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SUSITNA-WATANA HYDRO

Susitna-Watana Hydroelectric Project
Railbelt Large Hydro

Aquatic Resources Data Gap Analysis

Draft

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Executive Summary

This document examines existing information describing the aquatic resources of the current Susitna-Watana Hydroelectric Project (Project). The Project area is located approximately halfway between Anchorage and Fairbanks in the upper Susitna River basin (see Figure 3.1), as proposed by the Alaska Energy Authority (AEA). It would create a single dam on the Susitna River at River Mile 184 in the vicinity of Watana canyon.

A Susitna River two-dam hydroelectric project was first proposed in 1976 by the U.S. Army Corps of Engineers. The concept was adopted and managed in the 1980s by the Alaska Power Authority (APA), and comprehensive environmental studies were conducted to support Federal Energy Regulatory Authority (FERC) licensing efforts. The project was cancelled in 1986 due to declining oil revenues.

The 2010 Alaska Railbelt Regional Integrated Resource Plan (RIRP), a 50-year, long-range power generation and transmission plan of capital improvement projects, documented the need for a large amount of new power generation to support the railbelt region over the next 10–15 years. The same year, the Alaska Legislature passed House Bill 306, directing the State to receive 50 percent of its electrical generation from renewable and alternative energy by 2025. Constructing a hydroelectric project in the railbelt region is the only feasible way to achieve this goal. The RIRP identified the Watana canyon site as the preferred site for such a project.

This analysis evaluates available information for its relevance and applicability to the licensing of the Project. Study reports developed as part of the original Susitna Project licensing effort, along with more recent reports were reviewed. The authors used professional judgement to make this assessment, recognizing that this is a first effort beginning a long interactive public and agency process. Identified topic areas are listed as potential data gaps and these will likely be refined, modified, and developed as the study planning process evolves. Information gaps that are ultimately determined to be worthy of future study will be determined based on analysis of project issues and the needs of the regulatory process. This document identifies potential data gap topics for the following aquatic resources of the Susitna River:

- Adult salmon
- Resident and rearing fish
- Macroinvertebrates and periphyton
- Water quality
- Hydrology, ice, sediment, geomorphology, and climate
- Instream flow
- Marine mammals

A summary of the potential data gap topics and specific information needs are presented in Table ES.1.

Table ES.1 Summary of potential aquatic resources data gaps for the Susitna-Watana Hydroelectric Project

Potential Data Gap Topics	Specific Information Needed
ADULT SALMON	
AS-1: Synthesis of existing information for adult salmon	• Synthesis of historic/contemporary info on populations and habitats in watershed • Geodatabase with historic data plus historic/current aerial imagery
AS-2: Habitat change analysis	• 1980s and current digitized/orthorectified imagery of the middle and lower portions of the lower Susitna • Current LIDAR data of lower and middle Susitna • 1980s stream channel habitat classification/delineations • Comparison of habitat types based on historic and current aerial imagery • Geodatabase of current spawning distribution and habitat utilization • If possible, present channel geometry for 1980s APA Project study sites • Acoustic bathymetry data for main channel habitats • Available quantity of habitat/habitat response to flow changes under proposed project configuration
AS-3: Sockeye salmon spawning distribution and habitat utilization	• Locations of sockeye salmon spawning in main-stem, side sloughs, and side channels of the middle and lower portions of lower Susitna determined to be most sensitive to likely project effects • GIS layers from ADF&G radio telemetry studies (2006, 2007, 2008) • Evaluation of 2006, 2007, 2008 radio telemetry results in context of 1980s APA habitat utilization findings
AS-4: Chinook salmon abundance and distribution in the upper Susitna reach	• Abundance and spawning distribution of adult Chinook above Devil Canyon
AS-5: Chinook salmon spawning distribution and habitat utilization in the middle and lower Susitna reaches	• Spawning locations and habitat utilization in the middle river main stem, side sloughs, and side channels and portions of the lower river where determined to be highly or moderately sensitive to likely project effects • Investigation of main channel spawning in middle and portions of the lower Susitna reaches
AS-6: Coho salmon spawning distribution and habitat utilization	• Spawning locations and habitat utilization in mainstem, side sloughs, and side channels of Susitna • GIS layers from ADF&G radio telemetry studies (2008, 2009, 2010) • Evaluation of 2008, 2009, 2010 radio telemetry results in context of 1980s APA studies habitat utilization findings
AS-7: Chum salmon spawning distribution and habitat utilization	• Spawning locations and habitat utilization in middle and portions of the lower river main stem, side sloughs, and side channels where determined to be highly or moderately sensitive to likely project effects • GIS layers from ADF&G radio telemetry studies (2008, 2009, 2010) • Evaluation of 2008, 2009, 2010 radio telemetry results in context of 1980s APA studies habitat utilization findings
AS-8: Pink salmon spawning distribution and habitat utilization	• Absence or presence of spawning locations and habitat utilization in middle river and portions of the lower river main stem, side sloughs, and side channels where determined to be highly or moderately sensitive to likely project effects
AS-9: Genetic baselines for middle Susitna Chinook salmon	• Inventory of Chinook spawning stocks in current collections of ADF&G and USFWS conservation genetics laboratories • Identification of relevant unanalyzed collections and previously unsampled Susitna Chinook spawning populations in the middle reach of the Susitna • Analysis of existing genetic markers and identification of need for new markers to provide resolution needed for resolution of Susitna sub-stock structure

