channel and off-channel habitats.

Mesohabitat classifications are also presented as part of ISR FDA Study 9.6 (June 2014) outside of focus areas. These classifications identified run habitat within beaver complexes and interchanged classification of runs and glides (also see USFWS Modification 9). The inaccuracies noted in Study 9.6 could be partly due to the inaccuracies noted in the remote line maps and ground surveys. USFWS recommends that AEA accurately classify mesohabitats based on the classification definitions provided for in the approved plan. Aerial video for the Upper and Middle River main channel and side channels should be revisited and all mesohabitats accurately classified.

Modification 8: *USFWS recommends that AEA provide the results of the mainstem classification in tables showing lengths of each line on the line maps for all mainstem macrohabitats (main channel and off-channel) as specified in the approved plan.*

ISR Study 9.9 (June 2014) did not report study results as specified in the FERC approved plan. The RSP (December, 2012) states that, “The GIS database will create a hierarchical table that will be used to summarize the proportion of habitat by mapped unit of length (Tables 9.9-6 and 9.9-7). This tiered approach would have allowed for summaries at all five levels to support resource study planning. The table would also provide individual identification of all unique habitat types.” However, tables were not provided that could be used to summarize habitat at all five habitat classification levels, or if available electronically were not referenced.

USFWS recommends that AEA, upon completion of an accurate habitat classification, pursuant to the Project’s hierarchical habitat model, provide a table (hard and electronic formats) of results for classification Level 1 through 3 listing out all macrohabitats classified. Every macrohabitat should have a unique identifier so that macrohabitat length, macrohabitat area, mesohabitats, mesohabitat areas, and mesohabitat characteristics can be tied to the same location. The table should be clear enough that USFWS and FERC can identify the macrohabitat on the final line map and aerial photographs, and find the macrohabitat length. USFWS should be able to count the numbers and sum up the lengths and areas of each macrohabitat type for each geomorphic reach and river segment.

Additionally, USFWS and FERC should be able to identify which of these macrohabitats was ground surveyed. Ground surveyed mesohabitat types, characteristics, and photographs (when provided), within and outside of focus areas, should be linked to unique macrohabitat identifiers for every surveyed macrohabitat (100% of Middle River focus areas).

Modification 9: *USFWS recommends that AEA provide maps and tables showing Upper River and Middle River macrohabitat area as provided for in the approved plan.*

RSP Study 9.9 (December 2014) states that, "All habitat segments will be identified using a mid-channel line, which will provide habitat length; however, off-channel slough habitat will be drawn separately in an area (polygon) in the Middle River to identify the size of each slough and better characterize slough diversity for Instream Flow Study needs. Area mapping will be reported separately from the linear database." Area maps showing the area of each macrohabitat or tables of macrohabitat area have not been provided. This information is necessary to determine the representativeness of focus areas and to evaluate sampling unit selection for the FDA and productivity studies. Since aerial video was collected in 2012, it is reasonable to expect accurate and complete line and area maps prior to the second year of field sampling, proposed to occur in 2017. AEA has not identified area mapping as one of the steps to be completed in ISR 9.9 Part C (June 2014).

USFWS recommends that, after conducting accurate and complete habitat classifications, and prior to any additional FDA or River Productivity sampling, AEA provide maps showing the areas of all off-channel habitats. USFWS recommends that the area of the off-channel habitat be calculated for ordinary high water (vegetation line) and at target flows used for habitat classification (10,000 to 12,000 cfs), in order to document any loss or gain in fluvial habitat due to differences in river stage height.

Modification 10: *USFWS recommends that AEA complete the ground surveys of 5 to 10 Upper River mainstem mesohabitats and off-channel habitats, classification of mesohabitats for off-channel macrohabitats, and provide Tier III habitat characteristics as provided for in the approved plan. USFWS recommends that AEA complete the ground surveys of 5 to 10 Middle River mainstem mesohabitats and off-channel habitats, classification of mesohabitats within these off-channel habitats, and provide the Tier III habitat characteristics for these sites. USFWS recommends that AEA complete the 100% survey and classification of mesohabitats for all focus areas as specified in the approved plan. For each macrohabitat within each focus area, provide the percent of each mesohabitat, and Tier III habitat characteristics as specified in the approved plan.*

AEA's Upper and Middle River ground surveys have not been conducted as provided for in the approved plan. For the Upper and Lower River, these ground surveys will be the only source of information on the types and abundance of off-channel mesohabitats. This is critical to the study, since the first year FDA sampling was conducted and reported at the mesohabitat level, and must be referenced to habitat maps, if any scientific analysis is to be conducted. These ground surveys will also be used to determine the accuracy of macrohabitat and mesohabitat classification from remote line mapping.

For the Upper River mainstem, the RSP (December 2012) stated "a subset of off-channel and main channel habitat units will be ground mapped and include metrics as described for tributaries e.g. depth, width, wood, cover, etc." The approach described for tributaries states, "Channel metrics to be subsampled will be collected using a modified U.S. Department of Agriculture, Forest Service (USFS) Tier I and Tier III stream habitat survey protocol (2001)." The RSP describes ground surveys to be conducted over lengths of 20 times channel width. Tier III protocol includes the collection of the following mesohabitat metrics or characteristics:

- Habitat unit type
- Measured unit length
- Measured average wetted width (three measurements per unit)
- If pool, estimated or measured maximum depth
- If pool, estimated or measured pool crest depth
- Estimated average maximum depth of unit
- Measured width of unit
- Woody debris count in unit
- Estimated percent substrate composition in unit
- Estimated percent undercut, each bank in unit
- Estimated percent erosion, each bank in unit
- Estimated percent riparian vegetation cover in unit
- Dominant riparian vegetation type for each unit
- Estimated percent instream cover in unit
- Photograph of each unit
- GPS location of each unit

Therefore, the study should report each mesohabitat unit type, mesohabitat unit length, woody debris counts, substrate composition, cover, etc., and include a photograph and GPS location for each main channel mesohabitat and off-channel habitat survey over a length of 20 times channel width. These data were not provided in the ISR (June 2014), or SCR (October 2015), and it is not clear that ground surveys collected this information or were conducted over 20 times channel widths.

Ground survey results for the Upper and Middle River mainstem are provided in ISR Study 9.9 Tables 5.1-13 through 5.1.18. For Upper River and Middle River non-focus areas, the tables do not provide information on the types, lengths, or any other habitat metrics for any of the main channel or off-channel habitats surveyed. Average lengths, slopes, widths, and depths of mesohabitats are provided, but there is no information on what Level 3 macrohabitat these Level 4 mesohabitats represent. Provision of average width of a pool from combined main channel, side channels, side sloughs, upland sloughs, and split main channels was insufficient. For every off-channel habitat survey, survey length; including mesohabitat type, length, and width; woody debris, or any of the other habitat metrics specified within the survey need to be provided. Since only 5 or 10 surveys were proposed to be conducted if all of the metrics were measured, USFWS recommends that AEA clearly provide the river mile (PRM) of surveyed habitat, macrohabitat type (Level 3), survey length, the type and habitat metrics for each mesohabitat within the survey, and a summary of metrics for that macrohabitat.

Focus areas were supposed to be surveyed in their entirety, all mesohabitat types classified, and Tier III metrics measured. The ISR states that surveys in focus areas are completed or near completion, however the ISR Study 9.9 has not provided information on the types of mesohabitats or habitat metrics within these focus areas as provided for in the FERC-approved plan. A specific example of missing information includes the length of the side slough in FA 128, where AEA has been conducting a number of different studies. In this slough, the classified mesohabitats, and the length of each mesohabitat, depth, substrate type, woody debris, and riparian vegetation should have been provided. There is no information on the number of pools or residual pool depth, nor is there information on the number of beaver dams, dam height, or portion of side slough (by length and area) composed of beaver pond habitat. The photographs and GPS coordinate for each of the mesohabitats within this side slough were also not included. This was supposed to be collected, according to the approved plan. Since this information is not provided in the ISR, and AEA has not responded to USFWS requests for this information, USFWS concludes that it has not been collected.

Many of the habitat metrics (i.e., substrate, cover, woody debris) are used in models developed by the Instream Flow study. Therefore, in addition to understanding fish habitat associations, these data are critical for determining how habitat metrics that are used in fish habitat models vary among macrohabitats and how these metrics may influence the distribution and abundance of fish species before and after the proposed project. At this point in AEA's reporting, the agencies have been presented with a series of studies that are not integrated in any particular or clear way. This is particularly concerning for study 9.9, since it was to serve as the basis for valid surveys, reporting, and analyses of data collected in other studies.

USFWS recommends that prior to any additional FDA or river productivity sampling, AEA complete an accurate and complete classification of habitats including ground surveys and provide the study results in a single document that reports the information as provided for in the FERC SPD (April 1, 2013).

Modification 11: *USFWS recommends that beaver pond complex and backwater mesohabitats should be shown on classification maps for the entire Middle River and not just when they occur in Focus Areas.*

AEA only shows beaver pond complexes and backwaters in the detailed mesohabitat maps of Focus Areas (SCR Appendix B, October 2015) and not where they occur throughout the Middle River (SCR Appendix A). AEA states that since the FERC determination changed beaver complexes and backwaters from level 3 macrohabitats to level 4 mesohabitats, they only need to be shown in FA off-channel habitats and not in all off-channel habitats outside of focus areas. AEA states that they were only required to conduct level 4 mesohabitat classification in focus areas because riffles, runs, and pools couldn't be seen well from aerial imagery. However, since beaver dam complexes and backwaters are visible and were largely classified from aerial imagery, they could easily have been shown throughout the Middle River on habitat maps. They were shown where they occurred in off-channel habitats in and out of FAs on previous maps (ISR Appendix A, June 2014), and are to be selected for FDA sampling both inside and outside of FA, so this seems important and feasible.

Beaver-influenced areas are readily apparent, yet AEA only identified 10 Middle River beaver complexes; USFWS independently identified 20 from the same aerial video. AEA identified 8 backwaters on final classification line maps; however, we counted this amount in reach 8 alone.

There was also confusion in AEA's ability to discriminate between beaver influence and physical hydraulic controls. There was no consistency in backwater classifications and many main and side channel backwaters were classified as run/glide mesohabitats. However, since they are not shown where they occur in all off-channel habitats, it remains unclear if backwaters or beaver pond complexes were missed, misidentified, or just not shown on the maps.

Appendix A. Dichotomous key for classifying Susitna River macrohabitats based on AEA's definitions.

AEA's Mainstem Classification: Classification is flow dependent. Change in habitat due to differences in channel morphology must be assessed at the same Gold Creek discharge (11,600 cfs).

a. Channel is a dominant main channel. May be more than one channel.............................. c
b. Channel is not a dominant main channel. Flow is < main channel or non-dominant portion (10%) of total flow. Channel is separated from the main channel by an island whose length is ≥ mainstem width... e

c. Channel is a single channel... Single Main Channel
d. Channel is two or more channels divided by an island or bar without vegetation or with annual vegetation. .... Split or Multiple Split Main Channel

e. Channel is turbid and connected to the active main channel..........................Side Channel
f. Overflow channel within the floodplain disconnected from the active main channel....... g

g. Channel may be turbid or clear upstream end not vegetated........................... Side slough
h. Channel vegetated at the upstream end, rarely overtopped, water is clear ...Upland slough

Tributary Mouth- Clearwater areas that exist where tributaries flow into the main channel or side channels.

Unclassified- Habitat downstream from confluence of tributary and side slough or upland slough habitat.

Unclassified- Channel is two or more channels divided by islands or bars with perennial vegetation.

Appendix B. Table comparing AEA habitat classification from line maps with classification from ground surveys.

Table B1. Comparison of classification from ground surveys (AEA Appendix D) with revised line maps (AEA Appendix L, Revised Appendix A). UC is unclassified, BW is backwater, CP is clearwater plume, SM is split main, MS is multiple split, BC is beaver complex, MC is main channel, SC is side channel, SS is side slough, and US is upland slough. A 1 = different classification, a 0 indicates no difference in classification.

Appendix D Map	App D Macrohabitat	App A or L Macrohabitat	Revised Line Map	Different
14 of 31	UC	BW	38 of 55	1
14 of 31	CP	CP	38 of 55	0
31 of 31	MC	MC	55 of 55	0
30 of 31	SM	MC	54 of 55	1
28 of 31	MC	MC	52 of 55	0
27 of 31	MC	MC	51 of 55	0
26 of 31	MC	MC	50 of 55	0
20 of 31	MC	MC	44 of 55	0
18 of 31	MC	MC	42 of 55	0
16 of 31	MS	MC	40 of 55	1
15 of 31	MC	MC	39 of 55	0
14 of 31	MC	MC	38 of 55	0
13 of 31	SM	MC	37 of 55	1
13 of 31	MC	MC	37 of 55	0
12 of 31	MC	MC	36 of 55	0
9 of 31	MC	MC	29 of 55	0
6 of 31	MC	MC	26 of 55	0
4 of 31	MC	MC	24 of 55	0
2 of 31	MC	MC	22 of 55	0
17 of 31	MS	MS	41 of 56	0
30 of 31	SC	SC	54 of 55	0
30 of 31	SC	SC	54 of 55	0
30 of 31	SC	SC	54 of 55	0
30 of 31	SC	SC	54 of 55	0
30 of 31	SC	SC	54 of 55	0
30 of 31	SC	SC	54 of 55	0
30 of 31	SS	SC	54 of 55	1
27 of 31	SC	SC	51 of 55	0
26 of 31	US	SC	50 of 55	1

Appendix D Map	App D Macrohabitat	App A or L Macrohabitat	Revised Line Map	Different
26 of 31	SM	SC	50 of 55	1
26 of 31	SS	SC	50 of 55	1
21 of 31	SC	SC	45 of 55	0
20 of 31	SC	SC	44 of 55	0
20 of 31	SC	SC	44 of 55	0
20 of 31	SC	SC	44 of 55	0
20 of 31	SC	SC	44 of 55	0
20 of 31	SC	SC	44 of 55	0
20 of 31	SS	SC	44 of 55	1
19 of 31	SC	SC	43 of 55	0
16 of 31	SC	SC	40 of 55	0
14 of 31	SC	SC	38 of 55	0
13 of 31	SC	SC	37 of 55	0
13 of 31	SC	SC	37 of 55	0
13 of 31	SC	SC	37 of 55	0
13 of 31	SC	SC	37 of 55	0
13 of 31	BW	SC	37 of 55	1
13 of 31	SS	SC	37 of 55	1
13 of 31	SS	SC	37 of 55	1
9 of 31	SM	SC	29 of 55	1
6 of 31	SS	SC	26 of 55	1
6 of 31	SC	SC	26 of 55	0
6 of 31	SC	SC	26 of 55	0
2 of 31	SC	SC	22 of 55	0
2 of 31	SC	SC	22 of 55	0
31 of 31	SM	SM	55 of 55	0
31 of 31	SM	SM	55 of 55	0
31 of 31	SM	SM	55 of 55	0
31 of 31	SM	SM	55 of 55	0
31 of 31	SM	SM	55 of 55	0
31 of 31	SC	SM	55 of 55	1
28 of 31	SM	SM	52 of 55	0
26 of 31	SM	SM	50 of 55	0
26 of 31	SM	SM	50 of 55	0
26 of 31	SM	SM	50 of 55	0
26 of 31	SM	SM	50 of 55	0
16 of 31	MS	SM	40 of 55	1
16 of 31	MC	SM	40 of 55	1

Appendix D Map	App D Macrohabitat	App A or L Macrohabitat	Revised Line Map	Different
16 of 31	SM	SM	40 of 55	0
14 of 31	SM	SM	38 of 55	0
14 of 31	SM	SM	38 of 55	0
10 of 31	SM	SM	34 of 55	0
9 of 31	SM	SM	29 of 55	0
31 of 31	SS	SS	55 of 55	0
30 of 31	SS	SS	54 of 55	0
30 of 31	MC	SS	54 of 55	1
30 of 31	SS	SS	54 of 55	0
23 of 31	SS	SS	47 of 55	0
21 of 31	SS	SS	45 of 55	0
16 of 31	SS	SS	40 of 55	0
16 of 31	SS	SS	40 of 55	0
16 of 31	SS	SS	40 of 55	0
15 of 31	BW	SS	39 of 55	1
15 of 31	SS BC	SS	39 of 55	1
13 of 31	SS BC	SS	37 of 55	1
6 of 31	SS	SS	26 of 55	0
6 of 31	SS	SS	26 of 55	0
25 of 31	SS BC	SS BC	49 of 55	0
31 of 31	SC	UC	55 of 55	1
30 of 31	CP	UC	54 of 55	1
30 of 31	BW	UC	54 of 55	1
27 of 31	CP	UC	51 of 55	1
26 of 31	SM	UC	50 of 55	1
26 of 31	SM	UC	50 of 55	1
26 of 31	BW	UC	50 of 55	1
17 of 31	SS	UC	41 of 56	1
6 of 31	SC	UC	26 of 55	1
25 of 31	SS	UC BW	49 of 55	1
30 of 31	US BC	US	54 of 55	1
27 of 31	US BC	US	51 of 55	1
26 of 31	US BC	US	50 of 55	1
25 of 31	US BC	US	49 of 55	1
25 of 31	US BC	US	49 of 55	1
23 of 31	SS	US	47 of 55	1
23 of 31	US	US	47 of 55	0
20 of 31	US	US	44 of 55	0

Appendix D Map	App D Macrohabitat	App A or L Macrohabitat	Revised Line Map	Different
15 of 31	US	US	39 of 55	0
15 of 31	BW	US	39 of 55	1
15 of 31	US	US	39 of 55	0
15 of 31	CP	US	39 of 55	1
15 of 31	US BC	US	39 of 55	1
14 of 31	US BC	US	38 of 55	1
13 of 31	US Dry	US	37 of 55	0
25 of 31	US BC	US BC	49 of 55	0
18 of 31	US BC	US BC	42 of 55	0
14 of 31	US BC	US BC	38 of 55	0
15 of 31	SS	US BW	39 of 55	1

Appendix C. Figures

Figure C1. Screen capture of AEA 2012 video, inset of AEA remote line map classification, and classification legend showing Whiskers Creek tributary mouth within FA-104 misclassified by AEA as a side slough. Site should be classified as a tributary

mouth with backwater and clearwater plume mesohabitats

Figure C2. Aerial photograph of the mouth of Whiskers Creek showing the confluence with the side slough and mainstem Susitna River and the dominance of tributary habitat downstream from the side slough confluence.

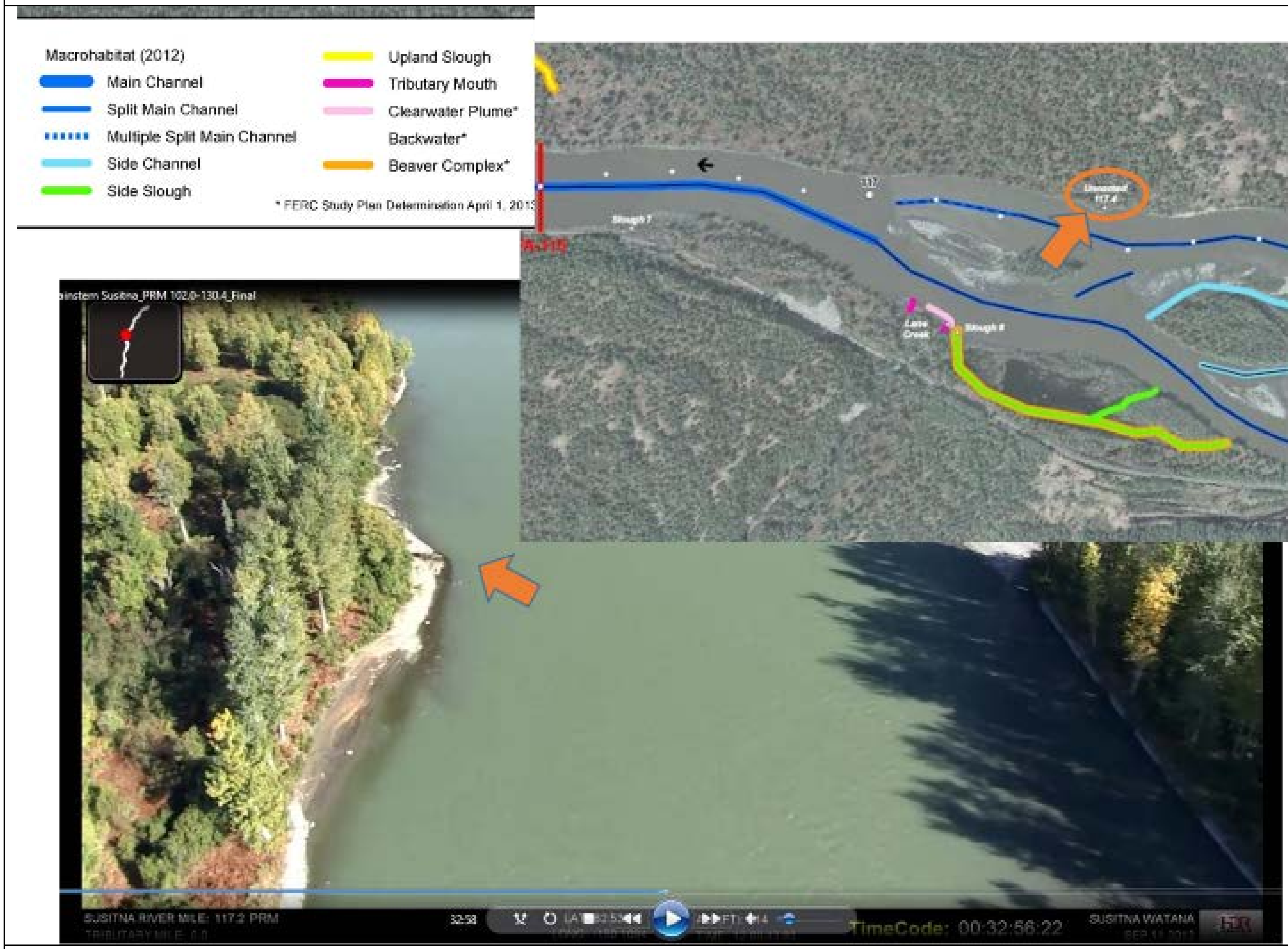

Figure C3. Tributary 117.4 (arrows) as an example of habitat not classified by AEA as tributary mouth macrohabitat and clearwater plume; however, the habitat is clearly visible in the AEA's 2012 imagery used for the remote line mapping as shown on inset.

Figure C4. Little Portage Creek tributary mouth and clearwater plume not classified by AEA where it discharges into the Susitna River. Misclassified side channel as island length is < channel width.

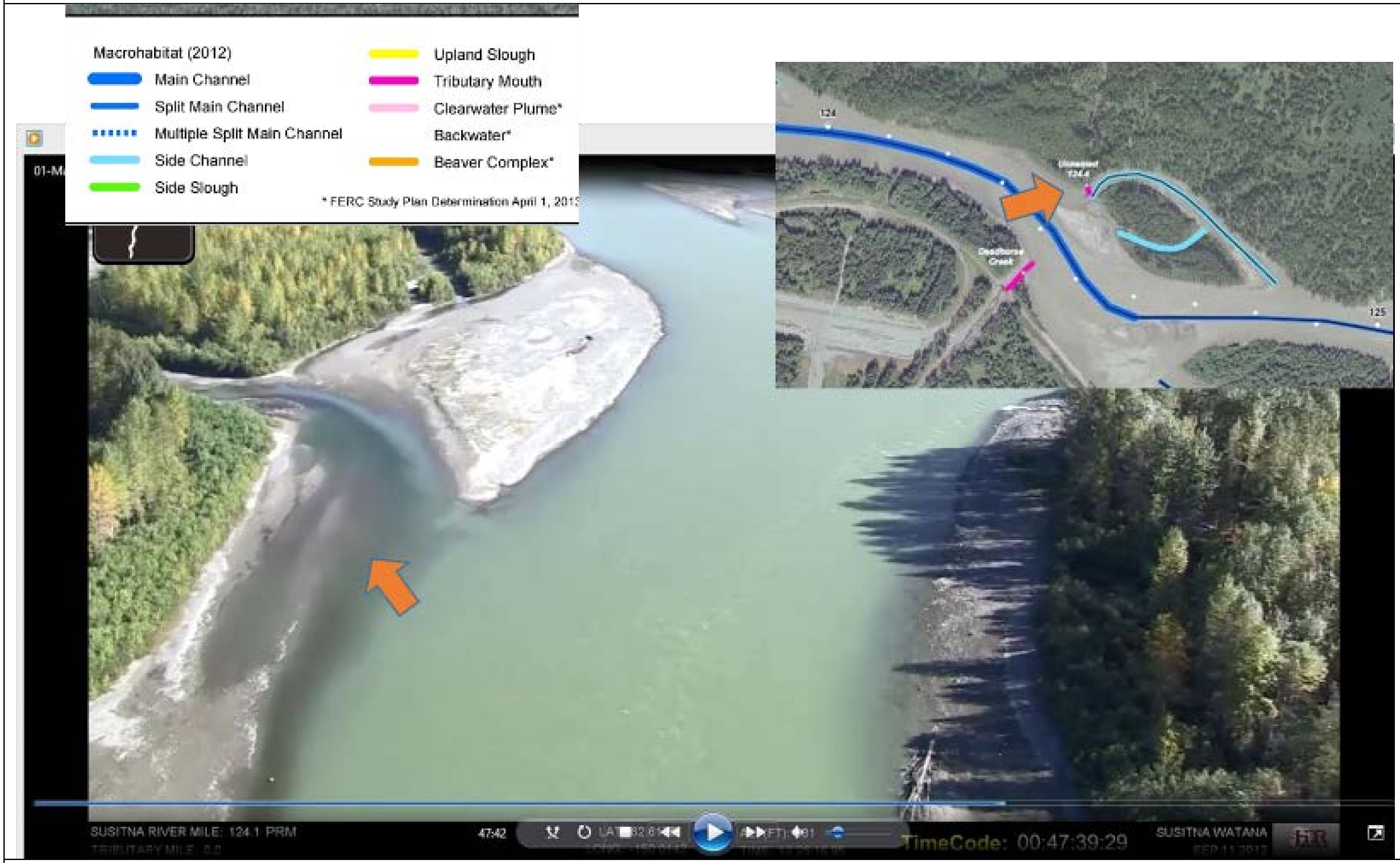

Figure C5. Tributary mouth classified by AEA (inset); however, obvious clearwater plume was not classified, although tributary plumes have been classified at other locations. AEA used clearwater plumes as one of the habitats for fish distribution and abundance sampling. Many tribuary plumes were not classified and therefore, were not available for site selection. The importance of these habitats to the Middle River will be underestimated if not accurately and consistently classified.

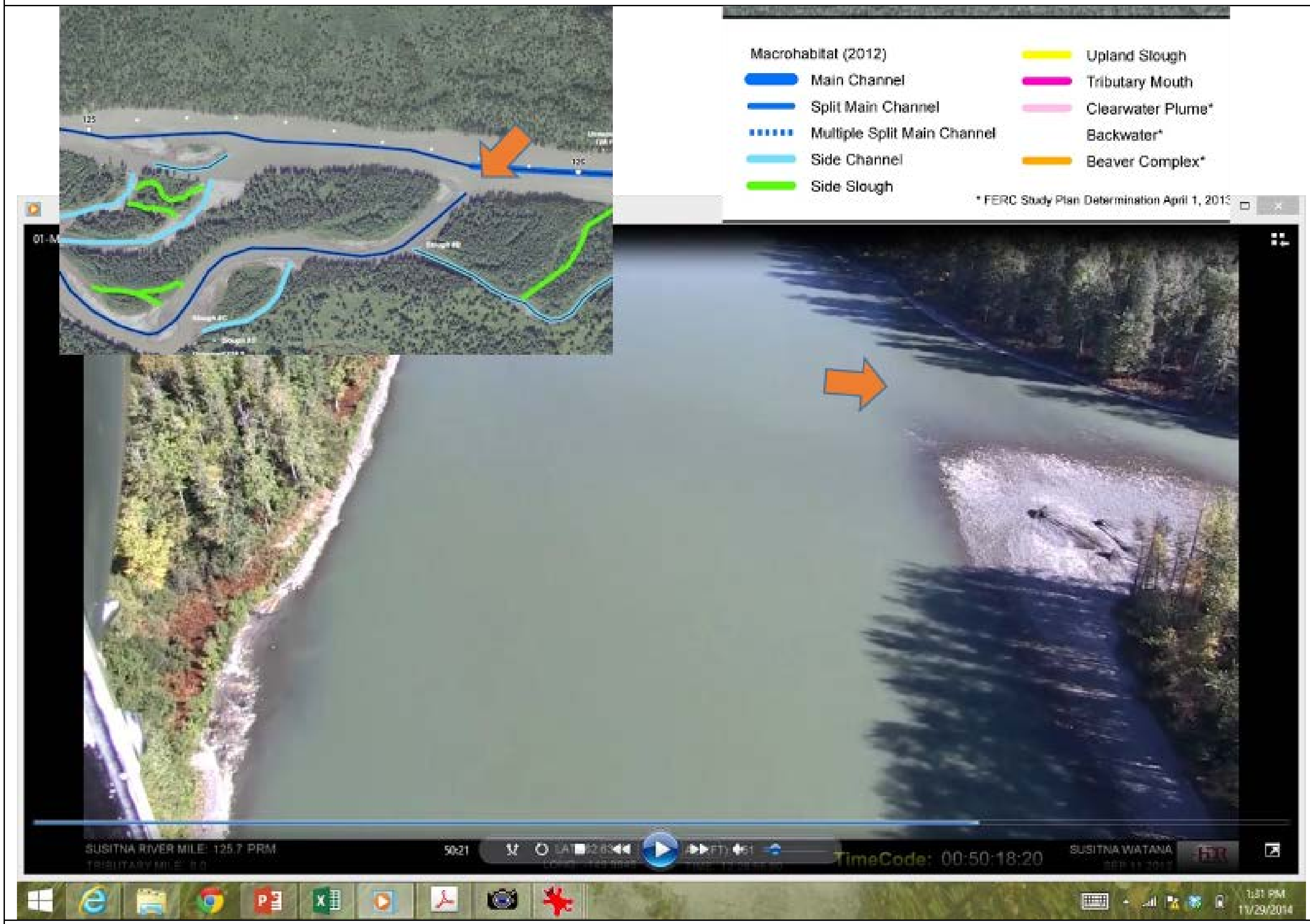

Figure C6. FA 128 Channel misclassified by AEA as a split main channel (inset). However aerial view in inset and video of the upstream end clearly shows that the channel is subdominant and therefore was misclassified by AEA. Channel should be classified as a side channel.

Figure C7. Upstream (top) (location shown with arrow on inset) and downstream (bottom) ends of channel within FA 104 from AEA 2012 video. Habitat was originally misclassified by AEA as side channel. The upstream end of the channel is partially vegetated and not connected to the mainstem and therefore, per AEA classification methods, the channel should be classified as a side slough. This channel was reclassified as side slough in AEAs latest classification maps.

Figure C8. Upstream and downstream ends of Oxbow I in FA 113. This channel was originally classified by AEA as side channel (inset) but was changed to a side slough in the SCR.

Figure C9. Two channels misclassified by AEA as side channels (inset). The right channel has clear water (bottom video capture) and upstream ends of both channels do not have an open water connection to the mainstem (top video capture). Based on AEA's classification methods both of these channels should be side sloughs. Side sloghs can not change into split main channel as shown in inset.

Figure C10. Channel if FA 128 classified as a side channel. However, the conditions at the upstream end of the channel and clear water are the same as the chanels in FA 104 and FA 113 which were classified as side sloughs. Characteristics are consistent with side slough and not side channel classification.

Figure C11. Differences in water turbidity and upstream connection to the main channel even under the higher flows in this aerial photograph shows that these side sloughs at PRM 131 were misclassified by AEA as side channels (inset).

Figure C11. Cross-island channel in Focus Area 141 classified by AEA as a side channel and selected by the river productivity study as a sampling location representative of this macrohabitat type. Channel does not comply with the side channel definitions.

References

Regnart, J. and C. O. Swanton. 2012. Operational planning–policies and procedures for ADF&G fisheries research and data collection projects. Alaska Department of Fish and Game, Special Publication No. 12-13, Anchorage.

9.11 Study of Fish Passage Feasibility at Watana Dam

Study Objectives

As presented in the Alaska Energy Authorities' (AEA) Final Study Plan (AEA, 2013) for the Susitna-Watana Dam project (Project), the goal of the FERC-approved Final Study Plan (FSP) is to develop, to the feasibility level, a fish passage strategy in support of the License Application for the proposed Project. This study plan outlines the process that will be used to achieve this goal. A variety of engineering, biological, sociological, and economic factors will be considered during this process. The study will explore various alternatives in support of three basic strategies related to fish passage:

1. The proposed Project without fish passage.
2. The integration of upstream and downstream passage features into the current dam design.
3. The retrofit of upstream and downstream fish passage features to a dam designed without passage.

It should be noted that the objectives stated in the FSP vary somewhat from those identified in earlier version of the proposed study plans for the Project. Specifically:

- The Proposed Study Plan (AEA, 2012), states that the, " primary goal of this study is to determine the biological assumptions and feasibility of developing upstream and downstream passage facilities at Watana Dam, whereas a variety of engineering, biological, sociological, and economic factors may need to be considered.
- The objective of this study is to compile existing information to support future discussions of potential fish passage measures with licensing participants during the FERC licensing of the Susitna-Watana Hydroelectric Project." In the Proposed Study Plan there was no statement regarding the strategy of fish passage studies; only that the studies would support future discussions with licensing participants.
- Specific terms and a defined strategy were developed only with the input provided by the USFWS during the refinement of the study plans. During the early consultation process, the USFWS provided valuable input regarding the structure of the proposed study plans, specifically to begin addressing known fish passage data gaps, and to prepare initial concepts for fish passage without consideration of limiting physical characteristics of the dam site or biological preference for species or life stage, all well in advance of any kind of economic feasibility determination.

Initial Study Report Review

Final Study Plan – Study Methods Summary

The proposed study methodology, as stated in the FSP, established six central tasks (i.e., Objectives) to evaluate fish passage systems for man-made barriers (NMFS, 2011). These tasks are to:

- Task 1 - Establish Fish Passage Technical Workgroup (FPTWG);
- Task 2 - Prepare for Feasibility Study;
- Task 3 - Conduct Site Reconnaissance;
- Task 4 - Develop Concepts;
- Task 5 - Evaluate Feasibility of Conceptual Alternatives; and
- Task 6 - Develop Refined Passage Strategy(ies)

The FSP also notes that the proposed studies are limited to analyzing the feasibility of fish passage at the Watana Dam site and not the necessity of fish passage at the dam site. It is important to note that the stated intent of the feasibility assessment is to address whether:

1. Fish passage alternative can be identified that will safely and effectively collect and pass migratory fish, and
2. Fish passage alternatives can be constructed and operated while allowing an economically feasible Project.

Additionally, the FSP defines 'feasibility' as it relates to the technical aspects of the Project, including both engineering and biological aspects such as fish passage. In AEA's terms, they recognize engineering feasibility as being governed by the physical characteristics of the dam, the water storage capacity, the release operations, and the longer term operating and maintenance costs. They recognize fish passage feasibility as being governed by fish behavioral responses to site conditions, and includes migration timing and migratory pathways. We have assumed this reference is to the natural or existing migration timing and migration pathways and any changes that may occur with implementation of the Project.

Initial Study Report – Study Methods Summary

The six individual tasks identified in the FSP are reiterated in the Initial Study Report. The particular methods of conducting these tasks as specified in the FSP vary, however, from the actual accomplishments achieved prior to the filing of the Initial Study Report. Specifically, by task, these variances are:

Task 1 - Establish the Fish Passage Technical Workgroup
The AEA was to establish a FPTWG consisting of representatives from state and federal agencies, FERC, and other interested licensing participants. The AEA did accomplish this part of the task. The FSP also suggests that the FPTWG would convene regularly on a bimonthly basis throughout the study to address additional data needs, develop evaluation criteria, and develop conceptual design passage strategies.

Task 2 - Prepare for Feasibility Study
The AEA was to compile the existing and background information available in an extensive list of items (Draft ISR 9.11, Appendix C), and disseminate this information to the FPTWG in preparation

for the conceptual development brainstorming workshop, which has not yet occurred. These data were posted and made available to the FPTWG for review prior to one workshop, and for several meetings and conference calls. However, this list of background data and information is not final and may include additions as new information is developed.

Task 3 - Conduct Site Reconnaissance
The site reconnaissance was held as proposed in September 2013, which included a helicopter flight to all points as described, and a brief meeting to discuss observations and summarize study objectives going forward.