Potential Data Gap Topics	Specific Information Needed
RESIDENT AND REARING FISH	
RR-1: Resident and rearing fish within the proposed impoundment zone	• Populations of adult Arctic grayling and Dolly Varden in selected tributaries within proposed impoundment zone • Spawning migration timing of Arctic grayling using proposed impoundment zone • Relative abundance/distribution of Dolly Varden, lake trout, and juvenile Chinook in impoundment zone • Physical parameters (water temperatures, velocity, substrate size) of round whitefish, longnose sucker, and burbot habitats in impoundment zone
RR-2: Resident and rearing fish along the access and transmission corridor	• Identification, presence, and/or absence of resident and juvenile anadromous fish species, distribution, life states, habitat characteristics, and abundance • Inventory of physical habitat characteristics, fish use, and sensitive habitats at corridor stream crossing sites • Summary of fish species presence, distribution, life stages, habitat characteristics, and abundance within subject water body
RR-3: Resident fish movement within the middle Susitna River	• Information on migration timing and movements of resident species in the middle Susitna.
RR-4: Eulachon synthesis document	• Synthesis of existing information on Susitna eulachon
RR-5: Northern pike	• Improved information on distribution, age composition,movements Relative abundance • Habitat requirements for overwintering, spawning, and rearing
RR-6: Middle river young-of-the-year sockeye from outmigration and rearing	• Rearing locations in lower Susitna • Determination of whether sockeye rearing in lower Susitna originate in middle or lower river • Outmigration age/destination of young-of-the-year sockeye from middle Susitna
RR-7: Juvenile Pacific salmon density estimates in mainstem and tributaries of Susitna River	• Density estimates for all species of juvenile salmonids in the mainstem of the middle and portions of the lower Susitna River where determined to be highly or moderately sensitive to likely project effects relative to tributary streams
RR-8: Peak outmigration timing for Pacific salmon	• Determination of whether outmigration timing of juvenile Pacific salmon has changed since 1980s
RR-9: Ambient water quality parameters, substrate size, and water velocity of active redds	• Ambient water quality, substrate size, temperature, and velocity data from salmon redds (all species) incubating in the middle and relevant areas of the lower Susitna River in conjunction with habitat suitability studies conducted for instream flow study
RR-10: Environmental requirements of rearing juvenile coho salmon in the Susitna River	• Better understanding of the types of habitat in the Susitna used by juvenile coho • Better understanding of the relationship between habitat and various abiotic (e.g., velocity, undercut bank, substrate size, and water quality) and biotic (e.g., macroinvertebrate assemblages) factors
RR-11: Resident and rearing fish habitat requirements in middle and lower Susitna River	• Habitat use by species, life stage, and season in the areas of the Susitna River determined to be highly sensitive to likely project effects; characterization of Bering cisco, Dolly Varden, Arctic lamprey, and longnose sucker spawning and rearing timing and locations; Bering cisco outmigration timing; Dolly Varden, Arctic lamprey, and longnose sucker overwintering locations • Biotic (e.g., macroinvertebrate assemblages) and abiotic (e.g., velocity, water temperature, and turbidity) factors associated with habitats indentified • Arctic grayling and burbot spawning locations, and abiotic variables (e.g., velocity, water temperatures, upwelling zones, and substrate sizes) at those locations • Round whitefish and humpback whitefish spawning, rearing, and overwintering locations, and abiotic variables (e.g., turbidity, substrate size, velocity, and water temperature) at those locations

Potential Data Gap Topics	Specific Information Needed
RR-12: Data rescue needs for resident and rearing fish	• Yearly sampling locations • Fish distribution • Fish relative abundance at each sampling location • Life stage information for each species at each location • Water quality and hydrologic data for each location • Spawning habitat (i.e., spawning, rearing, or overwinter) locations for each species
MACROINVERTEBRATES AND PERIPHYTON	
MP-1: Update baseline macroinvertebrate datasets	• Benthic macroinvertebrate community composition among mainstream Susitna habitats including stream margins and undercut banks, woody debris and debris dams, mid-channel, side-channel, sloughs; and brown water and clear-water tributary streams • Macroinvertebrate drift in mainstem near streambanks and mid-channel, and invertebrate drift in side channels, and near the mouths of clear-water and brown water tributary streams along with stream discharge
MP-2: Updated baseline information on primary productivity, transported, and benthic organic matter	• Algal samples collected and analyzed for chlorophyll-a and ash-free-dry-mass concentrations
WATER QUALITY	
WQ-1: Update baseline for turbidity, TSS, TDS, pH dissolved oxygen, temperature, metals, nutrients, organics, bacteria, and other parameters	• Ambient conditions (temperature, pH, DO, specific conductivity) in side channel and slough areas that may provide overwintering habitat or otherwise support aquatic life through critical time periods with groundwater upwelling • Full suite of water quality parameters, including ambient, fecal coliform, metals, major ions, alkalinity, nutrients, and organics in the mainstem and side channel areas upstream of the dam site based on Eklutna Lake simulations • Repeat of water quality monitoring study performed by USGS and R&M at key locations co-located with instream flow studies in mainchannel, side channel, and slough habitat • Data of such frequency and spatial distribution to adequately assess baseline for TSS and temperature
WQ-2: Temperature, TSS, and dissolved gas model for middle and lower Susitna River	• A hydrologic model that can incorporate likely Project operational flow regimes and predict downstream effects of temperature, TSS, and dissolved gas at various downstream control points
HYDROLOGY, ICE, SEDIMENT, GEOMORPHOLOGY, AND CLIMATE	
HG-1: Streamflow synthesis (USGS)	• Statistically derived flow record (incl. mean daily, mean monthly, mean annual, and flow peaks) for 1949-2011 for gages other than Gold Creek and Talkeetna
HG-2: Middle and lower river ice studies	• Additional middle and lower river baseline data where relevant • Middle river ice studies focused on relative timing and contribution of frazil production upstream and downstream of Watana • Increased understanding of relationship between ice processes and slough and side-channel formation on lower river to the extent releveant to anticipated project effects • Additional observations of ice cover formation on lower river • Understanding of relative contribution of upper Susitna basin to snowmelt peak • Relationship between streamflow, climate, and breakup processes on middle and lower river
HG-3: Slough groundwater/ surface water studies	• Additional winter observations to determine relationship between ice processes and slough occurrence on lower river