Task 4 - Develop Conceptual Alternatives
According to the FSP, development of conceptual fish passage alternatives would occur within Task 4, following delivery of background information and field study data (Task 1), and convening of the first of four FPTWG workshops to introduce these data and additional information from ongoing field studies in successive FPTWG meetings. This conceptual alternatives development was to have been accomplished during a conceptual alternatives brainstorming workshop. This workshop had not been held at the time of the filing of the Initial Study Report, therefore it is not possible to comment regarding the satisfaction of the FSP within the Initial Study Report.

As part of Task 4, a spreadsheet-based biological performance tool (BPT) to aid in the selection of a preferred alternative would be introduced and applied during the conceptual alternatives brainstorming workshop. Furthermore, use of the BPT was to be tested by the FPTWG workshop participants. Following the brainstorming workshop, refinement of the passage concepts and strategies was to occur, and those alternatives determined to be technically infeasible would be dropped from further consideration and the reasons for their elimination would be documented.

Task 5 - Evaluate Feasibility of Conceptual Alternatives
The FSP states that the feasibility of each of the alternatives developed during the brainstorming workshop would be examined in detail following the workshop, and that a Pugh matrix would be used to break down the alternatives into discrete elements for comparison, evaluation, and optimization. The results of this Pugh matrix evaluation would be used to further refine various fish passage system components and package, or repackage, these various elements into consolidated fish passage designs that could be evaluated for technical feasibility and input into Task 6 efforts. Task 5 was not initiated or concluded within the time period leading up to the filing of the Initial Study Report, therefore it is not possible to provide comment regarding the satisfaction of the FSP within the Initial Study Report on this task.

Task 6 - Develop Refined Passage Strategy(ies)
The FSP states that the alternatives determined to be technically feasible during Task 5 would be refined as part of Task 6. The Initial Study Report states that implementation of Task 6 was initiated and is scheduled for the next year of study. Since Task 6 was not accomplished in the time period leading up to the filing of the Initial Study Report, it is not possible to provide comment regarding the satisfaction of the FSP within the Initial Study Report on this task.

Study Results

Important accomplishments in 2013, according to the Initial Study Report included:

- Establishing the FPTWG;
- Selecting the potential target fish species;
- Visiting the site by the FPTWG in September 2013;
- Compiling some biological, physical, and Project feature information; and
- Partially developing the BPT.

This work listed above was substantially completed in 2013. A discussion of the study results is provided below.

Task 1 - Establish the Fish Passage Technical Workgroup

The FPTWG was established with representatives from state and federal agencies, and included contract regional experts selected cooperatively by AEA, participating state and federal agencies, and other interested licensing participants. The FPTWG convened regularly, on approximately a bimonthly basis, from the kickoff meeting on February 22, 2013 until the site reconnaissance meeting September 17-20, 2013. There were eight FPTWG meetings scheduled in 2013, however only six were conducted prior to the Initial Study Report. One web-call meeting and one Workshop were postponed to 2014.

Results:

- FPTWG was successfully formed and is comprised of AEA, AEA's consultants, the Services.
- The delayed schedule may have implications on Project design. An example of a potential negative implication is that the dam design may advance to a stage where incorporating certain fish passage components is not viable or much more difficult. This point was made by USFWS during the FPTWG meetings.

Task 2- Prepare for Feasibility Study

The AEA compiled the existing and background information available and distributed this information to the FPTWG in preparation for site reconnaissance meeting and the pending concept development brainstorming workshop. These data were largely compiled and made available to the FPTWG for review prior to, and at, Workshop #1. The data were revised, supplemented and made available in advance, and at the site reconnaissance meeting. These data included biological and physical data that pertains to the fish passage aspects of the project.

The FSP indicated these data would be used to develop the spreadsheet-based BPT, and the tool would be introduced to the FPTWG as a deliverable. Although an example of the BPT from another project was overviewed, the application of this BPT to the Project either had not yet been made or was not revealed to the FPTWG.

Additional information requests, notes, and questions that were brought forward at FPTWG meetings include:

1. Lake Trout life cycle, biological data, and predation behaviors of Lake Trout, including an assessment of the effect of Lake Trout in reservoirs on other fish populations (Vogel and Beauchamp, 2011; Yule and Luecke, 1993).
2. Reservoir suitability assessment for rearing Chinook Salmon (and other species). Other studies of proposed and existing reservoir systems have determined that beneficial rearing may occur (Connor, W.P., et. al., 2002; Rondorf, et. al. 1990).
3. Chinook Salmon (and other species) life cycle response to swimming through the reservoir to help determine direct tributary juvenile collector requirements (Venditti, D.A., et. al., 2000; Berggren, T.J., and M.J. Filardo, 1993).
4. It is understood that water temperature downstream of the dam will likely increase and flows will likely be moderated during summer migration periods, and it is possible both of these factors may improve upstream migration capabilities of fish through Devil's Canyon. A thorough assessment of the Devil's Canyon impediments including water level and velocity profiles at different flows and cross sections and an assessment of potential fish abundance affected by the proposed dam was recommended (Powers, P.D. and J.F. Orsborn, 1985, Salinger, D.H., and J.J. Anderson, 2006).
5. Tsusena Creek is a potential route for a natural fish ladder for part of the elevation gain required to pass the proposed Watana Dam. Tsusena Creek profiles and topographic data from approximately 1 mile upstream of the dam and 1 mile north of the dam are required to further assess this option.
6. Radio-tagging fish may or may not have adverse impacts to fish swimming capabilities and may affect natural behavioral tendencies (Gray, R.H., and J.M. Haynes, 1979; Mellas, E.J., and J.M. Haynes, 1985; Matter, A.L., and B.P. Sandford, 2003; Thorstad, E.B. et. al., 2000). If this is the case for the AEA radio tagging assessments then a bias may be introduced to the studies where the population of Chinook Salmon is being underestimated and where other species with similar swimming capabilities (such as Coho and Sockeye salmon) are being excluded. Tagging bias is a general assumption of radio-tagging studies.
7. The statement, "In general, Upper River Catch Per Unit Effort (CPUE) averages for juvenile Chinook Salmon were similar in magnitude to estimates of CPUE for Middle and Lower River sites (ISR 9.5, Draft Feb 2014)," suggest that a larger percentage of the Chinook Salmon run is migrating to the Upper River than the radio tagging program indicates. Timing modification of catch effort and replication in additional years may be required to confirm this statement.
8. It was recommended that AEA evaluate methods other than radio tagging for assessing upstream migration capabilities and population estimates in the Upper River for Chinook Salmon and other species with similar swimming, such as Coho Salmon.
9. Large Coho Salmon will have similar swimming capabilities as Chinook Salmon

(Bell, 1991) and Coho Salmon have been noted as having a Susitna River population (ISR 9.6 Appendix D, Draft Feb 2014), yet this species has not been observed by AEA in the Upper River reach. It was suggested during the FPTWG meetings that AEA further investigate Coho Salmon passage of Devil's Canyon.

10. Sockeye Salmon have been observed above the Watana Dam site by an Alaska Department of Fish and Game (ADFG Habitat Biologist retired, Mike Bethe) biologist in the 1980s; however he did not photograph his observations so the information is not being used in the fish presence studies. However, Sockeye Salmon have been noted in the Susitna River (ISR 9.6 Appendix D, Draft Feb 2014), and this information should be included in the evaluation of fish passage.
11. Research fish collection facilities and various effects on them with respect to ice conditions, including sheet ice, anchor ice, and frazil ice formation and breakup

Results:

- A reasonably comprehensive list of information available to date has been compiled and distributed to FPTWG members. It was stated that additional information will be supplied as it becomes available.

Task 3 - Conduct Site Reconnaissance
The site reconnaissance was held September 17-20, 2013. Staff from the Services, the AEA, the AEA's consultants, and the Services' consultants attended the site visit. The site reconnaissance was carried out with helicopter transport. The flight plan and itinerary included flying upstream along the proposed reservoir, flying up several of the tributaries, landing at several tributary confluences and near the main dam site, and flying down Devil's Canyon. A debriefing meeting was held in Talkeetna after the flight.

Results:

- The site reconnaissance meeting was carried out. The FPTWG convened and overviewed Project site conditions.

Task 4 - Develop Conceptual Alternatives
Only very limited and general discussions have taken place in regard to developing conceptual alternatives. This work was to occur during and after FPTWG Workshop #2. However, the meeting was postponed and there are no results to report.

Task 5 - Evaluate Feasibility of Conceptual Alternatives
This work task has not started and there are no results to report.

Task 6 - Develop Refined Passage Strategy(ies)
This work task has not started and there are no results to report.

Variance from Study Plan

The Initial Study Report stepped through each of the proposed tasks and methodology proposed in the FSP providing identified accomplishments, deliverables, and milestones, and identified continuing efforts necessary in coming years to fully satisfy the objectives of the FSP as proposed. Specifically, the Initial Study Report suggests the following with regard to variances within each of the six tasks identified in the FSP:

Task 1 - Establish the Fish Passage Technical Workgroup

The Initial Study Report states that, "AEA implemented the methods as described in the Study Plan with no variance." During the FPTWG kickoff meeting (Meeting #1) a schedule was presented for the Study Plan meetings and workshops. In 2013 there were six meetings scheduled, one of which included the site reconnaissance trip, and two workshops. Meetings #1-3 were held on schedule. Workshop #1, to review the dam design and operation, and to introduce biological, physical, and site specific information, was held in February 2013. Variances from the schedule included adding Meeting #3A to confirm Meeting #4 logistics, rescheduling Meeting #4 (site reconnaissance) from June to September, postponing Workshop #2 (brainstorming), and postponing Meetings #5 and #6. The conceptual alternatives brainstorming Workshop #2 was postponed and rescheduled for September 9-11, 2014. Workshop #3 to evaluate the feasibility of the conceptual alternatives and to provide critique and refinement of concepts and packaging of conceptual components into alternatives was originally scheduled for early 2014, was postponed. Workshop #4 was originally scheduled for the beginning of the 3rd quarter of 2014, was postponed.

Table 1 shows the proposed meeting schedule for the FPTWG meetings in 2013 and 2014, as presented in the Final Study Plan. Table 2 shows the proposed and actual meeting schedule for 2013, and into 2014.

Table 1. Final Study Plan Schedule (Task 4 work did not substantially occur in 2013).

Activity	2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
T1. Establish Team and Define Process	W1								
T2. Prepare for Feasibility Study									
T3. Site Reconnaissance									
T4. Develop Concepts			W2						
T5. Evaluate Feasibility of Alternatives					W3				
T6. Develop Refined Passage Strategies							W4		
Initial Study Report					Δ				
Updated Study Report									▲

Table 2. Summary of proposed and actual meetings of the FPTWG in 2013-2014.

Proposed meetings		Actual meetings	
Meeting description	Date	Meeting description	Date
Meeting #1 (Kickoff) Portland,	Feb 22, 2013	Meeting #1 (Kickoff)	Feb 22, 2013
Meeting #2 Web call	Mar 20, 2013	Meeting #2 Web call	Mar 20, 2013
Workshop #1 (Review Data) Bellevue, WA	Apr 9-10, 2013	Workshop #1 (Review Data) Bellevue, WA	Apr 9-10, 2013
Meeting #3 Web call	May 22, 2013	Meeting #3 Web call	May 21, 2013
Meeting #4 (Site Recon) Talkeetna, AK	Jun 19, 2013	Meeting #3A (web call)	Jul 9, 2013
Workshop #2 (Brainstorm Session)	Jul 23, 2013	Meeting #4 (Site Recon) Talkeetna, AK	Sep 17 - 20, 2013
Meeting #5	Sep 19, 2013		
Meeting #6	Nov 15, 2013		
Workshop #2- Conceptual Alternatives Brainstorming		MWH office Bellevue, Washington	Sept 9-11, 2014

We understand that the delays in the FPTWG meetings were driven by:

- Staff availability for some of the proposed bi-monthly meetings;
- Alaska state funding restrictions; and
- Delays in deliverables on approved and ongoing field work data summaries.

At the time of drafting these comments, work on Task 4 had not commenced, nor has word on when it may commence been received. Delayed Task 4 work could cause a cascade effect to the schedule, and delay subsequent tasks (e.g., Task 5 and 6) and reporting.

Task 2 – Prepare for feasibility Study

The AEA states in the FSP that Task 2 is focused on technical preparation for the conceptual alternatives development brainstorming session (Workshop #2) described in Task 4. This technical preparation is described as collection and dissemination of existing, past, and current data obtained from ongoing field work, previous studies, and other background information sources to the FPTWG participants, prior to regular meetings and workshops. In addition, AEA proposed to introduce and apply the spreadsheet-based BPT as part of Task 2. However, the BPT was merely introduced briefly in reference to another unrelated project where it was applied.

No additional information regarding the decision tree or matrix on which the performance tool bases any analysis of preference was provided, contrary to the implied understanding as provided in the FSP. This is considered a variance from the FSP, though AEA did state in the Initial Study Report that the BPT would be developed and explained in detail in Task 4 at a later time. However, the FSP also noted that the spreadsheet-based BPT tool would be introduced to the FPTWG as a deliverable along with base drawings, maps, and synthesized biological, physical, and site data from that information item list. The tool's application to the Project was not revealed to the FPTWG except for an example application for another unrelated project.

Task 3 - Conduct Site Reconnaissance
The site reconnaissance was completed in September 2013, although it was originally scheduled for the second quarter of 2013. No variance, except for the schedule change was apparent from the FSP.

Task 4 - Develop Conceptual Alternatives
Though the FSP anticipated that this workshop would occur in 2013, it was postponed and it is not known when it will be convened. Though the implementation of Task 4 as defined has not yet been accomplished, the Initial Study Report reports that this schedule change is not a variance.

Task 5 - Evaluate Feasibility of Conceptual Alternatives
The FSP states that the evaluation of feasibility of passage alternatives and strategy (ies) will occur following the conceptual alternatives brainstorming workshop. Neither Tasks 4 nor 5 activities have been scheduled beyond the September 2014 Workshop #2.

Task 6 - Develop Refined Passage Strategy(ies)
The FSP states that refinement of the feasible alternatives determined in Task 5 would occur in Task 6. Since Tasks 4 and 5 have not yet been accomplished, no comment can be made regarding a variance from the FSP

Conformance with Study Plan Objectives

The Section 9.11 Fish Passage Studies identified in the FSP (AEA, 2013) generally were not altered in the Initial Study Report, except for modification of the proposed schedule, as discussed above. In general, the Section 9.11 Fish Passage Studies are at this stage meeting the objectives of the FSP, though delays have occurred and will likely continue to occur in future.

It should be noted that the first of the two available annual data sets (from 2012) spanned an anomalous hydrologic event. A large freshet event occurred in the fall of 2012, resulting in very high river flows and difficult field data collection conditions. It is likely that valuable data were lost as a result.

In 2013, the Susitna River again experienced unusual increased flows in late August and early September. The effects of these late summer increased flows on species assemblages, passage conditions, and other passage-related environmental variables would have been observed in the sampling data collected in field studies in 2013, but were not distinguished as possibly having anomalous results.

However, it is important to note that these two successive, anomalous hydrologic years may skew data sets compared to a typical or average year. In particular, passage conditions through the Devil's Canyon and dam site reaches may have been more adverse than in a typical year for late arriving fish, leading to anomalous observations of anadromous adult and resulting juvenile progeny salmonid presence. The USFWS questions whether the species observations made in juvenile collection efforts would have been different had a more normal hydrologic year been experienced (i.e., steadily declining flows from the peak in June through late fall).

The lack of adequate ecohydraulic models and predictive capability for the Devil's Canyon reach is a problem when assessing passage conditions through the reach leading up to the dam. Without an accurate model or assessment of the Devil's Canyon reach, passage conditions cannot be correctly evaluated. We believe this shortfall should be addressed as soon as possible in the ongoing hydraulic and hydrologic studies of the Middle and Upper River reaches.

Effects of Study Discontinuity

As discussed above, the schedule for the Section 9.11 Fish Passage Studies slipped considerably since 2013. Incorporation of new information and data obtained from continuing field data collection efforts in 2013 was provided to the FPTWG as it became available, until about September 2013 (around the time of the Site Reconnaissance). Limited new data and observations from the 2013 field work season were presented in the Initial Study Report. More details may be forthcoming, and it is important to note that these new data are likely highly important to the successful continuation of Section 9.11 studies.

With the schedule apparently delayed for the Section 9.11 Fish Passage studies, and most importantly the meeting of the FPTWG having been postponed indefinitely, we are concerned that the overall project schedule will be compressed such that inadequate time can be provided to ensure a thorough development, assessment, and evaluation of fish passage strategies and alternatives before the design must be progressed to meet the overall FERC schedule for study deliverables. We suggest that the overall FERC schedule must be slipped a similar amount as the recent suspension of fish passage studies, in order to maintain the original study objectives.

Recommendations

Second-Year of Study

Since the continuing FPTWG activities have been postponed, our recommendations are primarily directed towards collection and dissemination of final field study summaries from 2013 and proposed schedules for field data collection and related studies.

USWS recommends the following tasks/objectives be completed to meet the FSP:

1. Work to get the study back on schedule.

2. Research Lake Trout life cycle, biological data, and predation behaviors of Lake Trout, including an assessment of the effect of Lake Trout in reservoirs on other fish populations (Vogel and Beauchamp, 2011; Yule and Luecke, 1993).

3. Conduct reservoir suitability research for rearing Chinook Salmon and other species (Connor, W.P., et. al., 2002; Rondorf, et. al. 1990).

4. Conduct evaluation of Chinook Salmon, and other species, life cycle response to swimming through the reservoir as this may help direct tributary juvenile collector requirements (Venditti, D.A., et. al., 2000; Berggren, T.J., and M.J. Filardo, 1993).

5. Evaluate the potential effects of the anomalous hydrology experienced in the Susitna River in 2012 and 2013 with unusual increased late summer flows on species assemblages passing into the Upper River reaches. Specifically, determine if these higher than normal late summer and early fall flows may have adversely impacted the presence or absence of typical target species in the Upper River (e.g. Sockeye and Coho Salmon in particular).

6. It is understood that water temperature downstream of the dam will likely increase and flows will likely be moderated during summer migration periods. Both of these factors may improve upstream migration capabilities of fish through Devil’s Canyon. Conduct a thorough assessment of the Devil’s Canyon impediments including water level and velocity profiles at different flows and cross sections and an assessment of potential fish abundance affected by the proposed dam (Powers, P.D. and J.F. Orsborn, 1985, Salinger, D.H., and J.J. Anderson, 2006).