Potential Data Gap Topics	Specific Information Needed
HG-4: Middle and lower river change analysis	• Updated representative change analysis for river between Devil Canyon and Cook Inlet with current aerial imagery, focusing on unstable reaches and middle river slough reaches • Cross-section measurements to verify degradation process in middle river during last 30 years • Analysis to identify sloughs or side channels that have been created or disappeared since original mapping
HG-5: Chulitna confluence and lower river sediment transport and aggradation study	• Updated estimates and measurements of sediment transport during summer high flows at Chulitna, Talkeetna, and Susitna Rivers • Evaluation of existing sediment transport and storage regimes in reaches downstream of Sunshine Station
HG-6: Large woody debris recruitment and transport	• Information regarding sources of LWD, locations of LWD in river channel where appropriate, and relationship of LWD to channel or slough habitat
HG-7: Climate change and variability	• Synthesis of long-term streamflow records from HG-1
HG-8: Glacial contribution to streamflow in the Susitna Basin	• Updated estimate of glacial meltwater contribution to streamflow in Susitna River, as well as trend of glacially derived streamflow for next century
HG-9: Hydrology and geomorphology data rescue	• Obtain aerial imagery for various reaches of river since 1982 • Digitized linework depicting channel banks and islands
INSTREAM FLOW	
IF-1: Instream flow study	• Instream flow in lower river below Talkeetna to the extend determined to be important and upper river above Devil Canyon • Instream flow needs for key species and life stages identified through the licensing process • Current abundance, distribution, and evaluation process of species in project area • Assessment of adequacy of habitat suitability criteria use in 1980s APA Project instream flow study for chum spawning and Chinook juvenile for applicability to Watana project • Analysis of suitability of 1980s study sites for re-use in future study • Determination whether assumptions about sensitivity of different habitat types to flow changes are adequate, and whether subsequent prioritization of habitat types remain applicable to current project • Impacts of CIBW Endangered listing and designation of Critical Habitat in lower Susitna on prioritization of species • Determination whether differences between data collected with 1980s technology and with current technology are significant enough to warrant additional study • Comparison of 1980s APA Project and Watana Project configurations for stream flow impacts • Understanding of current stakeholder interests and concerns

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Acronyms and Abbreviations

AAC	Alaska Administrative Code
ADFSC	Alaska Fisheries Science Center
ADF&G	Alaska Department of Fish and Game
AEA	Alaska Energy Authority
APA	Alaska Power Authority
AWC	Anadromous Waters Catalog
BOF	(Alaska) Board of Fish
C	Celsius
cfs	Cubic feet per second
CIAA	Cook Inlet Aquaculture Association
CIBW	Cook Inlet beluga whales
Corps	U.S. Army Corps of Engineers
DEIS	Draft Environmental Impact Statement
DIDSON	Dual Frequency Identification Sonar
DO	Dissolved oxygen
DPS	Distinct population segment
ENRI	Environmental and Natural Resource Institute
ENSO	El Niño Southern Oscillation
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FR	Federal Register
ft/sec	Feet per second
GSI	Genetic Stock Identification
GWh	Gigawatt hours
HB	House Bill
HSC	Habitat suitability criteria
ICRC	Integrated Concepts & Research Corporation
IFIM	Instream Flow Incremental Methodology
IFRR	Instream Flow Relationships Reports
LWD	Large woody debris
MMPA	Marine Mammal Protection Act
MW	Megawatts
µohm/cm	Micro-ohms per centimeter
mg/L	Milligrams per liter
mg/m^3	Milligrams per cubic meter
mm	Millimeters
NCI	Northern Cook Inlet
NMFS	National Marine Fisheries Service

NTU	Nephelometric turbidity unit
PCE	Primary constituent element
PDO	Pacific Decadal Oscillation
PDD	Preliminary decision document
PHABSIM	Physical Habitat Simulation
PIT	Passive integrated transponder
POA	Port of Anchorage
RIRP	Regional Integrated Resource Plan
RM	River mile
SANPCC	Southcentral Alaska Northern Pike Control Committee
TDS	Total dissolved solids
TEK	Traditional ecological knowledge
TSS	Total suspended solids
UAF	University of Alaska, Fairbanks
UCI	Upper Cook Inlet
USAF	U.S. Air Force
USGS	U.S. Geological Survey
WASSIP	Western Alaska Salmon Stock Identification Project

1 Introduction

This report documents efforts to examine existing information describing the aquatic resources of the Susitna-Watana Hydroelectric Project (Project) area, located in the upper Susitna River basin, as proposed by the Alaska Energy Authority (AEA). Potential "gaps" in the existing data are identified that help inform the National Environmental Policy Act (NEPA) scoping and study planning activities conducted as part of the Federal Energy Regulatory Commission (FERC) licensing process for the proposed Project. The purpose of this data gap analysis is to evaluate available information for its relevance and applicability to the proposed Project. Actual information needs will be determined when a more refined description of Project facilities, operations, and construction activities is developed. The data reviewed for this analysis are contained in selected documents developed as part of the original Susitna Project licensing effort in the early 1980s, along with more recent, readily available reports. The documents reviewed are listed in the References, Section 11. This document identifies potential data gap topics for the following aquatic resources of the Susitna River:

- Adult salmon
- Resident and rearing fish
- Macroinvertebrates and periphyton
- Water quality
- Hydrology, ice, sediment, geomorphology, and climate
- Instream flow
- Marine mammals

2 Project History

The Susitna River was identified as a potential large hydropower site in the 1940s by the Bureau of Reclamation. In a 1976 report to Congress, the U.S. Army Corps of Engineers (Corps) proposed a two-dam scheme capable of producing 7,300 Gigawatt hours (GWh) of hydropower (Harza-Ebasco 1987). This concept was adopted by the Alaska Power Authority (APA), which began managing the project in 1980, and contracted with Acres America to review economic and environmental feasibility and file a FERC license application. Later, Harza-Ebasco was contracted to update the license application and perform final design. The 1980s APA Project consisted of two dams: the first located in Watana canyon at approximately river mile (RM) 184 and a second located at Devils Canyon (referred to as the Devil Canyon site in most earlier studies) (RM 152). The 1980s APA Project effort culminated in the development of a license application filed with FERC in 1983, and an amended license application prepared in 1985. The project was cancelled in early 1986 in the face of declining oil revenues. In support of the 1983 and 1985 FERC license applications, the APA conducted comprehensive baseline environmental studies throughout the basin, with the most extensive aquatic efforts focused on the middle Susitna upstream of Talkeetna. A library of more than 3,500 reference documents was cataloged at the conclusion of the project (Harza-Ebasco 1987).

The current Susitna-Watana Hydroelectric Project being evaluated by the AEA is located approximately halfway between Anchorage and Fairbanks in the upper Susitna basin. It would create a single dam on the Susitna River at RM 184 in the vicinity of Watana canyon. The approximately 700-foot-high dam would have an approximate 557-foot difference between tail water and maximum pond elevation, with a maximum pond approximately at the 2,014-foot elevation (AEA 2010). Watana Reservoir would be 39 miles long and a maximum of 2 miles wide. The dam's installed capacity would be around 600 megawatts (MW), with the average annual generation estimated to be 2,600 GWh (AEA 2010). The AEA is currently studying design considerations in order to formulate a decision regarding the type of dam or powerhouse (underground or surface) that would be used or the actual final maximum reservoir level. At this time the actual operation characteristics of the project are not known, but the current concept is that the project would provide peaking operations using the reservoir storage to meet daily instream flow and power needs.

3 Data Gap Analysis

The licensing effort of the 1980s APA Project generated a substantial body of literature, some of which might be used to support future licensing. To evaluate potential impacts and protect wildlife and their habitats, the 1980s study effort sought to describe baseline conditions at a level of reliability necessary to detect and explain possible future changes caused by the proposed hydroelectric development as it was configured at that time (ADF&G 1985a). Additional reports related to resources in the vicinity of the proposed Project have been published since the mid-1980s.

3.1 Approach

Key licensing effort summary documents were reviewed from the first half of the 1980s, such as the 1985 amended draft license application (Harza-Ebasco 1985a, 1985b, 1985c, and 1985d), Draft Environmental Impact Statement (DEIS; FERC 1984a and 1984b)), and 1985 Plan of Study (Harza-Ebasco 1984a).

In 1985, just prior to 1980s APA Project cancellation, an aquatic plan of study was developed by APA for fiscal year 1985 (Harza-Ebasco 1984a). This plan identified remaining information needs to resolve issues raised by resource agencies regarding effects on the aquatic resources. These recommendations were used as a starting point review of available and relevant literature pertaining to the currently proposed Susitna-Watana Hydroelectric Project.

Additionally, resource-specific summary documents from the 1980s APA Project were reviewed, including information from the Susitna Hydroelectric Aquatic Studies Program. Contemporary literature sources were uncovered through library searches, online searches of agency publications, and personal contacts with biologists and aquatic scientests working in the Susitna watershed.

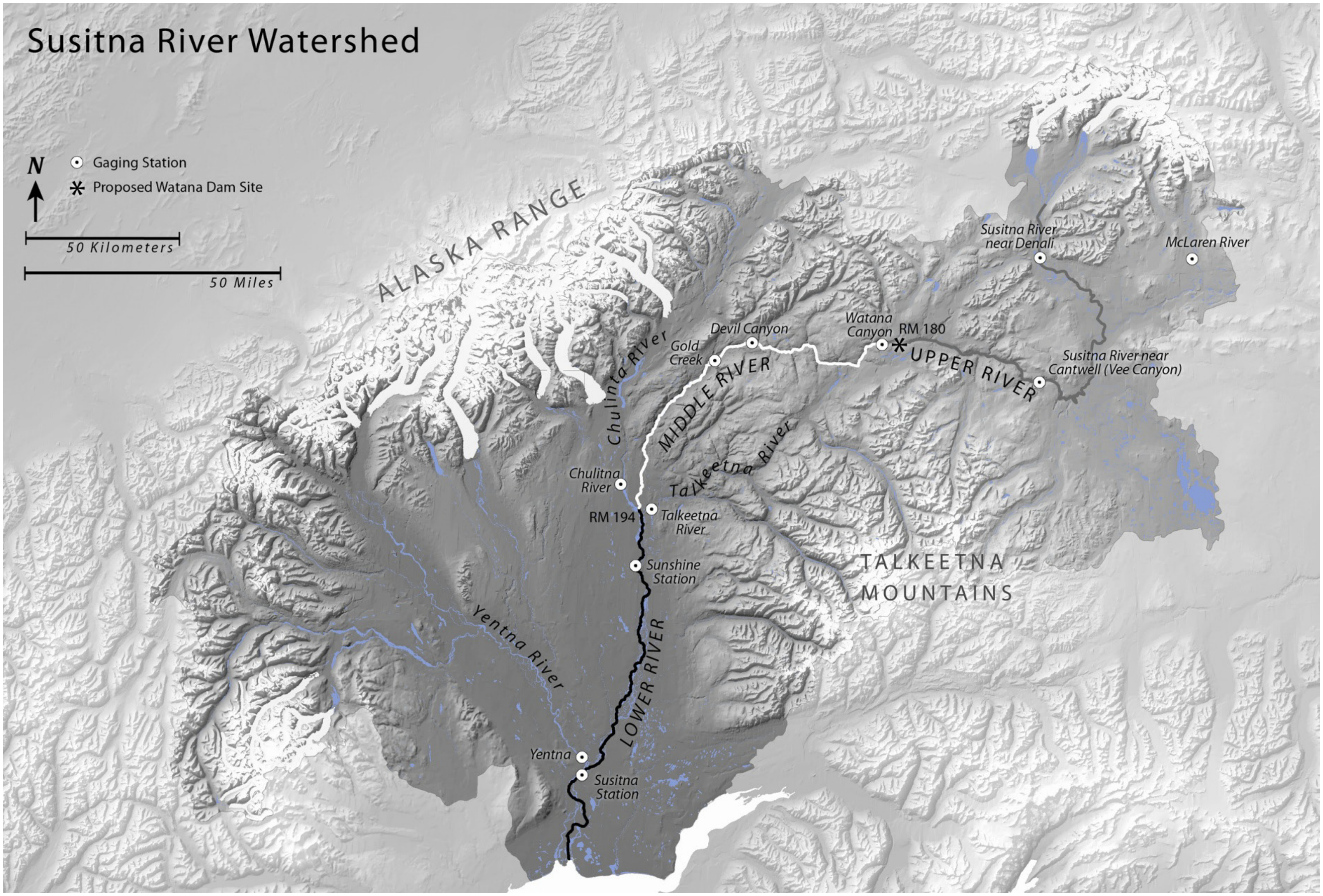
Information was considered in terms of relevance to current FERC licensing requirements for environmental analysis of the proposed project, completeness, and the applicability of methods used. Other sources of information included contact with agency project leaders and database searches.