7. Radio tagging fish has been suggested to potentially affect swimming capabilities and/or affect natural behavioral tendencies. If this is the case for the AEA radio tagging assessments then a bias may be introduced to the studies where the population of Chinook Salmon is being underestimated and where other species with similar swimming capabilities (such as coho and sockeye) is being excluded (Gray, R.H., and J.M. Haynes, 1979; Mellas, E.J., and J.M. Haynes, 1985; Matter, A.L., and B.P. Sandford, 2003; Thorstad, E.B. et. al., 2000).

8. The statement: “In general, Upper River Catch Per Unit Effort (CPUE) averages for juvenile chinook salmon were similar in magnitude to estimates of CPUE for Middle and Lower River sites” (ISR 9.5, Draft Feb 2014), may suggest that a larger percentage of the chinook run is migrating to the upper river than the radio tagging program indicates. Suggest that the timing of juvenile catch efforts could be modified, and additional years of replication might confirm upper river fish population and production.

9. Recommend AEA evaluate methods other than radio tagging for assessing upstream migration capabilities and population estimates in the upper river for chinook and other species with similar swimming capabilities such as coho. Perhaps other methods of determining upstream populations are available that would not introduce tagging effects.

10. Large Coho Salmon will have similar swimming capabilities as Chinook Salmon (Bell, 1991) and Coho Salmon have been noted as having a Susitna River population (ISR 9.6

Appendix D, Draft Feb 2014), yet this species has not been observed by AEA in the upper river reach. We recommend that AEA further investigate Coho Salmon passage into and through Devil's Canyon.

11. Sockeye Salmon have been observed above the dam site by an ADFG biologist in the 1980s; however he did not photograph his observation so the information is not being used in the fish presence studies, yet it should be. However, sockeye have been noted in the Susitna River (ISR 9.6 Appendix D, Draft Feb 2014), and this information should be included in the evaluation of fish passage.
12. Research fish collection facilities and various effects on them with respect to ice conditions, including sheet ice, anchor ice, and frazil ice formation and breakup.

Topics for Further Consideration

It does not appear that AEA has considered provision of temporary fish passage around the dam during construction. Although the scope of passage facilities proposed for assessment and study in the Initial Study Report are comprehensive, no mention is made of addressing temporary passage.

Under the "retrofit" alternative, AEA should identify any temporary measures that would be implemented to maintain Chinook Salmon (and other target species) access into the upper watershed, above the dam site, during both the construction and initial operation of the proposed project (pending the construction of more permanent facilities). Maintaining access into this portion of the watershed would insure no net loss of any unique genetic life history characteristics that may be associated with upper basin subpopulations.

Temporary facilities may also provide important insight into the efficacy of a variety of different passage facility designs and locations, and behavioral responses to site conditions. Conducting studies of fish movement at these temporary sites would also provide a means of eliminating some of the scientific uncertainty surrounding potential project impacts on chinook and other migratory species.

The target species identified in the data list and background information for ISR 9.11 for the upper Susitna River does not currently include a number of species observed in the middle and lower Susitna River. Fish population sampling conducted during the 2012 and 2013 seasons identified a number of salmonid and non-salmonid fishes inhabiting the entire Susitna River watershed, both above and below the dam site (AEA, ISR 9.5, 2014). The Initial Study Plan Results section suggests that species other than Chinook Salmon are considered resident species. However, several of these species are known to be migratory and some are anadromous. Hence, the proposed fish passage facility alternatives need to incorporate structural characteristics that would not only facilitate adult and juvenile salmonid passage but also the unique passage requirements of Arctic Lamprey, Burbot, Longnose Sucker, and other native target species with relatively unique swimming/migration characteristics and constraints. Fishway gradient, entrance conditions, diffuser grating size, water velocities, corners/angles, and other features within the upstream and downstream collection facilities should accommodate these species.

When the conceptual fish passage alternatives analysis is commenced, it should consider operations and maintenance issues as well as fish passage, collection, and transportation issues. For example, in addition to ice, the amount of organic debris that would be transported in the river/reservoir upstream of the proposed dam site during periods of project operation should be evaluated during the design process and any means of addressing this debris load should be incorporated into the downstream passage facility design concepts.

Study Modifications and Additions

Modification 1: Given that the Project is expected to modify downstream water temperatures in winter, USFWS recommends that water quality studies include consideration of temperature effects on benthic macro invertebrate populations and juvenile salmonid egg and embryo development and timing. Water temperature effects on invertebrate and salmonid eggs and embroyo development is connected to the fish passage studies because Middle and Upper River fish populations including anadromous, adfluvial, and resident species will be affected by water temperature modifications. For example, warmer winter water temperature in the Upper and Middle River reaches below the dam may increase the speed of development of salmonid and other species' eggs and move up the timing of embryo emergence (BC Hydro, 2012). If this timing occurs before the annual increase in benthic invertebrate abundance, the emerging salmonid fry may experience difficulty in finding adequate food sources.

No new fish passage studies are recommended. However, we emphasize that the listed studies in the Initial Study Report should be regularly reviewed, and any previous or new data links requiring information from other dependent or independent studies should be clearly identified. If concurrent dependent work is conducted in any of the study areas, it will be important to note potential critical path items and bring immediate focus on those areas requiring more detail or results from other studies prior to continuation with any other study. The entire effort should seek to avoid missing information that is critical to other project feature design rather than exclude from consideration those portions or features that depend on other information.

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9.12 Fish Passage Barriers in the Middle and Upper Susitna River and Susitna River Tributaries

Summary of Proposed Study Modifications and New Studies

INTRODUCTION

The Alaska Energy Authority (AEA) has developed studies to identify and evaluate existing conditions and potential project effects to fish passage into tributaries, sloughs, and side channels of the Susitna River.

The study objectives are to:

1. locate and categorize all existing fish passage barriers (e.g., falls, cascades, beaver dams, road or railroad crossings) located in selected tributaries in the Middle and Upper Susitna River,
2. locate the barriers using a global positioning system (GPS), identify the type (permanent, temporary, seasonal, partial), and characterize the physical nature of any existing fish barriers located within the Project's *zone of hydrologic influence* (ZHI),
3. evaluate the potential changes to existing fish barriers (both natural and man-made) located within the Project's ZHI, and
4. evaluate the potential creation of fish passage barriers within existing habitats (tributaries, sloughs, side channels, off-channel habitats) related to future flow conditions, water surface elevations, and sediment transport.

The general study approach is to:

1. identify target fish species and life stages,
2. develop fish passage criteria for these species and life stages,
3. identify all the locations of migration barriers under existing conditions, and
4. evaluate how project operations can influence fish passage.

The U.S. Fish and Wildlife Service (USFWS) is providing these proposed study modifications; in addition, we believe that the approved study plan remains incomplete and does not provide the methods necessary to meet the study objectives. This is largely because a Technical Working Group (TWG) was not organized during the licensing process to develop suitable methods. The proposed study has identified target fish species, life stages, and proposed passage criteria for these species and life stages. Proposed passage criteria remain incomplete. Those specific criteria proposed for use in defining leap barriers, depth barriers, or velocities and times to fish exhaustion (prolonged and burst speeds) are still unclear. The use of proposed criteria to identify fish passage barriers requires measured or modeled water depths and velocities over distance, measured or modeled leap heights and pool depths, and comparison of modeled hydraulic characteristics to target fish burst and sustained swimming speeds and leaping ability. The approved study plan does not describe the methods that will be used to model these hydraulic and physical habitat characteristics (outside of focus areas). It also did not describe the methods that will be used to collect field data for use as model input for sites within the ZHI, where barriers are likely to occur (Upper River and Middle River tributaries, beaver dams, railroad crossings).

Methods have not been developed to model post-project hydraulic conditions necessary to evaluate passage criteria in Upper River tributaries. This would need to be performed at proposed reservoir pool elevations, under different project operational scenarios, and to model and consider the potential changes to Upper River tributary channel geometry that would likely occur, in response to project operation. Prior questions about baseline conditions also exist. Important questions to consider are as follows: What are the existing distances to the first migration barrier, including velocity barriers, for all target fish species, and how would this vary under different operational scenarios (reservoir pool elevations), tributary discharge, and migration timing? How will the loss and alteration of riparian vegetation and changes in sediment transport alter channel geometry in the reservoir zone between high and low pool elevation (varial zone)? Finally, how will these changes influence fish passage under different operational scenarios?

The FERC study determination stated that, "A reasonable approach to address this potential project effects would be for AEA to specify the methods (e.g. two-dimensional modeling or other modeling approach) that it would apply at each off-channel and tributary delta location for the depth barrier analysis after it selects its proposed study sites in consultation with the TWG. This would include an explanation of its proposed methods during both the open-water period for adult and juvenile fish, and ice-cover period for juvenile fish, both of which would be necessary to evaluate project effects (section 5.9(b)(5))." ***Since this FERC recommendation has not been accomplished, the study has not been implemented as described in the approved plan and is subject to recommended study modifications necessary to meet study objectives***.

As with the Upper River, AEA has also not described how they intend to model hydraulic conditions in the Middle and Lower River tributaries under variable mainstem and tributary flows. Initial Study Report (ISR) thalweg surveys of depth and velocity, at a single tributary flow, at 10 meter intervals, are insufficient for the evaluation of passage criteria and cannot be used to model hydraulic conditions (in two dimensions) and fish passage under variable mainstem water surface elevations and tributary flows. Modelling efforts being conducted in study 6.5 have not been described, do not specify that water velocity will be modeled, are only being applied to a subset of streams, and do not clarify how passage criteria will be evaluated.

A two-dimensional model of hydraulic conditions has been developed for a mainstem slough at one focus area (FA-128). This may be an effective method to evaluate passage criteria, depending on the accuracy of modeled depths and velocities and the ability to account for residual groundwater flows. Modeled depths that are accurate to the nearest foot (as shown in the Proof of Concept presentations) may not be accurate enough to evaluate migration barriers to juvenile salmon, and the groundwater study has yet to present quantitative measures of residual flows in off-channel habitats due to groundwater discharge. This study is also stand-alone in this single focus area and AEA has not demonstrated the ability to model hydraulic conditions in other focus areas.

Current ice processes modelling is one-dimensional and ice thickness was not modeled or measured. Winter hydraulic modelling assumes a uniform ice thickness of one meter. This assumption is unrealistic, meaning that modeled depths and velocities under the ice are most likely unrealistic. Winter passage within off-channel habitats may be dependent upon residual flows from groundwater discharge and pressurization of the channel network due to icing; however, the groundwater study has yet to provide quantitative measures or models of groundwater flows within focus areas. Since modelled depths and velocities are inaccurate and residual flows unknown, the study will not be able to evaluate passage criteria for target fish species during winter. This is a critical time period and load-following project operational scenarios are predicted to cause significant changes in water surface elevations and velocities in off-channel habitats during winter.

Flow routing under proposed operational scenarios indicates that project effects will extend downstream from the three rivers confluence, into the Lower Susitna River. Adult salmon studies have documented salmon spawning in Lower River mainstem side slough and side channel habitats and juvenile salmon studies have confirmed the importance of beaver dams as rearing habitats. The FERC study determination states, that “If the results of the 2013 study in the Middle River (as documented in the initial study report) indicate that the project would cause significant adverse effects on fish passage into tributaries and off-channel habitats, and/or the preliminary results from the flow-routing, instream flow, or geomorphology modeling efforts indicate that project effects would extend downstream of the three rivers confluence, additional study areas could be added downstream in 2014 or in subsequent study years (sections 5.15(d) and 5.15(e)).” USFWS is recommending new studies in the Lower River to assess Project effects to fish migration.

The USFWS recommends the following seven Modifications. Additional details and justification are described under the relevant Study Objective:

1. In Upper River tributaries, collect field data at the necessary spatial scale and conduct two-dimensional hydraulic modeling to evaluate fish passage.
2. In Middle River tributaries, from Portage Creek downstream, collect data at the necessary spatial scale and conduct two-dimensional hydraulic modeling to evaluate fish passage criteria.
3. In the Middle River focus areas conduct winter field surveys of velocity/depth, longitudinally, through all sloughs to identify current fish barriers.
4. Install water level loggers in all Middle River focus areas and develop discharge rating curves so velocities can be predicted during ice development.
5. In the Upper River tributaries, collect field data at the necessary spatial scale and model all fish passage barriers (velocity, leap, and depth) from the low pool elevation to first leap barrier above the high pool elevation.
6. In the proposed inundation zone, conduct geomorphology modeling of new tributary delta formation and use flow modeling to predict the potential for future fish passage barriers.
7. The ZHI has been shown to extend downstream of the Middle River reach. Therefore, the study’s goal of evaluating project effects on salmon passage in and out of suitable habitat must include the Lower River reach.

STUDY MODIFICATIONS AND SUPPORTING DOCUMENTATION

Objective 1. Locate and categorize all existing fish passage barriers (e.g., falls, cascade, beaver dam, road or railroad crossings) located in selected tributaries in the Middle and Upper Susitna River (Middle River tributaries to be determined during study refinement).

Modification 1: The USFWS recommends that for Upper River tributaries AEA collected field data and model velocities and water depths over distance to determine the location of the first velocity migration barrier upstream from the mainstem Susitna River for all target fish species and life stages. As an alternative to AEA proposed velocity criteria, the USFWS recommends the use of 2-D modeling in Middle River Tributaries and development slope-distance passage criteria, for all target fish species and life stages. USFWS also recommends longitudinal field surveys in Upper River tributaries to identify the distance from the mainstem to the first existing barrier (depth, velocity, or leap), for all target fish species and life stages.

AEA stated in their Study Implementation Report (SIR) that all field data have been collected; however, Upper River surveys have only been conducted to identify adult salmon leap barriers (water falls). Based on Upper River Fish distribution (Study 9.5), adult salmon and other target fish species migrating from the Susitna River probably encounter velocity barriers at some distance downstream from the identified falls. Understanding current conditions and meeting study objectives requires an understanding of the longitudinal extent of tributary habitats available to target fish species, as determined by the distance upstream from the Susitna River to the first barrier. Evaluating project effects will be accomplished by comparing the currently available habitat for all target fish species, with the distance fish can migrate upstream from the reservoir into tributaries under different reservoir pool elevations (AEA Objective 3). As there are other kinds of passage barriers other than waterfalls, AEA cannot assume that reservoir inundation of water falls will result in an increase in available tributary habitat, relative to current conditions.

The identification of velocity barriers requires comparison of tributary velocities with fish burst and sustained swimming speeds (e.g. Fish Xing). Velocity barriers occur where minimum cross-section water velocities (with sufficient depth) exceed target fish species burst swimming speeds. Barriers can also occur where velocities are greater than prolonged swimming speeds over a distance that results in fish exhaustion. Water velocities are typically modelled using relationships with discharge, channel slope, cross-sectional area, and bed roughness to determine locations of barriers. Slope-distance relationships are sometimes used as a surrogate for velocity. AEA has provided no information on how passage criteria will be evaluated in Upper River tributaries to determine the location of temporary or permanent velocity (or depth) barriers.

We recommend that AEA use aerial videography and results from the Characterization and Mapping of Aquatic Habitats study (9.9) to identify locations of potential velocity or depth passage barriers to target fish species in Upper River tributaries. AEA should conduct field surveys to measure channel cross-sections, water velocity, water depth, channel bed and water surface slopes, substrate size distribution, and any other information necessary to model water velocity. AEA should use regional regressions developed by U.S. Geological Survey to estimate tributary discharge. AEA should propose passage flows based on estimated discharge and the periodicity of target fish species. AEA should use modeled velocities to evaluate passage criteria for target fish species, in order to identify the location of the first velocity barrier upstream from the Susitna River in all Upper River tributaries.

We recognize that modelling water velocities in Upper River tributaries to evaluate AEA's passage criteria may be difficult. As an alternative, the USFWS recommends that AEA identify the combination of channel slope and distance that will likely result in velocity barriers. For example, the Alaska Forest Resources and Practices Act Regulations (11 AAC 95.265) have developed an approach to determining the upper extent of anadromous waters based on a combination of surface water slope and distance. AEA, using field measures of channel width, depth, and substrate obtained through the Characterization and Mapping of Aquatic Habitats study (9.9), should be able to simulate water velocities and develop slope and distance combinations that would reasonably identify where water velocities may exceed fish passage criteria of target fish species. Tributary water surface elevations, over distance, may be available from LiDAR data or may require additional fieldwork.

Modification 2: The USFWS recommends that for all Middle River tributaries, downstream from and including Portage Creek, AEA collect field data and conduct two-dimensional velocity modeling to evaluate passage criteria for target fish species and life stages.

Survey data provided within the ISR and SIR are insufficient to model water velocities and water depths at Middle River tributary mouths to evaluate passage criteria for target fish species, over a range of mainstem and tributary flows. Similar to Upper River tributaries, methods have not been developed to assess passage criteria in tributary mouths within or outside of focus areas. In order to evaluate passage criteria, cross-sectional and longitudinal surveys must be conducted at a scale that will allow for modeling water depths and velocities at multiple different tributary and mainstem flows. Survey data presented in the ISR and SIR do not provide the detail necessary to evaluate passage criteria to locate velocity and depth barriers and AEA has not demonstrated the modeling approach prescribed in the FERC determination.

Survey data in ISR 9.12 Appendix B show water depth, point velocity, and slope data along the channel thalweg, from the Susitna River to the upper zone of hydraulic influence. Depth data are point measures, and while we presume that the thalweg is the point of maximum depth, we have no knowledge of depths longitudinally between survey points and there are often large distances between points. For example, at Lane Creek water depth is 1.2 feet at station 0 and 0.5 feet at station 17.5. Results do not show if there is a point between station 0 and 17.5 where a single water depth may present a migration barrier. In Fourth of July Creek there is a 26 foot distance between the first two survey points, with no information on water depths between these two points. Results also do not provide any measure of tributary discharge or the portion of flows represented by this discharge. These data are too coarse to provide for confident predictions and assessments of the Project.

Velocity data in ISR 9.12 cannot be used to evaluate velocity barriers to juvenile salmon. While passage criteria have not been confirmed (see Appendix B), thalweg velocities at many of the tributary survey points exceed the burst swimming speeds of juvenile Coho Salmon and Arctic Grayling. However, there are likely lower velocities on the channel margins, but these areas were not measured. We are unable to plot the minimum cross-sectional velocities, over distance, to test whether burst swimming speeds are exceeded or if combinations of velocity and distance will exceed fish swimming abilities (fish become exhausted). Based on current data, barriers likely exist at most tributaries under low mainstem flow conditions.