The authors used professional judgement to make this assessment, recognizing that this is a first effort beginning a long interactive public and agency process. Identified topic areas are listed as potential data gaps and these will likely be refined, modified, and developed as the study planning process evolves. Information gaps that are ultimately determined to be worthy of future study will be determined based on analysis of project issues and the needs of the regulatory process.

3.2 General Description of River Basin

The Susitna River is approximately 320 miles long, drains an area of approximately 19,600 square miles, and empties into Cook Inlet (Figure 3.1). Its northern and western headwaters are in the Alaska Range, and its eastern headwaters are in the Talkeetna Mountains. Freeze-up begins in the upper reaches in October, and breakup usually occurs in late April or early May. The following naming convention for major Susitna River reaches was used in the 1980s studies and is used in this document.

Figure 3.1 Susitna River watershed



3.2.1 Upper River

The "upper river" is defined as the reach above the proposed Watana Dam (located at approximately River Mile (RM) 180), including the upper Susitna and McLaren Rivers, which arise directly from large temperate glaciers of the Alaska Range. Their upper reaches traverse the wide valley south of the Alaska Range in broad, braided channels. Approximately 60 miles downstream, the Tyone River, draining the Lake Louise and Susitna Lake basins, and the Oshetna River, draining the northern Talkeetna Mountains, join the Susitna. The river then turns 90 degrees toward the west and enters Vee Canyon. Through the Vee and Watana Canyons, the river is mostly confined to a single channel characterized by a series of rapids.

3.2.2 Middle River

The "middle river" encompasses the 90-mile reach between the proposed Watana Dam site and the Chulitna River confluence, located at RM 94. The river flows from Watana Canyon into Devil Canyon, the narrowest and steepest reach on the Susitna River. In Devil Canyon, constriction creates extreme hydraulic conditions including deep plunge pools, drops, and high velocities. The Devil Canyon rapids form a partial barrier to the migration of anadromous fish; only a few adult Chinook salmon have been observed upstream of Devil Canyon. Downstream of Devil Canyon, the middle Susitna River widens but remains essentially a single channel with stable islands, occasional side channels, and sloughs.

3.2.3 Lower River

The "lower river" describes the approximate 94-mile reach between the Chulitna River confluence and Cook Inlet (RM 0). An abrupt change in channel form occurs where the Chulitna River joins the Susitna River near the town of Talkeetna. The Chulitna River drains a smaller area than the middle Susitna River at the confluence, but drains higher elevations (including Denali and Mount Foraker) and many more glaciers. The annual flow of the Chulitna River is approximately the same as the Susitna River at the confluence, though the Chulitna contributes much more sediment than the Susitna. For several miles downstream of the confluence, the Susitna River becomes braided, characterized by unstable, shifting gravel bars and shallow subchannels. For the remainder of its course to Cook Inlet, the Susitna River alternates between single channel, braided, and meandering planforms with multiple side channels and sloughs. Major tributaries drain the western Talkeetna Mountains (the Talkeetna River, Montana Creek, Willow Creek, Kashwitna River), the Susitna lowlands (Deshka River), and the Alaska Range (Yentna River). The Yentna River is the largest lower river tributary, supplying about 40 percent of the mean annual flow at the mouth.

4 Adult Salmon

The Susitna River is among the most important salmon-producing systems in upper Cook Inlet (UCI) with fishery resources contributing to the Cook Inlet commercial salmon harvest as well as important sport and subsistence fisheries (Shields 2010; Oslund and Ivey 2010; Jennings 1984). The five species of Pacific salmon found in North America occur in the Susitna watershed:

- Sockeye salmon (*Oncorhynchus nerka*)
- Chinook salmon (*O. tshawytscha*)
- Coho salmon (*O. kisutch*)
- Chum salmon (*O. keta*)
- Pink salmon (*O. gorbuscha*)

All are subject to harvest in the UCI commercial salmon fishery. Sockeye salmon are the most abundant species harvested and are of the highest economic importance to commercial fisheries. The UCI fisheries management area consists of the Central and Northern districts; current regulation allows only set gillnet gear in the Northern District, while both set and drift gillnets are used in the Central District (Shields 2010). The estimated exvessel (at the dock) value of the 2010 UCI commercial fishery was $33.2 million and the average annual exvessel value from the previous 10 years (2000–2009) was $16.1 million (Shields 2010).

In addition to commercial fisheries, the Susitna River and its major salmon-producing tributary streams also provide a multi-species sport fishery accessible from Anchorage and other Cook Inlet communities (Jennings 1984, Oslund and Ivey 2010). Chinook and coho are the most important salmon species for sport fisheries. Recreational fishing is a significant factor in fisheries management in Cook Inlet where commercial and non-commercial user conflicts existed in the 1980s (Mills 1980), and continue to present day.

Salmon provide an important food resource for many Susitna Basin residents and the village of Tyonek, approximately 30 miles southwest of the Susitna River mouth, is supported primarily by subsistence fishing on Susitna River Chinook stocks (ADF&G 1984d). The Tyonek subsistence fishery was reopened in 1980 after being closed for 16 years (Jennings 1984). In 2009, 89 permits were issued and 1,081 salmon were reported harvested of which 636 (59 percent) were Chinook salmon; the historical average harvest is 1,561 salmon (Holen and Fall 2011). Subsistence fishing also occurs directly within the Susitna Basin in the Yentna fish wheel fisheries.

A substantial effort was put forward to examine adult salmon resources from 1978 and 1984 as part of the 1980s APA Project. Much of the original work was performed by the Alaska Department of Fish and Game (ADF&G), and is well documented in an extensive series of reports. Significant accomplishments of the Susitna Hydroelectric Aquatic Studies Program 1981 to 1984 included the following (Jennings 1984):

- Documented migration timing of salmon runs in the Susitna River.
- Estimated population size and relative abundance of salmon in sub-basins of the Susitna River.
- Estimated total slough escapements for salmon in sloughs above RM 98.6.

- Estimated relative abundance of spawning salmon in tributaries above RM 98.6.
- Quantified selected biological characteristics for salmon stocks in the Susitna River (i.e., sex ratio, fecundity, age, and length).

In the 1985 Plan of Aquatic Studies (completed just prior to 1980s APA Project termination; see also Section 3.1), 12 specific issues pertaining to fisheries resources were delineated by APA in consultation with the resource agencies, of these, 7 were directly related to adult salmon and include the following:

- Comprehensive fisheries resources report
- Adult salmon - lower river spawning surveys
- Adult salmon - middle river spawning surveys
- Middle river - main channel escapement monitoring at Talkeetna Station (RM 103)
- Lower river tributary access analysis
- Evaluation of middle river mainstem and tributary spawning habitat relationships
- Adult salmon stream life study-middle reach sloughs

In addition, a lower river study plan was put forward in response to resource agencies' concern that prior years study efforts lacked focus on the lower river (Harza-Ebasco 1984a).

Due to cancellation of the APA Project in 1986, tasks outlined in the 1985 Aquatic Plan of Study were not completed. Adult salmon monitoring and assessment programs have since been focused on the needs for sustainable management and harvest allocation of the salmon resources of the Susitna and upper Cook Inlet management area. ADF&G is the lead management agency and has responsibility for establishing escapement goals, monitoring runs, and regulating harvest in accordance with complex regulatory management and allocation plans.

4.1 Sockeye Salmon

The most abundant and economically valuable salmon species in the Susitna River system is sockeye salmon. The Susitna River is considered the third largest producer of sockeye salmon in UCI, following the Kenai and Kasilof river systems. Estimates of annual sockeye salmon runs into the Susitna River have ranged from 147,000 to 773,000 fish (Fair et al. 2009). Due to their commercial value, sockeye salmon in the Susitna River have been studied more extensively than other salmon species.

Sockeye salmon spawning distribution is widespread throughout the Susitna River drainage, with a strong preference for tributaries and lakes. Important spawning and rearing lakes include Judd, Shell, Hewett and Chelatna in the Yentna portion of the drainage and Bunco, Swan, Byers, Larson and Stephan in the northwestern portion of the main Susitna Migratory timing has been well described (Yanusz et al. 2007; ADF&G 1985a; ADF&G 1984a; Jennings 1984). A first run of sockeye described by Jennings (1984) spawns exclusively in Papa Bear Lake and inlet streams in the Talkeetna River from mid July through early August. The second run (Jennings 1984) is abundant in the middle Susitna River from late July through the end of August. Radio telemetry studies of Susitna sockeye salmon were conducted by ADF&G in 2006, 2007 and 2008 (Yanusz et al. 2007, 2011) and provide the most comprehensive accounting of distribution of adult spawners completed to date.

The ADF&G is responsible for managing the Susitna River sockeye stocks and regulates commercial fisheries for high sustained yields by achieving published escapement goals. The annual abundance of Susitna River sockeye salmon stocks is difficult to quantify due to the nature of the large glacially occluded watershed. Early attempts by the ADF&G to monitor escapement into the main stem of the Susitna were abandoned due to these challenges. A Bendix side scan sonar monitoring sockeye salmon escapement on the Yentna was established in 1976 (Westerman and Willette 2010) and became a proxy for the escapement into the entire Susitna watershed. Sonar targets were allocated to species by fishwheel catches at an adjacent site. Recent data show that the sonar program that was used to estimate passage in the Yentna River for approximately 30 years was biased significantly low (Fair et al. 2009). Transition to the newer DIDSON (Dual Frequency Identification Sonar) resulted better detection of fish targets, but issues with fish wheel selectivity made passage estimates by species unreliable (Fair et al. 2009).

Sockeye salmon runs to the Susitna River drainage over the past decade have been reported to be declining (Shields 2010). At the 2008 Alaska Board of Fisheries meeting, Susitna River sockeye salmon were found to be a stock of yield concern[1]. As a result, an action plan was developed by ADF&G, identifying conservative management measures and a research plan. Studies contained in the research plan were funded beginning in 2006 and included:

- Mark-recapture and radiotelemetry projects intended to estimate the number of sockeye salmon entering the system, which also allowed for the identification of spawning areas in the drainage
- Limnological investigations of numerous lakes throughout the drainage to assess production potential
- Fry and smolt population estimates in as many as seven different lakes
- Evaluation of the effects of northern pike (*Esox lucius*) predation and beaver (*Castor canadensis*) dams on production
- Comprehensive generic stock identification (GSI) study of sockeye salmon fisheries in UCI to determine the river of origin of all harvested fish. Based upon the results from the 2006 season, minor modifications to the GSI project have been implemented.

Continuing studies will attempt to quantify fish wheel selectivity and develop corrections for use in species apportionment of sonar passage estimates. In the meantime, escapements goals have been established and are being monitored at four lakes (Judd, Shell, Chelatna, and Larson) that are known to be the major producers of sockeye salmon in the drainage. Attempts are also being made to identify and decrease the impacts of beaver dams and northern pike predation on sockeye salmon production. At the 2011 Alaska Board of Fisheries meeting, ADF&G recommended that Susitna River sockeye salmon remain a stock of yield concern. The impetus behind this recommendation is to allow more time for studies currently underway to provide information needed to formulate management strategies that will further the goal of increased yields (Shields 2010).