AEA must demonstrate an approach through which identified passage criteria can be evaluated for target fish species and life stages at multiple mainstem and tributary flows.

Modification 3: The USFWS recommends that AEA conduct winter field surveys during January and February in all Middle River Focus areas to measure water depth and velocity, longitudinally throughout side channels, side sloughs, and upland sloughs to identify locations that are currently barriers to fish migration.

The ice processes study is currently unable to accurately model water velocities or depths in main channel or off-channel habitats, when ice cover is present. The current location of depth and velocity barriers to fish migration and total available winter habitat is unknown under current conditions. We have documented potential velocity barriers in tributary mouths and side sloughs, and depth barriers to fish migration in side sloughs, upland sloughs, and tributary mouths that are influenced by mainstem ice formation and location (Davis et al. 2013, Davis et al. 2015). During low winter flows, sloughs and side channels can consist of isolated pools with no open surface water connection between pools, or with the main channel, resulting in multiple depth barriers. For example, no open water was found at the mouth of Oxbow I (FA 113) during the winter of 2014 or the mouth of Rabideux Creek during the winter of 2013. Alternately, mainstem ice formation can divert mainstem flows into the upstream ends of side sloughs or side channels resulting in velocities within the channel that exceed the prolonged and burst swimming speeds of juvenile salmon. We have not conducted extensive winter surveys to document the extent of these conditions during winter.

Measures of depth and water velocity in side channels and off-channel habitats also will provide information that can be used to calibrate winter ice processes and enhance the realism of hydraulic model simulations.

Modification 4: The USFWS recommends that AEA install water level loggers and develop stage discharge relationships (rating curves) at multiple locations in all Middle River focus area side sloughs and side channels in order to estimate water velocity and fish passage barriers during winter ice development.

AEA’s study objective was to locate and categorize all fish passage barriers in the Middle River. We have observed that during ice development rising river stage heights can result in backwater conditions at the mouths of side sloughs and side channels or cause breaching flows at the upstream ends of these channels. Backwaters into the mouths of side sloughs and side channels can increase stage height approximately 4 feet (see AEA 2013-2014 Winter IFS Study). Changing ice conditions can shift flows downstream resulting in rapid draining of the backwater causing water velocities in the slough mouth to exceed juvenile salmon prolonged or burst swimming speeds. Similarly, breaching flows can increase water velocities over prolonged or burst swimming speeds of juvenile salmon in side sloughs and side channels during mainstem ice formation. These high water velocities may exclude fish from these channels for the remainder of the winter and this has significant implications to evaluating weighted usable area through instream flow analyses and fish habitat modeling. Load-following during winter also may result in periodic breaching flows into off-channel habitats causing short-term velocity migration barriers.

We recommend that AEA estimate water velocities in side sloughs and side channels within focus areas during ice development using relationships between channel cross-section area, stage height, and discharge. AEA has demonstrated the ability to measure changes in stage height in off-channel habitats during ice development and it should require little additional effort to apply these methods to Middle River focus areas.

Objective 2. Locate using geographic information system (GIS), identify the type (permanent, temporary, seasonal, partial), and characterize the physical nature of any existing fish barriers located within the Project's ZHI.

AEA has proposed passage criteria; however, final criteria have not been established for many fish species and life stages. To meet this objective, passage criteria must be finalized, and methods developed to evaluate passage criteria throughout the Project area. Currently, the only methods proposed are based on open water hydraulic modelling within Middle River focus areas.

Objective 3. Evaluate the potential changes to existing fish barriers (both natural and man-made) located within the Project's ZHI.

Modification 5: For Upper River tributaries, the USFWS recommends that AEA collect field data and conduct two-dimensional depth and velocity modeling, to identify all barrier types, from low pool elevation upstream to the first barrier upstream of the high pool elevation.

The fish passage barriers study has located all waterfalls that are leap barriers to adult salmon, and the study implies that inundating these barriers in the reservoir will increase available stream habitat for target fish species. However, AEA has provided no information on other types of potential barriers within stream channels upstream of the reservoir proposed pool elevations. Additional barriers are likely in Upper River tributaries other than waterfalls. Locating these barriers is necessary to determine how far target fish species can migrate from the reservoir up tributaries and to compare available tributary habitat. We recommend that AEA implement the methods described previously for Upper River tributaries (recommendation 1.1) to identify the location of all passage barriers within and upstream from proposed low pool elevation to high pool elevation.

Modification 6: The USFWS recommends a study modification that would incorporate results from the riparian instream flow and geomorphology study to model tributary delta formation and channel morphology, water depths, and water velocities within the reservoir varial zone.

Creation of a reservoir will modify riparian vegetation and alter fluvial processes and sedimentation in tributaries within the varial zone. Upland vegetation inundated by the reservoir will perish and soil conditions will be altered. Bed sediments transported in tributaries will be deposited in the reservoir potentially creating a delta at the tributary mouth. During low pool elevations rapid incision will likely occur in tributary deltas. We recommend that the Fish Passage Barriers study coordinate with the riparian vegetation and geomorphology study to model post-project changes in tributary channel geometry, and ultimately model post-project water velocities and depths to evaluate fish passage criteria.

Objective 4. Evaluate the potential creation of fish passage barriers within existing habitats (tributaries, sloughs, side channels, off-channel habitats) related to future flow conditions, water surface elevations, and sediment transport.

The ability of current studies to meet Objective 4 has not been determined. AEA will need to demonstrate the ability to model changes in bed morphology in (1) main channel and off-channels within focus areas, (2) Upper River tributaries in the reservoir varial zone, and (3) all Middle and Lower River tributary mouths. AEA will need to demonstrate the ability to (1) accurately model water velocity and depth during open water and ice covered conditions in all Middle River focus areas under all project operational scenarios, (2) model water velocities and depths in all Upper River tributaries within the reservoir varial zone under tributary passage flow conditions, (3) model water depths and leap heights at beaver dams, and (4) model water velocities and depths in all Middle River tributaries under all mainstem stage heights expected under all operational scenarios, and tributary passage flow conditions. AEA will need to demonstrate the ability to evaluate passage criteria at all of these locations and under all operational scenarios.

New Study Modification: New Data Collection and fish passage barrier assessment in the Lower Susitna River from Talkeetna to the Cook Inlet.

AEA describes the Lower Susitna River Segment (defined as the approximate 102-mile section of river between the Three Rivers Confluence and Cook Inlet) as representative habitat that would be less susceptible to project effects. However, the scientific literature related to riverine hydropower impacts does not support that assumption (Drinkwater and Frank 1994; Rosenberg et al. 2000). Furthermore, initial findings from ISR 8.5 Instream Flow Study Part C – Appendix K (AEA 2014c) indicate that post Project operations will change the flow hydrograph in the Middle and Lower river, resulting in maximum potential water level changes ranging from 9.7 feet near the proposed dam, 5.7 feet near Gold Creek, and 2.1 feet near Susitna Station in the Lower Susitna River, below the Yentna River and ~20 miles upstream from Knik Arm. This amount of water level change may have a large effect on connectivity between the main channel, side channels, off-channels, beaver ponds, and tributaries. Additionally, the predicted hourly water level effects associated with ramping rates for hydro peaking (load following flows) ranged from 0 to 2.1 feet under dry conditions and 0 to 8.0 feet under wet conditions near the dam site, 0 to 4.1 feet near Gold Creek, 0 to 4.0 feet near the Sunshine gage in the upper reach of the Lower Susitna River, and approximately 0 to 2.0 feet near the Susitna gage in the Lower Susitna River, just below the confluence with the Yentna River. This indicates that the ramping rates associated with a hydro-peaking operation will have large effects on the water surface elevations throughout the Middle and Lower Susitna River. In turn, these flow alterations will affect habitat conditions, lateral and longitudinal habitat connectivity, river processes (instream flow and riparian), and ice processes (flow under and over existing ice formations).

We anticipate measurable alteration to the Lower River will occur as a result of the proposed project operations and therefore we request an increased scope, geographically, to include needed studies in the Lower Susitna as necessary to better understand the extent to which the proposed Project may affect focal species and their life stage-specific habitats. This study request involves the ability of salmonids and other target species to gain access to and from main channel, side channel, and off channel habitats including beaver ponds. Other study requests will evaluate the effect of flow fluctuation on the survival of fishes.

The goal and objectives of this study modification are consistent with those reported in the Final Study Plan for Fish Passage Barriers (9.12). The goal is to evaluate the potential effects of Project-induced changes in flow and water surface elevation on free access of fish into, within, and out of suitable habitats (fish passage) in the Lower Susitna River (Three Rivers confluence (RM 98.5) to at least Susitna Station (RM 24.9)). This goal will be achieved by meeting the Study 9.12 objectives.

We encourage AEA to develop an operational plan for this study consistent with the state's (Alaska Department of Fish and Game) fisheries research Operational Planning guidance document (Regnart and Swanton 2012). We recommend that studies be conducted at Lower

River side sloughs or side channels important for salmon spawning and representative beaver dams that support juvenile salmon rearing. These studies are necessary to evaluate Project effects to fish passage. At least one side channel or side slough should also be selected that supports Eulachon spawning. All road or railroad culverts within the zone of hydrologic influence would also need to be evaluated as potential fish passage barriers. Specific study locations should be identified by the study planning team, including consultation with the Services, prior to the field investigation in the Lower River; however, sampled sloughs should not be located within the same complex but distributed to best represent habitat from river mile 24 to 98. The number of study sites within each slough should be sufficient to conduct an evaluation of Project effects that may affect access to habitats used by each life stage of anadromous salmonids and other target species. Because budget constraints will limit the total number of study sites, study site selection should consider areas where flow fluctuations caused by the Project are most likely to affect access to habitats by juvenile and adult fishes during each season of the year. Load following flows are expected to be greatest during winter months, indicating that fish passage during winter months must be evaluated.

Potential Project effects on spawning and rearing activities of salmon and other fishes would be addressed through the Instream Flow Study (Study 8.5), but it is anticipated that the Instream Flow Study would coordinate with the Fish Passage Study and provide necessary data describing channel characteristics and hydrology to evaluate fish passage at selected sites.

Hydraulic modeling (one-dimensional) during open water and ice cover, similar to the approach being applied to the mouth of Birch Creek, should be used to assess fish passage criteria in sloughs and side channels and beaver dams. Fish Xing should be used to evaluate passage criteria through road and railroad culverts at all mainstem water surface elevations.

Within sloughs and side channels, longitudinal surveys should be conducted during low water periods to identify those locations within a slough or side channel that are potential fish passage barriers. Cross-section transects and hydraulic modeling should occur at these locations and at the upstream end of the slough or side channel, to determine the water surface elevation that results in main channel breaching.

The primary information to be obtained from the proposed study modification is (1) determine the extent of potential changes to existing fish barriers (both natural and man-made) located within the Project's zone of hydraulic influence throughout the Lower Susitna River, and (2) determine the extent to which Project-related flows create or exacerbate fish passage barriers within existing habitats (tributaries, sloughs, side channels, off-channel habitats, road and railroad culverts), including the effects of water surface elevation and sediment transport. This will be accomplished with methodologies reported in the Final Study Plan and Implementation Plan while also considering comments provided by this review of the Fish Passage Barrier ISR and SIR. Fish Passage Barriers studies in the Lower Susitna River must be closely coordinated with instream flow studies (Study 8.5), fish distribution and abundance studies (Study 9.6), fluvial geomorphology studies (Study 6.6), and tributary delta formation studies (Study 6.5). This coordination is critical because these other studies are tasked with providing the physical data necessary to evaluate fish passage. Therefore, the Fish Passage Study Team must identify specific sites where physical measurements and flow modeling results are necessary. Furthermore, consultation with the Services regarding fish passage criteria must be finalized for each target species and life stage.

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9.14 Genetic Baseline Study for Selected Fish Species

Summary of Proposed Modifications and New Studies

These USFWS comments are provided prior to the completion of the Study's final report and as such do not reflect a final assessment of the project with respect to meeting the five objectives of the genetic baseline study. A full assessment of the project outcome and study conclusions by AEA will only be possible after the final report is complete. On behalf of AEA, the Alaska Department of Fish &Game Conservation Genetics Laboratory, anticipates that the results of analyses and associated reporting will be completed in the Fall of 2016.

Introduction

The comments below consider the study progress with respect to the five study objectives as reported in the following documents:

1. 2014 Study Implementation Report of the Genetic Baseline Study for Selected Fish Species (from AEA).
2. Meeting Summary and Decision Points from the Fish Genetics Study 9.14 Technical Meeting, April 12, 2016 (from AEA).
3. Susitna-Watana NCI Chinook pre-consultation analysis November 2015.xlsx (spreadsheet from ADF&G).
4. Susitna-Watana middle and upper Susitna River Chinook Salmon pre-consultation a….xlsx (spreadsheet from ADF&G).
5. ISR meeting presentation, March 22, 2016 (Power point file from ADF&G)

Because the project is not completed (final analyses in progress) our comments focus primarily on results that are unlikely to change during final analysis.

Comments by Objective

Objective 1: Develop a repository of genetic samples for target resident fish species captured within the lower, middle, and upper Susitna River drainage.

- Samples from 15 species of resident fish were collected opportunistically and archived at the ADF&G Gene Conservation Laboratory. No analyses are planned. Sample sizes were not met, therefore we do not consider the Objective to have been met.

Objective 2: Contribute to the development of genetic baselines for Chum, Coho, Pink, and Sockeye salmon spawning in the middle and upper Susitna River drainage.

- Additional baseline samples were collected for the four species. The Chum, Coho, and Pink salmon baselines benefited most from this effort as very few, if any, samples existed prior to the study. The Sockeye Salmon baseline for Cook Inlet was augmented during this study but these new samples were not from new locations.

Objective 3: Characterize the genetic population structure of Chinook Salmon from upper Cook Inlet, with emphasis on spawning ground aggregates in the Middle and Upper Susitna River. As part of this objective, the following three hypotheses regarding Chinook Salmon in the Upper Susitna River will be tested:

> $H1_a$: Chinook Salmon above Devil's Canyon represent self-sustaining population(s) that are genetically isolated from Chinook Salmon aggregations below Devil's Canyon and potentially locally adapted;
>
> $H1_b$: Chinook Salmon above Devil's Canyon represent successful reproduction in the Upper River but also experience a high level of introgression from Chinook Salmon aggregations below Devil's Canyon;
>
> H2: Chinook Salmon above Devil's Canyon originate from aggregates below Devil's Canyon.

- This objective has not been completed so the stated objective has not been met. A detailed review is not justified at this time but the USFWS provides the following comments:
  - The sample size targets for collections outside the Susitna River drainage were not met. However, the samples did augment existing archived collections. Population structure was evaluated for all upper Cook Inlet collections using 36 SNP loci (Document 3). Population structure will be further evaluated using an additional 47 SNP loci (Document 2). These additional loci may increase statistical support for the inferred population structure.
  - It will be impossible to test temporal stability of allele frequencies in the upper Susitna River collections because temporal replicates were not collected (Documents 1 and 4). Because no further sampling is planned, it will not be possible to fully evaluate the three hypotheses. Temporal replicates (inter-annual) are needed to confirm the diversity and origin of the putative upper river populations. The USFWS recommends the necessary temporal replicates be sampled if the Project continues.
  - The Decision Points for further analysis (Document 2, page 3) are appropriate given the samples in hand and the results to date. Further comments on the outcome of this objective should be provided when the final analyses are complete. The USFWS looks forward to commenting on the final reporting for this study.
  - AEA made two modifications to the study plan (Document 5):
    - 1) Use of buccal swabs instead of caudal fin to acquire DNA from juveniles. Caudal fin clips can adversely affect juvenile salmon, including causing mortality. Buccal swabs are not likely to be lethal but may not yield as much or as good a quality DNA. We recommend that the final report comment on both methods as a source of DNA and whether or not the change could have influenced genotyping of

juveniles. The investigators reported low DNA volumes and concentrations resulted in a lack of SNP data for some juvenile collections (Document 2).

- 2) Increase the number of markers to include 190 SNPs and 12 microsatellites for all Chinook Salmon captured in the Middle and Upper Susitna River. This is a reasonable modification to increase statistical power for identifying population structure. However, it is unlikely that all samples will be evaluated for 190 SNPs (Document 2 and see modification 1 above). It appears that most samples were successfully analyzed for 12 microsatellites.

Objective 4: Examine the genetic variation among Chinook Salmon populations from the Susitna River drainage, with emphasis on Middle and Upper River populations, for mixed-stock analysis (MSA).

- This objective has not been completed. A detailed review is not justified at this time but the USFWS provides the following comments :
  - The preliminary analyses presented by ADF&G at the April 12, 2016 meeting (see Documents 2 and 3) suggests it may not be possible to distinguish Middle River populations from mainstem populations for MSA. This is because the Fst estimates among Middle River tributaries (i.e., Indian River, Portage Creek) and mainstem tributaries (Chunilna and Montana Creeks) are zero or near zero. Suggesting that it may be difficult to ID these groups using MSA. In addition, temporal stability of allele frequencies in Upper River collections has not been tested. The USFWS recommends that temporal stability of allele frequencies be tested.
  - Simulations to evaluate the baseline for MSA were not completed at the time of this review.

Objective 5: If sufficient genetic variation is found for MSA, estimate the annual percent of juvenile Chinook Salmon in selected Lower River habitats that originate in the Middle and Upper Susitna River in 2013 and 2014.

- AEA proposes a study modification to remove this objective (Document 2). Sampling juvenile Chinook Salmon in the lower Susitna River proved to be challenging and the number collected was insufficient for MSA. Nevertheless, it is important to determine if and to what extent Upper River fish use the Lower River habitats if the population structure analysis reveals self-sustaining populations in the Upper River. Therefore, the USFWS recommends that this Objective be retained. We do not agree with the proposed modification.

9.16 Eulachon Distribution and Abundance
Summary of Proposed Modifications and New Studies

Study Objectives

1. Determine eulachon run timing and duration in the Susitna River in 2013 and 2014.
2. Identify and map eulachon spawning sites in the Susitna River.
3. Characterize eulachon spawning habitats.
4. Describe population characteristics of Eulachon returning in 2013 and 2014.

In order to meet the overall Eulachon Distribution and Abundance study objectives, the USFWS recommends the following six modifications:

1. USFWS requests that at least two additional years of data be collected throughout the entirety of both eulachon spawning runs to:
   - Document the phenology and size of each annual run.
   - Capture the variability in spawning distribution of Eulachon.
   - Evaluate and determine the characteristics of spawning habitat in the Susitna River.
2. Implement methods to enumerate each spawning run size in its entirety including during breakup.
3. Extend the water quality investigation to include the lower river (all the way to Cook Inlet) and the pre-breakup period.
4. Extend the geomorphology modeling into the Lower River or develop alternative means to predict project induce change to Susitna channel below the Yentna River confluence.
5. Extend the ice modeling to the Lower River or find some other method to access likely Project effects on ice processes in the Lower River.
6. Explicitly identify how the assessment of Project effects on Eulachon will be completed.

ISR REVIEW COMMENTS

This section evaluates the AEA study plans and the studies completed to date to determine if the objectives of the studies have been met. For those objectives that were not met, study modifications have been requested to ensure that the Project studies adequately address potential Project impacts. This section provides a brief description of the analysis approach, a list of study objectives that were a) requested by USFWS, and b) objectives specified in AEA's study plan. This section also provides a summary of whether the studies completed to date met either the USFWS's or AEA's study plan objectives. The section is broken out by objective. For those objectives that were not met, a requested study modification is provided.

The AEA study plan, the revised AEA study plan, the Final AEA study plan, and interim and final study reports related to the Eulachon studies and the studies that were relied upon by the AEA study plan that addressed Project effects on physical processes in the river were reviewed to determine if USFWS's objectives and the stated AEA objectives were met by a) the study plans, and/or b) the studies completed to date. Where inadequacies in the study plans themselves or in the studies, as conducted, were identified, study modification requests were developed and detailed in the document.

STUDY OBJECTIVE SUMMARY

The USFWS supports NMFS's May 31, 2012 letter (letter) regarding study request that identified one objective specific to Eulachon: *"collect additional data to support efforts to determine the timing, distribution, and relative abundance of eulachon in the lower reach of the Susitna River"*. NMFS's letter also states: *"An essential objective is to determine how potential changes in the natural system as a result of the proposed Project may affect the critical habitat and prey dynamics, and ultimately, impact the conservation or recovery of the Cook Inlet Beluga whales and other marine mammals"*. Since Eulachon are a primary prey item for marine mammals in Cook Inlet that spawn in the Susitna River, this objective would also apply. The USFWS' supports NMFS's request and also asks that this specific request be required of the Eulachon study.

The goal of the Eulachon study, as specified in AEA's study plan, was to collect baseline information regarding Eulachon run timing, distribution, and habitat use in the Susitna River. The stated objectives of this baseline study are as follows:

1. Determine eulachon run timing and duration in the Susitna River in 2013 and 2014.
2. Identify and map eulachon spawning sites in the Susitna River.
3. Characterize eulachon spawning habitats.
4. Describe population characteristics of eulachon returning in 2013 and 2014.

The Eulachon study plan also indicates that the analysis of the Project effects rely on the results of the fish distribution and abundance, fish and aquatics instream flow, water quality, geomorphology, and the ice processes studies.

Study Objectives Evaluation and Modification Requests

USFWS requests the following study objective be achieved: *"collect additional data to support efforts to determine the timing, distribution, and relative abundance of Eulachon in the lower reach of the Susitna River"*. This objective was addressed by AEA's study objectives, but AEA's objectives were not achieved in their study. USFWS requests that the objective above be achieved. AEA's achievement of their study objectives are individually addressed below.

> *An essential objective is to determine how potential changes in the natural system as a result of the proposed Project may affect the critical habitat and prey dynamics, and ultimately, impact the conservation or recovery of the Cook Inlet belugas whales and other marine mammals.*

The degree to which this essential objective is addressed by AEA objectives is discussed following the individual evaluation of AEA's study objectives.

USFWS Recommended Study Modifications:

1. Implement methods to enumerate each spawning run size in its entirety including during breakup (Objectives 1 & 2).
2. Extend the water quality investigation to include the Lower River (to Cook Inlet) and the pre-breakup period (Objective 3).
3. Extend the geomorphology modeling into the Lower River or develop alternative means to predict project induce change to Susitna River channel below the Yentna River confluence (Objective 3).
4. Extend the ice processes modeling to the Lower River or find some other method to access likely Project effects on ice processes in the lower river (Objective 3).
5. Explicitly identify how the assessment of Project effects on Eulachon will be completed (Objective 3).

Objective 1: Determine Eulachon run timing and duration in the Susitna River in 2013 and 2014.

The Eulachon study plan indicates that Eulachon studies will be conducted from approximately May 1 (or ice-out) through June 30 (or the end of the Eulachon migration onto spawning grounds). The surveys were expected to use a combination of acoustic surveys, radio telemetry, and "standard" fish capture and habitat sampling methods to characterize the Eulachon spawning migration.

Did the study and/or study plan meet the objective?

No. The studies did not start until sea ice was gone in the study area. Eulachon have been documented moving into the river prior to breakup (Vincent-Lang and Queral 1984). The study needs to start sampling before ice out or the study may miss much of the first spawning run.

Study Modification Request for Objective 1

Recognizing that working in water during ice breakup is difficult; implement methods to enumerate each spawning run size in its entirety. Previous investigators have been able to document early under-ice runs (Vincent-Lang and Queral 1984). USFWS requests that at least two additional years of data be collected throughout the entirety of Eulachon spawning runs to document the phenology and size of each annual run.

Objective 2: Identify and map Eulachon spawning sites in the Susitna River

Telemetry and mobile acoustic surveys were to be used to identify the distribution of spawning locations in the study area and to evaluate fish behavior on spawning sites. The proposed sample size was expected to be adequate.

Did the study and/or study plan meet the objective?

No. Although the methods are adequate, the studies did not start until sea ice was gone in the study area. The study needs to start sampling before ice out or the study may miss much of the early run. In addition, we have only one year of data; additional years of information are needed to adequately describe the distribution of eulachon spawning sites.

Study Modification Request for AEA's Objective 2

Recognizing that working in water during ice breakup is difficult; find some method to enumerate the run size while ice is still in the river. Previous investigators have been able to document early under ice runs (Vincent-Lang and Queral 1984). USFWS requests that at least two additional sequential years of data be collected throughout the entirety of the eulachon spawning run to better capture the variability in spawning distribution of Eulachon.

Objective 3: Characterize Eulachon spawning habitats.

The study plan proposed to use a combination of active sampling and side scan sonar to identify the characteristics of the substrate where Eulachon are spawning. Water quality parameters, including pH, water temperature, dissolved oxygen, specific conductance, and turbidity were to be collected at spawning sites. Water depth and water velocity were sampled at several locations at the spawning locations. The study plan indicates that correlation analyses will be used to evaluate the relationship between water temperature and run timing and to evaluate relationships between other water quality and hydrologic parameters and Eulachon spawn timing.

The study plan indicates that the data collected during the study is intended to be used to determine if there is a relationship between eulachon runs timing or abundance and flow, substrate, or water quality. The study assumes that predicted changes in water quality, substrate, geomorphology and flow from the other study components will be available to assess potential Project effects on Eulachon. AEA's study plan includes a figure (Figure 1 under Section 2: Cook Inlet Beluga whales) depicting the interdependent relationship between the Eulachon study and the other Project studies.

Did the study and/or study plan meet the objective?

No. The study plan indicated that 2 years of data would be collected. Only one partial year of data was collected, and that data missed the early portion of the run. USFWS requests that at least two additional sequential years of data be collected to better characterize Eulachon spawning habitats.

Although the Eulachon study plan indicates that the analysis of the Project effects rely on the results of the fish and aquatics instream flow, water quality, geomorphology, and the ice processes studies, no modelling of fish habitat, geomorphology or ice proposed in the lower river was completed. Therefore, inputs from those studies are not available. Water quality modelling (including temperature) is only proposed during the ice free months, so there will be no water quality modelling results available at the start of the Eulachon run. In 2014, AEA proposed a different method for evaluating Project impacts on Eulachon, but that study has not been implemented. Therefore, the information that the study plan assumed would be available to assess potential Project effects on Eulachon is not available.

The adequacy of the inter-related studies in meeting their objectives as they relate to Eulachon and Cook Inlet marine mammals is discussed below.

Study Modification Request for Objective 3

USFWS requests that at least two additional sequential years of data be collected throughout the entirety of the spawning run to evaluate and determine the characteristics of spawning habitat in the Susitna River. In addition, USFWS requests the following to suitably assess potential Project effects on Eulachon:

- Extend the water quality investigation to include the lower river and the pre-breakup period.
- Extend the geomorphology modeling into the lower river.
- Extend the ice modeling to the lower river or find some other method to access likely Project effects on ice processes in the lower river.
- Explicitly identify how the assessment of Project effects on Eulachon will be completed.

Objective 4: Describe population characteristics of Eulachon returning in 2013 and 2014.

Absent some measure of baseline Eulachon abundance over multiple spawning seasons, we cannot know what population level effects the Project may have on this important freshwater and marine prey species.

Did the study and/or study plan meet the objective?

Because the study did not capture the early portion of the early run during study year one, and no attempt was made to study population characteristics in year 2, the objective was not met. One partial year of data is inadequate for characterizing natural variability in population characteristics.

Study Modification Request for AEA's Objective 4

Recognizing that working in water during ice breakup is difficult; implement methods to enumerate the run size while ice is still in the river. Previous investigators have been able to document early under ice runs (Vincent-Lang and Queral 1984). USFWS requests that at least two additional sequential years of data be collected throughout the entirety of the Eulachon spawning runs to quantify the population characteristics of Eulachon in this watershed, providing at least some indication of natural variability in run strength.

SUMMARY COMMENTS

One partial year of data collection of Eulachon run and habitat characteristics is an insufficient substitute for two full years of data collection, especially when two full years of data is the absolute minimum needed to gain any insight into inter-annual variability. The USFWS recommends conducting at least two additional sequential years of this study spanning the entirety of the annual Eulachon spawning run.

REFERENCES

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10.14 Surveys of Eagles and Other Raptors

Summary of Proposed Study Modifications and New Studies

The Surveys of Eagles and Other Raptors Study is still in progress.

The study objectives as stated in FERC Study Plan Determination are:

1. Enumerate and identify the locations and status of raptor nests and territories that could be affected by the Project construction and operation. Four specific tasks are associated with this objective:
   a. Review and synthesize existing nest data for eagles and other raptors.
   b. Conduct field surveys to locate and characterize nests.
      - Golden Eagle occupancy survey methodology needs some refinement. We recommend that a methodology employed by Golden Eagle expert Carol McIntyre be implemented, whereby the helicopter returns and sets down near "possibly occupied nests" and observes the nest for an hour or two. This will reduce the number of "possibly occupied" nests.
   c. Create a geospatial database of all nests and territories.
   d. Calculate local average territory size for Bald and Golden Eagles.
      - Where Golden Eagle nests are concentrated on linear features, such as cliffs, but foraging areas are widespread below, the mean in-nest distance may not encompass all important parts of the territory.
2. Estimate Project effects on productivity of raptors. Four tasks were included with this objective:
   a. Review existing productivity data.
   b. Determine the average and range of productivity of nests of each species.
      - Project effects on raptor productivity may be complicated and long-lasting and not characterized by a simple direct extrapolation of loss of footprint (with current productivity X) into a measure of potential of lost productivity. Such methodology has not yet been proposed or explained, and a framework or model must be established to explain how the study will do this (task d).
   c. Consider impacts on productivity at the local and larger population level, using current and historical data.
      - To understand impacts on productivity at the local and larger population level, we need to understand and know the raptor population outside of the reservoir inundation site. This project will have a much larger project footprint that will extend many miles downstream. To understand project effects on raptors, habitat availability for displaced raptors should be addressed.
   d. Establish the framework for comparisons of productivity to evaluate whether realized take is consistent with permitted take, and to ensure the level of take is compatible with the preservation of eagle populations
3. Estimate effects on nesting and foraging habitat by delineating suitable habitat features in a geospatial database.
   - Has not been started.

4. Conduct field surveys and literature reviews to identify, map, and characterize the habitat-use patterns at fall and winter communal roost and foraging sites of Bald and Golden Eagles and other raptor species. Describe seasonal habitat use, highlighting areas or conditions that may result in impacts on raptors.
    - It does not appear that this objective has been planned or met. No methodologies are described or implemented yet to identify whether or not habitats adjacent to the project area may be available for use by displaced nesting birds.
5. Assess the extent to which planned overhead transmission lines may pose a collision risk to migrating or nesting raptors and to identify migratory corridors.
    - We have not yet confirmed that the 18 sites were located at the most optimal points for the migration data collection. Besides optimum detectability, some consideration should be given to sites where there are particular pre-concerns or available alternatives (both landscape-scale and topographically) for transmission line placement.
    - Migration surveys should also begin earlier and extend later in the season as it is believed that a potentially significant number of some birds, particularly Golden Eagles were likely missed (Steve Lewis, pers. comm.).
6. Provide information on the distribution, abundance, food habits, and diet of piscivorous raptors; feather samples for characterization of mercury levels; and information on the effects of methylmercury on piscivorous raptors, for use in the Mercury Assessment and Potential for Bioaccumulation study.
    - Transferred to the Mercury Assessment and Potential for Bioaccumulation Study (see ISR 5.7).

Study Modification Requests

Objective 1: Enumerate and identify the locations and status of raptor nests and territories that could be affected by the Project construction and operation.

Modification 1: Nest surveys have successfully documented cliff nesting raptors, Bald and Golden Eagles, but have not been successful for woodland raptor species, including owls and smaller raptors. The USFWS recommends developing survey protocols to identify woodland raptors, including owls and smaller raptors that have not been successfully documented in other surveys.

Modification 2: The USFWS recommends at least one, and possibly more, additional years of surveys will be needed to characterize occupancy, productivity, and migration rates of eagles. In the case of Golden Eagles, surveys in years of high prey availability will be necessary. Both surveys that have been completed to this point have been in years of low prey productivity.

Additional years of surveys will be required in order to get acceptable estimates of eagle/other raptor migration numbers and rates. This is because of inter-annual variability, which can be particularly high for Golden Eagles, and the fact that 2013 was an extremely anomalous year in Alaska, in terms of spring and summer weather and this likely affected migration timing and perhaps routes (Steve Lewis, pers. comm.). The Service can use the information to help assess whether future activities may result in loss of one or more eagles, a decrease in productivity of bald or golden eagles, and/or the permanent abandonment or loss of a nest site, communal roost site, or important foraging area. This information will allow the Service to refine permit conditions and recommendations in future versions of eagle management guidelines to minimize take of eagles.

Modification 2: The Surveys of Eagles and Other Raptors Study has documented the use of the proposed reservoir inundation area by eagles and raptors within a 3-mile buffer area of the reservoir site (10 miles for Golden Eagles). However, it does not address raptor populations downstream of the proposed dam site. The creation and operation of such a large dam structure will alter river flow and hydrology for many miles downstream. Initial results of the open-water flow routing model indicate post Project operations will drastically change the flow hydrograph for the Middle and Lower rivers. Raptor use of the area downstream of the Project was not part of this study; however, it should be considered. As the hydrology of the river system changes the use of the system by raptors will also change. A pre-construction baseline of the raptor use below the proposed dam is necessary to fully understand the effects of the project on raptors.

References

Lewis, Steve B. Personal communication via telephone with Maureen de Zeeuw on August 8, 2014.

10.15 Waterbird Migration, Breeding, and Habitat Use (10.15)

Summary of Proposed Study Modifications

The Waterbird Migration, Breeding, and Habitat Use has been completed. A Study Completed Report was filed in October 2015.

The study objectives established include:

1. Document the occurrence, distribution, abundance, habitat use, and seasonal timing of waterbirds migrating through the Project area in spring and fall:
   - Study complete
   - Objective was met
2. Determine the occurrence, distribution, abundance, productivity, and habitat use of waterbirds breeding in the Project area.
   - Study complete
   - Objective was met
3. Review available information to characterize food habits and diets of piscivorous waterbirds documented in the study area as background for the Mercury Assessment and Potential for Bioaccumulation Study (5.7)
   - Further analysis and study has been postponed pending the results of the pathways analysis for Study 5.7

The year 2013 has been widely recognized as an extremely anomalous year in Alaska, in terms of spring and summer weather; this likely affected migration timing and perhaps routes.

The low values for migration numbers and rates relative to earlier studies in the area is curious and needs to be more fully explored, especially in light of the anomalous 2013 weather (18 CFR §15.5(d)(2)). The year 2013 has been widely recognized as an extremely anomalous year in Alaska, in terms of spring and summer weather; this likely affected migration timing and perhaps routes (Steve Lewis, pers. comm.). This represents anomalous environmental conditions as described in 18 CFR §15.5(d)(2). No ground-based migration surveys were done in 2014.

Modification 1: The Waterbird Migration, Breeding, and Habitat Use Study documented the use of the proposed reservoir area by waterbirds within a 3-mile buffer area of the reservoir. However, it does not address waterbird populations downstream of the proposed dam site. The creation and operation of such a large dam structure will alter river flow and hydrology for many miles downstream. Initial results of the open-water flow routing model indicate post Project operations will drastically change the flow hydrograph for the Middle and Lower rivers. Post Project operations Waterbird use of the area downstream was not part of this study; however, it should be considered. As the hydrology of the river system changes the use of the system by waterbirds will also change. A pre-construction baseline of the waterbird use below the proposed dam is necessary to fully understand the effects of the project on waterbirds, a USFWS trust resource.

References

Lewis, Steve B. Personal communication via telephone with Maureen de Zeeuw on August 8, 2014.

10.16 Landbird and Shorebird Migration, Breeding, and Habitat Use

Summary of Proposed Study Modifications

The Landbird and Shorebird Migration, Breeding, and Habitat Use Study is still in progress.

Four study objectives were identified:

1. Collect data on the distribution and abundance of landbirds and shorebirds during the summer breeding season.
    - The Service has concerns that detectability of songbirds was not corrected for the drop in singing rates that occurs mid-morning, though the final distance analyses may exclude late-morning survey data that could introduce downward biases in density estimates. Point count surveys regularly extended until noon or 1 pm, well past the time when singing rates drop off and standard survey protocol recommends ending (Handel and Cady 2004, Ralph et al. 1993)
    - Colonially nesting swallow surveys in the next study season will provide another year of data to improve the abundance estimates reported in this ISR. As with other landbird species, swallow abundance is likely to fluctuate substantially between years as a result of variability in reproductive success and survivorship. For this reason, a second year of surveys will be helpful in understanding the abundance of breeding swallows in the study area. Additional surveys also will result in a better understanding of swallow nesting activity, habitat use, and colony location changes throughout the study area. The 2013 results in combination with another study year may provide sufficient data to meet the study objectives, provided Service concerns with detectability, survey phenology, and/or habitat selection.