[1] A stock of yield concern is defined in the State of Alaska's *Policy for Management of Sustainable Salmon Fisheries (5 AAC 39.222)*, as a concern arising from a chronic inability, despite the use of specific management measures, to maintain expected yields, or harvestable surpluses, above a stock's escapement needs.

For many years Susitna River sockeye were managed based solely on sonar escapement estimated into the Yentna River. From 1999–2005, the Yentna River sockeye salmon escapement estimates were below the sustainable escapement goal during five of seven years. In response to this, mark-recapture experiments with fish wheels and weirs along with radio telemetry studies were conducted (Yanusz et al. 2007; Fair et al. 2009). Results of abundance estimates from these experiments were limited by fish wheel selectivity issues. The Yentna sonar counts are no longer used to index escapement to the Susitna although an extensive effort has been made to replace the old Bendix sonar counters with modern DIDSON sonar units. Weirs have been operated on key lake systems (Judd, Shell, Chulatna, and Larson) to count escapement. These escapement counts were found to be a much more reliable index of sockeye salmon escapement than the previous sonar program (Fair et al. 2009).

4.2 Chinook Salmon

The Susitna River Chinook salmon stock is fourth largest in Alaska (Ivey et al. 2009). The ADF&G has management responsibility and conducts a majority of the ongoing stock assessment programs for the stock. Although Susitna River Chinook salmon make a small contribution to commercial fisheries, they are important as recreational and guided sport fisheries. Sport fisheries in the Susitna drainage are managed under the Eastside Susitna and Westside Susitna subunits. Important Chinook salmon sport fishing streams in the Eastside are typically clear and many are accessible from the Parks Highway. From 1979 to 2009, the Eastside Susitna Chinook sport harvest ranged from 1,298 in 1979 to a high of 22,688 in 1993. From 2001 to 2009, Eastside Chinook sport harvests declined from 13,504 to 3,462 (Oslund and Ivey 2010). In February of 2011, the Alaska Board of Fisheries declared Willow Creek and Goose Creek Chinook salmon as a stock of yield concern at the regulatory meeting for the Northern Cook Inlet (NCI) Management Area.

West side streams are remote and accessed only by boat or air; tributaries are larger and Chinook are more abundant. Westside Susitna Chinook sport harvests from 1979 to 2008 ranged from 5,768 in 1979 to 21,836 in 1991. The 2009 sport harvest of 4,713 was the lowest in 30 years (Oslund and Ivey 2010). In 2008, the king salmon fishery closed, and in October 2010, the ADF&G recommended that the BOF declare Alexander Creek Chinook salmon a stock of management concern[2] at the regulatory board meeting for the Northern Cook Inlet (NCI) Management Area in February of 2011 (ADF&G 2011a).

The ADF&G has conducted annual aerial escapement surveys on nine Eastside streams and five Westside streams since 1979. Sustainable escapement goals as defined under the *Policy for Statewide Salmon Escapement Goals* (5 AAC 39.223), were established in 1993, and are formally reviewed on a three year regulatory cycle by ADF&G and the BOF.

In October 2010, the ADF&G recommended that the board declare Willow Creek and Goose Creek Chinook salmon as a stock of yield concern at the regulatory board meeting for the

[2] A stock of management concern is defined in the State of Alaska's *Policy for Management of Sustainable Salmon Fisheries (5 AAC 39.222)*, as a concern arising from a chronic inability, despite the use of specific management measures, to maintain escapement for a salmon stock within the bounds of the SEG, BEG, or OEG or other specified management objectives for the fishery.

Northern Cook Inlet (NCI) Management Area in February of 2011. The ADF&G has conducted annual single aerial surveys on Willow Creek and Goose Creek since 1979 in order to index spawning escapement of king salmon. Willow Creek and Goose Creek king salmon are harvested primarily in sport fisheries (ADF&G 2011b).

4.3 Coho Salmon

Susitna River coho salmon stocks contribute to both commercial and sport fisheries in the northern Cook Inlet area. Coho salmon enter the Susitna River in mid-July and are abundant in the lower Yentna River from the third week of July until the third week of August (ADF&G 1984a, Jennings 1984). The majority coho pass Sunshine Station (RM 80) between the end of July and the end of August. Coho salmon are numerous in the Talkeetna to Devil Canyon segment of the middle Susitna after the last week of July.

Mark-recapture estimates of annual escapement into the Susitna above RM 80 were made as part of the APA Project environmental studies from 1981 to 1984 ADF&G 1984a, ADF&G 1985a), Annual estimates averaged 86,000 fish (Jennings 1984). It should be noted that significant coho salmon stocks returning to tributaries below river mile 80 are excluded from this estimate. In 2002, ADF&G estimated the total abundance of coho in the entire drainage at 663,000 fish (Willette et al. 2003).

Presently, the ADF&G has only limited ability to gauge run size of coho stocks as they enter the fresh waters of the Susitna (Oslund and Ivey 2010). From 1997 to 2003, a weir was operated on Willow Creek and a weir has operated on the Deshka River since 1995 (Oslund and Ivey 2010). Fishwheels operated in conjunction with the sonar have been used to estimate coho salmon abundance in the Yentna River from 1981 to 2008 (Westerman and Willette 2010). A four-year spawning distribution study targeting Susitna coho salmon was started by ADF&G in 2009 (Merizon et al. 2010). This study used radio telemetry methods and described spawning distribution throughout the Susitna River drainage.

4.4 Chum Salmon

Susitna River chum salmon stocks contribute to both commercial and sport fisheries in the northern Cook Inlet area. Chum salmon enter the Susitna River in late June and are abundant in the lower river at Yentna Station by the third week of July (Jennings 1984, Merizon et al. 2010).

During the 1098's APA Project study years 1981–1983, the annual chum salmon total escapement in the Susitna River averaged 356,200 fish (Jennings 1984). The total chum salmon escapement was derived by the summation of population estimates at Yentna Station (RM 28) and Sunshine Station (RM 80) plus an additional five percent estimated to spawn in other portions of the basin. The majority (83 percent) of Susitna River chum salmon entered the Talkeetna-Chulitna sub-basin.