2. Identify habitat associations for landbirds and shorebirds.
    - Preliminary habitat associations have been completed; however, the Vegetation and Wildlife Habitat Mapping Study (Study 11.5) will be used as the basis for the final analyses. It has not yet been completed.

3. Evaluate changes in distribution, abundance, and habitat use of landbirds and shorebirds through comparison with historical data.
    - Ongoing.

4. Characterize the timing, volume, direction, and altitude of landbirds and shorebirds migrating through the dam and camp facilities area.
    - Completed and reported in Study Completion Report Study 10.15 (Waterbird Migration, Breeding, and Habitat Use)
    - The spring raptor migration survey date range is probably not broad enough to fully account for potential passerine peaks. The spring radar surveys at the dam site may also have been initiated late, given that the peak movement of all birds was recorded just two days. How much these issues affect passerine, shorebird, or

other bird species or group results, or whether this was primarily waterbirds, is not clear from the reporting.

Study Modification Requests

Objective 1: Collect data on the distribution and abundance of landbirds and shorebirds during the summer breeding season

Modification 1: The USFWS recommends additional year(s) of sampling. There are several reasons why additional years of point count and riverine/lacustrine sampling are warranted. For example, additional sampling can be argued based on a stated target for precision of the density of population size estimates (say $CV \leq 0.15$). Also, migrants arrived late in both 2013 and 2014 so and the additional year of 2015 is only planned for 27% of the study area. If density estimates are to be calculated by habitat, then additional samples may be needed to fill in poorly sampled habitats. Minimum sample sizes for estimating detection functions are 75–100 detections so additional sampling could be justified.

Objective 4: Characterize the timing, volume, direction, and altitude of landbirds and shorebirds migrating through the dam and camp facilities area.

Modification 2: The USFWS recommends further technical discussions regarding the quality and objectives of the migration data, if a second year of radar data collection is not completed, and to explore how more species-specific information may be obtained. First, a single year of data on nocturnal migration patterns cannot provide for an adequate understanding given inter-annual variation. Also, insofar as potential impacts such as collision risk and reservoir or dam-lighting attraction may be species-dependent, a discussion of how more species-specific data may be collected is warranted.

Objectives 1, 2, 3, and 4

Modification 3: The USFWS recommends broadening the scope of the Study to include areas below the Project. Initial results from the open water flow routing model show the post Project flow hydrograph for the Middle and Lower river will drastically change. The Project has the potential to not just impact landbirds and shorebirds within the project footprint, but for many miles downstream. Migratory birds are a trust resource for the USFWS to fully understand the implications of the post Project landscape the USFWS recommends surveys downstream of the Project.

References

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New Study Request for Susitna-Watana Integrated Modeling and Decision-Support System

Introduction

The goal of this request is to formally incorporate two inter-related subjects – Integrated Modeling and a Decision Support System (DSS) – that have been, in effect thus far, an informal part of the study Integrated Licensing Process (ILP) since 2012. While much attention has been given to the need for integrated modeling to organize and synthesize all of the data, research, and computer models that have been parts of the study plan, adequate results have not been achieved and appear unlikely to be obtained without this proposed, more focused study. Similarly, the need for a DSS that presents an integration of models developed from the various studies has been discussed in Technical Working Groups, Technical Team meetings, public meetings, and Initial Study Report (ISR) meetings but sufficient details have not been developed.

The model integration and DSS are two distinct but closely related tasks. Model integration refers to the process of linking together individual study data inputs, analyses, and models to form a complete picture of baseline resource conditions. Similarly, the tools are intended to assist the development of a scientifically sound basis for making the necessary predictions to identify, assess, and quantify (if possible) the potential impacts of the Project under alternative future scenarios across resource disciplines.

A properly designed and well-supported DSS will incorporate the results of the model integration along with other qualitative (e.g., literature searches) and quantitative information (e.g., historic raw data) from other studies and provide a framework for the Alaska Energy Authority (AEA), decision makers, and stakeholders to compare the environmental impacts of alternative operational scenarios as compared to conditions without the Project. The model integration and DSS are unique aspects of the Project as they involve many (if not all) of the individual studies pursued as part of the FERC application for this proposed Project.

The model integration and DSS will ultimately serve as the primary mechanisms for helping AEA, decision makers, and stakeholders to understand the existing pre-Project conditions in the Susitna River watershed as well as to predict the potential impacts of the proposed Project and its alternatives. Given the importance of these two tasks, the U.S. Fish and Wildlife Service (USFWS) recommends that a separate New Study be devoted solely to the topics of model integration and the DSS. In that way, it will also be possible to obtain the specialized expertise dedicated to those specific responsibilities.

To facilitate FERC's review of this new study request, USFWS will address each of the new study justification criteria set forth at 5.15(e):

5.15(e)(1) There are no material changes in the law or regulations applicable to the information request.

5.15(e)(2) The goals and objectives of the approved studies cannot be met with the approved study methodology.

All of the other studies and methodologies are discrete items directed at addressing specific information requirements in order to produce a scientifically solid basis to assess the environmental impacts of the Project for that specific study topic. With respect to model integration, many of the studies and methodologies also produce computer simulation models but those models are specific to the requirements for that particular aspect of the overall Study Plan. As such, none of the studies do, nor should they be expected to do, what an integrated model would do.

AEA has discussed and presented general concepts related to the development of a DSS to assess Project effects on the Susitna River but details of a DSS are not defined in the ISR or supporting documentation. This is critical information for determining the applicability of the methods and framework that will be used to integrate the numerous study results/outputs proposed and discussed above to assess the Project effects on natural resources throughout the Susitna River.

5.15(e)(3) This study request was made earlier.

The USFWS and National Marine Fisheries Service (collectively, the Services) requested this particular study in 2013 and 2014. We are renewing the request here in a formal manner because, as the record demonstrates, the integrated modeling and DSS have not been developed or prioritized to a degree necessary to produce results that are meaningful and useful within the timeframe for making licensing decisions and for developing measures to protect, mitigate for, and enhance Project-affected resources. Planning and implementation of these two tasks is currently incorporated in Section 8.5 - Fish and Aquatics Instream Flow Study of the Project. As required by FERC, AEA included aspects of both the integrated modeling and DSS in their original study plans as approved by FERC; however, this information was too limited to be effective as demonstrated by stakeholder requests for separate model integration workshops and AEAs development of the very limited proof-of-concept assessment. A comprehensive effort to develop the integrated model and the DSS is critical to the decision process for licensing the proposed Project, and the process and efforts to develop these tools should occur before resources are expended to conduct additional studies.

5.15(e)(4) There are significant changes in the project proposal and significant new information material to the study objectives has become available.

The proposed Project (i.e., design, schedule, construction)—as specified in the studies to date—continues to change. Alternatives to the Project have not been defined at a level of detail amenable to analysis. The ideas for how the proposed Project will be built, operated, and maintained continue to change. The foundational studies, upon which evaluations of the “final” Project Alternatives, Project design, construction, and operation/maintenance are based, continue to change. Importantly, the studies continue to yield information that will and should provide “lessons learned” to guide future studies, refine the proposed Project, and define Project Alternatives.

The USFWS notes that as recently as the March 2016 ISR meetings, FERC stated that they expect AEA will complete the development, calibration, and validation of the computer models with outputs to be included in the Updated Study Report (USR) ILP process step. AEA's consultant, Phil Hilgert (R2), acknowledged FERCs expectation by saying, "Yes, we will have to be able to demonstrate the models will work."

5.15(e)(5) This new (or, renewed) study request satisfies the study criteria in § 5.9(b).

With regard to the model integration itself, the only progress reported to date is the "Proof-of-Concept" ("POC") demonstration and development of a software tool to facilitate model and data integration to support computations for the fish habitat models that was presented more than 2 years ago. The POC demonstration was presented at the IFS-TT: Riverine Modeling Proof-of-Concept Meeting (April 2014) and described in the Initial Study Report (ISR), 8.5 Fish and Aquatics Instream Flow Study, Part C, Appendix N: Middle River Habitat and Riverine Modeling: Proof-of-Concept. The POC provided an example of computing fish habitat based in the output from two 2D hydraulic models (SRH-2D for open water conditions, River2D for ice covered conditions), and multiple GIS-based datasets of physical conditions (e.g., channel morphology and substrate, groundwater inputs, water quality). The various inputs were combined with Habitat Suitability Curves (HSC)/Habitat Suitability Indices (HSI) to compute salmon spawning-incubation and salmonid rearing habitat for one Focus Area (FA-128, Slough 8A) in the Middle River under two scenarios (Existing Conditions and Operating Scenario OS-1b) under three representative weather years (dry, average, wet). AEA stated that the "POC demonstrated that the models and approaches being applied by AEA are conceptually sound and will provide the level of detail needed to evaluate Project effects."

The now-2-year-old POC focused on a single small reach of the river (one Focus Area), and did not demonstrate how results would be spatially extrapolated to the entire river, as proposed. Spatial and temporal extrapolation methods were discussed at the meeting, but AEA has yet to decide which extrapolation method will ultimately be used. There was no analysis of the error and uncertainty propagation from one model to the next. Each model contains some degree of uncertainty, and how that uncertainty is transferred from one model to the next is critical to ensure high confidence in the accuracy and precision of the overall results. Finally, the POC incorporated outputs from just two simulation models, and "example inputs" were used for other models that were not yet complete to "demonstrate linkages and compatibilities." While this is a reasonable approach given differing schedules for various models, it falls short of proving that the full-scale model integration will be able to represent existing conditions with reasonable accuracy and confidence.

With regard to the DSS, AEA outlined a concept of a matrix-based approach after discussions of alternative frameworks during the November 2013 IFS-TT Riverine Modeling meeting. AEA considered this approach to be the "most efficient and flexible approach for Project decision making" (ISR 8.5 Part C Section 7.8.1.1.1). As conceived, the matrix approach might allow users to compare existing conditions against alternative future operating scenarios based on multiple evaluation metrics (e.g., weighted usable area of fish habitat for different species and life stages, timing/intensity/duration of ice breakup, among others). AEA provided a conceptual example of a matrix containing a subset of evaluation metrics in Table 7.8-2 of the ISR 8.5 Part C.

5.9(b)(1) A description of the goals and objectives of this study proposal and the information the study will obtain.

The specific goals related to model integration and the DSS, as stated in the 2013 Final Study Plan (Section 8.5.1) are listed below. The USFWS believes that the tool(s) should not be limited to just aquatic habitat, but rather it should incorporate the numerous resource studies and the tools that need to be developed by a group of broader subject matter experts beyond the aquatic resource specialists for it to be meaningful and useful to decision makers and stakeholders.

We request that the new study goals include the following:

1. Integrate the numerous simulation models, data analyses, and other information generated by individual studies to predict various biological and other metrics under existing conditions, alternative design and construction plans, alternative operational scenarios, and Project Alternatives.

2. Develop a DSS to assist AEA, decision makers, and stakeholders with understanding the complexity and relationships between various processes and resources throughout the watershed, and to assist with comparative analyses of the impacts of alternative operational scenarios relative to existing conditions based on multiple evaluation metrics (see #1 above).

The USFWS requests that FERC issue an order to AEA for a New Study that we envision would have at least the following components:

- Create a new Technical Working Group of agencies, consultants, and stakeholders to:
  - analyze "top down" resource linkages and factors in designing an integrated model and DSS from the perspective of the potential users (analysts and stakeholders);
  - analyze "bottom up" resource linkages and factors in designing an integrated model and DSS from the perspective of the work that has already been done (research, literature reviews, field studies, modeling) to identify how the linkages could tie into the top down users.

- The Technical Working Group would be assigned the responsibility to design a study framework, schedule, and milestones for the detailed work by appropriate specialists to yield a work product of one or more integrating computer simulation models to support a Decision Support System that is credible, understandable, and accessible to decision makers and stakeholders to perform the types of analyses described in this Request.

- AEA would be assigned the task of reporting on the progress and results of the Technical Working Group, incorporating the products into the overall Study Plan, building the integrated model(s)/DSS, and ultimately making the models and DSS available for use by decision makers and the stakeholders.

5.9(b)(2) An explanation of the relevant resource management goals of the USFWS or Indian tribes with jurisdiction over the resource to be studied.

Native Alaskan families, tribes, and their corporations live, work, and have major land holdings in the immediate vicinity of the proposed Project and therefore will be directly affected by the proposed Project. These groups are major stakeholders in understanding the full depth and range of the environmental impacts of building, operating, and maintaining the proposed Project. Development of high quality model integration capability and resource-based DSS is needed to clearly and effectively present the science to the public and other stakeholders.

5.9(b)(3) USFWS is a resource agency and is not required to explain any relevant public interest considerations.

5.9(b)(4) A description of existing information concerning the subject of the study proposal, and the need for additional information.

Numerous models have been or are being built to simulate various aspects of the Susitna River watershed environment. Similarly, huge quantities of data, research results, and literature reviews have been generated by the 58 studies conducted as part of the ILP. This information has been reported elsewhere. The key consideration with respect to this New Study Request is that presently there is no systematic way for analysts to synthesize the analyses and there is no orderly way in which stakeholders can review the results, simulate alternatives (e.g., designs, construction techniques, operational plans, operating rules, etc.), and keep track of the complex interactions throughout the watershed.

5.9(b)(5) An explanation of the nexus between Project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements.

The USFWS believes that integration of the studies, literature research, data, and other work that has occurred (or will occur) and organizing that work into a valid and accessible DSS is vital for stakeholders to have realistic understanding of the full range of:

- Project Design alternatives;
- Project scheduling and construction alternatives, including having the information basis to assess the direct, indirect, and cumulative environmental impacts of all of the alternatives;
- Project operating plans and their alternatives including ongoing maintenance methods and alternatives, which includes having the information basis to assess the direct, indirect, and cumulative environmental impacts of all of the alternatives;
- Alternative standards and licensing requirements that FERC and other regulatory agencies might place on the construction, operation, and maintenance of the Project; and
- Alternatives to the Project.

5.9(b)(6) An explanation of how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge.

No hydroelectric project of comparable size, remote location, and complexity in a relatively un-studied watershed has been proposed, or studied in any comparable level of depth, for decades. That said, integrated watershed modeling and a corresponding DSS have become “standard” tools to evaluate proposed hydroelectric projects throughout the world. The degree of depth and sophistication of such model integration and DSS development varies with the size, complexity, and location of the project.

The examples of modeling and DSS tools that are currently available would require considerable adaptation and data input to reflect the specific conditions of the Susitna watershed and the particular features (and alternatives) for the proposed Project.

No fieldwork is envisioned for the proposed New Study. No new scientific work is expected beyond that which is required in any case for the individual studies to be robust at the level of scientific/statistical quality that is already expected of them.

The results of this study would greatly increase the ability of the relevant stakeholders, including Native Alaskans and tribes, to understand the proposed Project, its alternatives, and its impacts. For these reasons, we believe this New Study Request is critical at this time.

5.9(b)(7) A description of considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

The information needs have been described in previous sections of this New Study Request. USFWS believes that development of an integrating model and DSS early in the analysis process will be the most efficient path to develop these vital tools.

Conserving Salmon Habitat in the Mat-Su Basin

Executive Summary

The Strategic Action Plan of the Mat-Su Basin Salmon Habitat Partnership

2013 Update

Mat-Su salmon PARTNERSHIP

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Cover photos by Clark James Mishler (left), Jeremiah Millen (top), Katrina Mueller (bottom), and Corinne Smith (back).

I. Executive Summary

Chinook, Coho, sockeye, pink, and chum salmon all return in great numbers to the streams and lakes of the Matanuska-Susitna (Mat-Su) Basin each summer to spawn. The Susitna River run of Chinook salmon is the fourth largest in the state. Yet rapid growth and urbanization in the Mat-Su Basin is threatening the fish habitat necessary to sustain healthy salmon populations and ultimately the quality of life for residents. Across the Mat-Su Basin, residents value healthy fish and wildlife populations, open space, clean air and water, recreational opportunities, and a rural lifestyle. For many, salmon are an integral part of their heritage and culture, and fishing is a regular part of life and an important means of caring for their families. The current pace of population growth in the region, combined with the current regulatory framework, enforcement, and common development and recreation practices, have many people concerned that these life-quality values cannot be maintained. The greatest risk to habitat for salmon and other freshwater fish in the Mat-Su Basin may be many small actions that compound over time to degrade riparian habitat, block fish passage, and impact water quality, quantity and flow.

Mat-Su Basin Salmon Habitat Partnership

The Matanuska-Susitna Basin Salmon Habitat Partnership formed to address increasing impacts on salmon habitat from human use and development in the Mat-Su Basin with a collaborative, cooperative, and non-regulatory approach that would bring together diverse stakeholders. Rapid population growth and the accompanying pressures for development will increasingly challenge the ability of stakeholders to balance fish habitat conservation with these changes over time. Water quality, water quantity, and other fish habitat-related conditions are among some of the more important issues that will have to be addressed to maintain the fish habitat required to sustain fish productivity. *From the beginning, the Partnership has acted with the belief that thriving fish, healthy habitats, and vital communities can co-exist in the Mat-Su Basin.*

There has been a history of fish habitat conservation efforts in the Mat-Su Basin, including upgrading traditional culverts to improve fish passage and maintain natural stream processes, stream restoration, and stream bank stabilization. Many of these were cooperative efforts between government agencies and local organizations. In the fall of 2005, The Nature Conservancy (TNC), the Matanuska-Susitna Borough (MSB), Alaska Department of Fish and Game (ADF&G), and U.S. Fish and Wildlife Service (USFWS) formalized a broad-based public and private partnership. From the beginning, this diverse partnership has attracted local community groups; local, state, and federal agencies; businesses; non-profit organizations; Native Alaskans; and individual landowners. The Partnership has sought to include anyone concerned about conserving salmon in the Mat-Su Basin.

This focus on a bottom-up, locally driven, voluntary and non-regulatory effort was inspired by the approach outlined in the National Fish Habitat Action Plan[1]. The mission of the National Fish Habitat Partnership is to "protect, restore, and enhance the nation's fish and aquatic communities through partnerships that foster fish habitat conservation and improve the quality of life for the American people."

[1] www.fishhabitat.org

The Intent of this Strategic Action Plan

In 2007 the Mat-Su Salmon Partnership embarked on an 18-month-long process to develop a Strategic Action Plan. In the 2008 plan, the Partnership selected eight areas of conservation strategies to address plus three over-arching science strategies to increase our knowledge about the location and characteristics of salmon habitat in the Mat-Su: fish distribution and life-cycle use, water quantity, and water quality.

In the last five years, much has happened in the Mat-Su Basin. Population growth and the accompanying development have continued in the Knik-Wasilla-Palmer core area and along the Parks Highway. Industry interest in coal mining in the Matanuska Valley has returned, and the state is reconsidering a decades-old plan to dam the upper Susitna River for hydroelectric power. Invasive aquatic plants have found their way to southcentral Alaska. Scientists have learned more about predicting climate change and the impacts it will have to precipitation, temperatures, and other climatic attributes. By the summer of 2013, the State of Alaska had designated seven salmon populations as Stocks of Concern,[2] resulting in sportfishing closures and restrictions on commercial fishing in Cook Inlet.

The Mat-Su Salmon Partnership has also been busy in the last five years addressing the strategies of the 2008 Strategic Action Plan. Partners have replaced over 70 culverts that prevented adult and juvenile salmon from accessing key spawning and rearing habitat in Mat-Su streams. The state started a streambank restoration cooperative program that has helped restore riparian areas on private and public lands. Over 5000 acres of wetlands, riparian areas, and uplands important for salmon habitat have been protected through conservation easements, transfer to state conservation units, and wetland preservation banks. In the core area, wetlands have been mapped and characterized more accurately, the borough has a Wetlands Management Plan, and the Corps is working with partners to develop a functional assessment of wetlands. Throughout the borough, a higher resolution and more recent map of impervious surfaces has been created, and the borough is working on a Stormwater Management Plan.

One thing that hasn't changed since 2008 is the purpose of this strategic action plan. The Partnership Steering Committee developed the Strategic Action Plan to identify Partnership long-term goals and strategies and to provide a tool the Partnership can use to prioritize projects related to fish habitat goals in the Mat-Su Basin. The intent of this Strategic Action Plan is to identify long-term goals, strategies, and voluntary actions that the Partnership and others can undertake to conserve salmon habitat. The Steering Committee planned to revisit the original Strategic Action Plan every 3 to 5 years, and this edition is that first update to address changes in the Mat-Su Basin that could significantly affect the situation for salmon habitat.

The Partnership developed this Strategic Action Plan to identify collaborative projects and other actions that will protect and restore important habitat for wild salmon in the Mat-Su Basin. The Steering Committee initiated the plan under the guidance of the NFHP and administered the planning process. The NFHP clearly identifies fish habitat as the focus for partnerships. The Steering Committee decided that the planning process would focus exclusively on habitat-related issues to remain consistent with the intent of the NFHP and the Mat-Su Salmon Partnership. The

[2] Note that as this updated 2013 plan 'went to press,' the Alaska Board of Fisheries listed the Sheep Creek population of Chinook as a Stock of Concern.

plan scope includes not only freshwater fish habitat in the Mat-Su Basin, but nearshore, estuarine, and marine habitat in Upper Cook Inlet as well (Figure 1).

The Steering Committee identified three specific purposes for the plan:

1. Identify important habitats for salmon and other fish species in the Mat-Su Basin.
2. Prioritize fish habitat conservation actions, including protection, enhancement, and restoration of key habitat, education and outreach, research, and mitigation.
3. Identify potential collaborations and funding sources for partners to address fish habitat conservation.

The future of Mat-Su salmon depends upon what happens to them during each life stage, from their incubation and rearing in freshwater, to their maturation in saltwater, and during their return back to freshwater to spawn. While debate continues about the reasons for decline of some salmon stocks across Alaska and in the Mat-Su, it is well-known that freshwater habitat loss and fragmentation are some of the primary drivers in the decline of anadromous fish elsewhere in the U.S. and the world. The Partnership's goal is to ensure that Mat-Su salmon have healthy habitats in the Mat-Su and upper Cook Inlet so that habitat loss does not contribute to the other stresses that Mat-Su salmon must endure. In the Mat-Su, healthy salmon habitat exists throughout the basin, and our top priority is to protect and maintain that habitat wherever possible.

Overall Health of Mat-Su Basin Salmon and Habitat

In 2008, the assessment of the health of wild salmon and their habitat indicated that, *taken as a whole across the Mat-Su Basin*, salmon and most of their habitats were healthy and required minimal human intervention for long term survival. A more local look at individual attributes of health, however, pointed out concerns about long-term sustainability of Mat-Su Basin salmon and some of the habitats they require for survival. For salmon, that assessment suggested that numbers for some sockeye, pink, and chum salmon runs may have been below a sustainable level and that some stocks might be seriously degraded in time without conservation action. Data for Mat-Su salmon populations is limited so the status of many stocks, especially in the Matanuska River watershed, is based on anecdotal information, professional judgment, or is unknown.

Since 2008, it has become evident that some Susitna salmon are experiencing significant declines. That year, the Alaska Board of Fisheries listed Susitna sockeye salmon as a Stock of Concern. Chinook salmon in that drainage missed their escapement goals for six years, and the Alaska Board of Fisheries listed six populations as Stocks of Concern in 2011. Little Susitna Coho salmon have missed escapement goals for the past four years.

Not surprisingly, the health of Mat-Su Basin salmon habitat is linked to the level and location of human activity in the basin. The ecosystems that coincide with the more developed areas of the Mat-Su Basin may become seriously degraded without human intervention. Reduced health of these ecosystems is linked to alteration of native riparian vegetation, degraded water quality, and water flow changes, all of which have reached levels that may impair these ecosystems in the long-term. Within these areas, ADEC has identified over two dozen waterbodies that lack sufficient data to determine water quality and has designated four as Impaired. Some water pollution in these areas may be due to the replacement of more than 10% of native vegetation with impervious surfaces that concentrate stormwater runoff in surface waters.

Ecosystems coinciding with areas of little development have good overall health. Yet even these terrestrial ecosystems contain waterbodies that lack sufficient data, and ADEC has determined that insufficient information exists to assess how well Cook Inlet meets water quality standards. These are also largely the areas where the Stocks of Concern live out the freshwater portions of their life.

The current state of salmon and ecosystem health directs us to which species and ecosystems may require protection and prevention measures versus restoration to regain health. Preventative conservation measures in the undeveloped areas can ensure that these ecosystems remain healthy for salmon and other aquatic species. The more impacted terrestrial ecosystems of the developed areas will require not only protection against additional alteration and degradation but also mitigation and restoration actions to restore health.

Potential Threats to Salmon & Their Habitats

Many human activities pose potential threats to salmon and their habitats. Human activities can affect salmon by degrading or eliminating habitat; removing vegetation from wetlands and the banks of streams and lakes; degrading water quality; changing river flows; disconnecting flows between streams, lakes, and wetlands; or blocking fish passage. Lack of data to make management decisions can also be an impediment to conserving salmon and their habitats. Most of these activities are vital to human communities and can be mitigated to reduce or eliminate negative impacts to salmon and salmon habitat.

For the 2013 plan update, the scoping process confirmed that the seven potential threats in the 2008 plan were still important areas for the Partnership and recommended that four more potential threats be included in the Strategic Action Plan. An existing threat was expanded to include invasive aquatic plants along with northern pike. Climate change was included in this updated plan because more information exists and a clearer role for the Partnership emerged. Motorized off-road recreation has continued to negatively impact some salmon habitat in the Mat-Su, and some partners have been working with user groups to address the problem. Large-scale resource development includes diverse activities like hydropower and coal mining because the Partnership's roles around these potential threats – science and education – are anticipated to be similar. This plan outlines the potential impacts to salmon habitat from each threat and summarizes the current status or level of activity of the threat in the Mat-Su Basin.

Potential Threats to Mat-Su Basin Salmon
Aquatic Invasive Species
Climate Change
Development in Estuaries and Nearshore Habitats
Ground & Surface Water Withdrawals
Household On-site Septic Systems & Wastewater
Large-scale Resource Development
Motorized Off-road Recreation
Residential, Commercial, & Industrial Development
Roads & Railroads
Stormwater Runoff

Conservation Strategies

The Mat-Su Salmon Partnership's broad goals are to protect salmon and their habitats in the Mat-Su Basin and Upper Cook Inlet, mitigate threats to salmon and their habitats, restore connectivity between salmon habitats, and increase knowledge about salmon and their use of freshwater and marine habitats. The strategies for the Mat-Su Basin echo those that the National Fish Habitat Partnership uses to guide work at the national and partnership level.

A situation analysis for each threat brought into focus the more discrete issues upon which the Partnership can act and identified 11 conservation strategies to conserve salmon in the Mat-Su Basin. These strategies address the sources of the impacts and the impacts themselves. Some impacts have multiple sources that can be addressed collectively. Other potential threats have unique situations that lend themselves to being addressed specifically. For that reason, the conservation strategies are organized around a mix of impacts and threats.

Conservation Strategies	
1	Overarching Science Strategies
2	Alteration of Riparian Areas
3	Climate Change
4	Culverts that Block Fish Passage
5	Filling of Wetlands
6	Impervious Surfaces & Stormwater Pollution
7	Aquatic Invasive Species
8	Large-scale Resource Development
9	Loss or Alteration of Water Flow or Volume
10	Loss of Estuaries & Nearshore Habitats
11	Motorized Off-road Recreation
12	Wastewater Management

Conservation strategies are composed of objectives, which define a vision of success, and strategic actions that will achieve the objectives. The Partnership's strategies fall into four broad categories: protection, restoration, education, and science. In many places in the Mat-Su Basin, salmon and their habitats are healthy so protective measures, like reservations of water, land use planning, and voluntary land protection, can prevent degradation. In other places, restoration is necessary to re-establish fish passage and productive habitat. Public education, including best management practices, can prevent and mitigate impacts from human activities and help the general public connect their own individual actions to impacts on salmon habitat and water quality. Better understanding of salmon's needs throughout the Mat-Su Basin and Cook Inlet would improve management of salmon habitat and implementation of the recommendations in this plan. Three science strategies are highlighted because the information they will gather will inform multiple conservation strategies.

The Partnership's conservation strategies encourage collaboration among multiple partners to achieve common objectives that would be difficult for any one partner to accomplish alone. In some cases, comprehensive protection can be accomplished with revisions to local and state laws and increased enforcement of such laws; some strategies recommend such changes but in no way bind affected agencies to implement these strategies. What follows are objectives and strategic actions that the Partnership thinks it can accomplish in the next 10 to 20 years.

1. Overarching Science Strategies

Objective 1.1: Anadromous Waters Catalog

By 2020, ensure that all anadromous fish habitat in the Mat-Su Basin is included in the Anadromous Waters Catalog and thus given basic protections afforded under state law. Efforts to catalog anadromous fish should identify life stage information and document non-anadromous fish.

Objective 1.2: Habitat Quality

By 2020, characteristics of habitats that are critical for salmon at each life stage (spawning, rearing, and overwintering) will be identified and used to develop critical habitat definitions to identify places that provide these habitats.

Objective 1.3: Comprehensive Surface and Groundwater Studies

By 2018, an increased understanding of surface and groundwater exchange, including locations, quantities, flows, and variability in the Mat-Su Basin, will be sufficient to aid in identifying critical salmon habitat for each life stage.

Objective 1.4: Water Quality Monitoring

By 2018, a comprehensive baseline and monitoring program for water quality exists to track and manage changes in Mat-Su Basin waterbodies.

2. Alteration of Riparian Areas

Objective 2.1: Identification of Priority Riparian Areas for Salmon

By 2018, 50% of salmon riparian areas will be field surveyed, mapped and prioritized for long-term legal protection and/or restoration.

Objective 2.2: Protection of Priority Salmon Riparian Habitat

By 2018, secure long-term protective status (e.g., conservation easements, designated parks, land acquisition) of at least 10% of priority riparian habitats that have not been significantly altered.

Objective 2.3: Restoration of Priority Riparian Habitat

By 2018, 5% of priority riparian habitats that have been altered are restored.

3. Climate Change

Objective 3.1: Comprehensive Baseline and Monitoring for Stream Temperatures

By 2015, comprehensive baseline and monitoring program for stream temperatures exists to track and manage changes in priority Mat-Su Basin waterbodies and impacts on salmon and salmon habitat.

Objective 3.2: Integrate Climate Change into Priorities
By 2015, integrate climate change into habitat conservation strategies and prioritizations.

4. Culverts that Block Fish Passage

Objective 4.1: No New Barriers
By 2015, effective fish passage is maintained at new road crossings through improved coordination between agencies, sufficient resources for applying current state statutes, and use of improved design and construction practices for effective fish passage.

Objective 4.2: Fish Passage Restoration
By 2015, fish passage will be restored in 65 priority culverts that currently block passage of juvenile or adult fish.

5. Filling of Wetlands

Objective 5.1 Identify, Map and Assess Functions of Wetlands for Salmon
By 2018, wetlands that are important for salmon will be identified, mapped and assessed for their functional importance for salmon.

Objective 5.2: Conserve Wetlands for Salmon
By 2020, loss of wetlands that are important for salmon either as spawning or rearing habitat, re-charge of streams, or filtration of streams, will be avoided, minimized, or mitigated with protection, management, and enhancement.

6. Impervious Surfaces and Stormwater Pollution

Objective 6.1: Minimization of Impacts on Water Quality
By 2018, new housing and urban development sites will not result in stormwater runoff that alters the quantity or quality of water in streams and lakes. All water flowing into salmon habitat will equal or exceed the quality necessary to protect the growth and propagation of fish as determined by state water quality standards for aquatic life.

Objective 6.2: Minimize Road Runoff
By 2018, the extent and potential of road runoff as a contributor to water quality issues at salmon streams will be known and Best Management Practices developed to minimize impacts.

Objective 6.3: Imperviousness Impact Assessment
By 2018, understand the magnitude of impact of impervious surfaces and stormwater runoff in the most developed watersheds.

7. Aquatic Invasive Species

Objective7.1: Prevention

By 2016, identify potential vectors for introducing or spreading Aquatic Invasive Species (AIS) in the Mat-Su and conduct outreach to inform and influence target audiences so that their activities do not introduce or spread AIS.

Objective 7.2: Early Detection and Surveillance

By 2015, periodic surveillance surveys designed to have a high likelihood of detecting AIS at an incipient stage of infestation will be completed at priority waterbodies. Priorities are determined based on level of risk for introduction of AIS.

Objective 7.3: Rapid Response

By 2015, procedures are in place to respond rapidly to any newly discovered introductions or to newly detected expansion of existing AIS.

Objective 7.4: Control

By 2015, an effective program of integrated pest management for invasive species is developed and implemented, including elements of containment, eradication, control, and restoration.

8. Large-scale Resource Development

Objective 8.1 Education and Outreach about Large-scale Resource Projects

By 2017, the public will have access to information about proposed large-scale resource development projects and their potential to affect salmon and their habitats.

Objective 8.2: Agency Assistance for Large-scale Resource Projects

By 2017, state and federal agencies and stakeholders involved in permitting processes for large-scale resource development projects have the data, analytical tools, and expertise that they need to understand the potential to affect salmon and their habitat.

Objective 8.3: Address Data Gaps

By 2017, data gaps for large-scale resource development projects will be identified and filled as feasible for the licensing and permitting processes.

9. Loss or Alteration of Water Flow or Volume

Objective 9.1: Instream Flow on Anadromous Waters

By 2020, partner organizations have filed applications for reservations of water with ADNR to preserve the flow regimes of priority anadromous lakes and streams.

Objective 9.2: Community Water Needs Study

By 2020, current and future use and need of ground and surface water by Mat-Su Basin communities are quantified in order to assess impacts to water quantity.

10. Loss of Estuaries and Nearshore Habitats

Objective 10.1: Salmon Ecology of Cook Inlet
By 2018, implement the Knik Arm Salmon Ecology Integrated Research Plan (HDR, 2010) to significantly improve the understanding of salmon ecology in Knik Arm.

Objective 10.2: Conserve Estuaries for Salmon
By 2018, assure no long-term impairments of vulnerable coastal habitats from incompatible shoreline developments.

11. Motorized Off-road Recreation

Objective 11.1: Impacts to Salmon and Salmon Habitat
By 2018, qualify the impacts to salmon and salmon habitat from off-highway vehicles (OHV) use regarding stream morphology and water quality to specifically determine physical damage to the stream and banks and hydrocarbon and sedimentation inputs to streams.

Objective 11.2: Mitigate OHV Use at Streams
By 2018, establish effective and publicly acceptable mechanisms to support stream health near OHV trails and at stream crossings.

12. Wastewater Management

Objective 12.1: Improved Wastewater Disposal
By 2018, septic systems are designed and constructed based on parcel size, number of parcels in a subdivision, and soil suitability, with an emphasis on developing community systems and connecting to public systems, so that septic systems do not contribute to degraded water quality.

Objective 12.2: Expanded Wastewater Infrastructure
By 2018, Mat-Su Borough and its communities have a wastewater infrastructure and treatment facilities that can handle sewage discharges in the Mat-Su Borough.

Objective 12.3 Wastewater Pollution Prevention
By 2018, quantify the extent and sources of possible wastewater pollution to surface and ground waters from on-site septic systems and wastewater discharge.

The Future for the Mat-Su Salmon Partnership

The Mat-Su Salmon Partnership developed its first Strategic Action Plan in 2008 and updated the plan in 2013 in an effort to help partners set priorities for collaborative actions to conserve habitat for wild salmon that spawn, rear, or over-winter in the Mat-Su Basin. Relevant actions that could be guided by this plan include regulatory development; permitting; protection, restoration, and mitigation activities; assessment and research projects; and education and outreach activities.

This Strategic Action Plan sets out priorities for this Partnership to conserve wild salmon and their habitat in the Mat-Su Basin. Achievement of these goals and objectives will depend upon commitment by partner organizations and collaboration between partners. The history of salmon in other parts of the world indicates that wild salmon cannot persist in their full abundance unless stakeholders work together to protect salmon habitat. Within this Partnership, each partner has unique capabilities, responsibilities, and resources that can address a key component for salmon habitat. Only in working together, can all the key components for salmon habitat be protected to ensure healthy, abundant salmon runs in the Mat-Su Basin into the future.

The Scope of the Strategic Plan: Mat-Su Basin and Upper Cook Inlet

Thriving fish, healthy habitats, and vital communities in the Mat-Su Basin

Mat-Su Basin Salmon Habitat Partnership

2013