A four year spawning distribution study targeting Susitna chum salmon was started by ADF&G in 2009 (Merizon et al. 2010). This study used radio telemetry methods and has reporting of spawning distribution throughout the Susitna drainage.

4.5 Pink Salmon

Susitna River pink salmon stocks contribute to both commercial and sport fisheries in the northern Cook Inlet area. Pink salmon enter the Susitna River in late June to early July and are numerous in the lower river at Yentna Station (RM 28) from the second week of July to the third week of August (Jennings 1984; ADF&G 1984a). Pink salmon exhibit dominance in even years and utilize a minimum of 40 tributaries within the Susitna Drainage for spawning (ADF&G 1985a). Estimates of pink salmon escapement were made from mark and recapture studies at Flathorn Station (below the Yentna River confluence) in 1985 (Thompson et al. 1986). The point estimate of total escapement was 479,500 fish with a standard deviation of 83,700 fish. An estimated 42,600 pink salmon reached sunshine station, suggesting that most spawning appears to be in the lower river. Mark and recapture studies have been conducted on pink salmon by ADF&G in 2009 and 2010. The objective of these studies is to understand the proportion of west bank oriented fish at Susitna Station that are destined for the Yentna River (Willette 2011, pers. comm.). These data are not yet reported.

4.6 Potential Data Gap Topics

AS-1: Synthesis of existing information for adult salmon

Rationale

A large amount of information regarding adult salmon within the Susitna watershed has been gathered and reported on by ADF&G, FERC, and private industry consultants. Information on adult salmon is well documented in a variety of sources, including:

- Multiple historic Susitna hydroelectric development studies reports (1974–1986)
- 1985 amended FERC license application
- 1984 draft environmental impact statement
- Contemporary ADF&G fisheries management reports, including:
    - Regional Information Reports
    - Fisheries Annual Management Reports
    - Fisheries Data Series Reports
    - Stock Status Action Plans
    - Escapement Goal Reviews
- ADF&G unpublished data and ongoing research

Understanding the current state of knowledge is necessary for resource managers to assess the potential impacts of the proposed hydroelectric development. However, these historic and contemporary studies have not been synthesized into a concise and comprehensive report. Furthermore, results of all relevant studies have not been examined since historic data are not available in electronic format. Therefore, strong need exists for a reference document. Summarizing the existing information regarding adult salmon in the Susitna River basin into a practical format is beyond the scope of this analysis.

A synthesis of information on adult salmon is related to all other aquatic information needs and should be assembled concurrently with the other areas of study in order to guide study plans in support of licensing. This task will assist in designing a research program to fill environmental information required to license the project.

Available and relevant information

Studies conducted to support the 1980s APA Project provide detailed information on adult salmon from 1974 through 1985: "This is likely the most comprehensive look at adult salmon life histories, physical characteristics, and spawning habitat for any Cook Inlet drainage, and probably more information than is available for most drainages within the State" (Region II Forest Practices Riparian Management Science/Technical Committee 2004).

In 1979, funding became available to begin 1980s APA Project evaluation studies. The primary study goal outlined in the 1979 plan was to provide the necessary background information to enable proper evaluation of impacts of the proposed hydroelectric development on the fish and wildlife resources of the Susitna River by the State and FERC (Harza-Ebasco 1984a).

Comprehensive adult salmon abundance and distribution investigations under the Susitna Hydro Aquatic Studies Program began in 1981 and continued through 1983. In 1984, studies ceased and the final reports were published in 1985 and 1986. The body of work completed by ADF&G and other resource agencies is relevant to the modern Susitna-Watana Hydroelectric Project. Significant developments in technology have been introduced such as radio telemetry studies (e.g., Yanusz et al. 2007; Merizon et al. 2010) and genetic stock identification (Habicht et al. 2009).

Specific information needed

- Synthesis of historic and contemporary information on salmon populations and their habitats within the Susitna watershed
- Identify, locate and prioritize pertinent historic data and incorporation into a geodatabase with historic and current georeferenced aerial imagery covering the mainstem Susitna River and associated side channels, sloughs, and tributary confluences. This geodatabase should cover the area from Cook Inlet to the upstream extent of anadromous fish presence.

AS-2: Habitat change analysis

Rationale

Better spawning distribution and habitat utilization information would be helpful to evaluate impacts from hydroelectric development. This information can also be used determine proportion of spawning habitat types (i.e., main channel, side channel, slough, tributary mouth) utilized by each salmon species (i.e., sockeye, Chinook, coho, chum, pink) within each reach (i.e., lower, middle, above canyon, above dam), in order to characterize potential impacts to habitat. Available information from the 1980s, though extensive, is more than 25 years old and may not adequately describe the current spawning distribution and habitat utilization. It is unknown to what extent habitats have changed through natural geomorphological processes and to what degree spawning distribution may have changed in response; understanding is essential to determining validity and usefulness of habitat utilization relationships developed in the 1980s. A habitat change analysis is also important for planning future instream flow and geomorphology studies (see also HG-4 and IF-1).

Information on current salmon spawning distribution and habitat utilization, particularly in the middle river and its triburaties is needed to document biological baseline conditions. Specific distribution of spawning and proportion of habitats currently being utilized are required to assess potential project impacts due to changes in flow. This information also contributes to development of habitat versus flow relationships, components of the instream flow study.

Available and relevant information

Historic and contemporary studies of spawning distribution and habitat utilization have been studied using through a variety of methods and varying levels of effort. Previous studies conducted between 1981 and 1984 documented spawning distribution for all five species of Pacific salmon. However, spawning locations may have been underestimated due to sampling constraints, particularly in the main channel of the Susitna where turbid water limited visibility and very few fish were ever observed.

As part of the 1980s APA Project instream flow studies, channel geometry data was collected by ADF&G in 1982 and 1983 at twenty on side channel, upland and side slough and tributary habitats located in the Talkeetna to Devil Canyon reach of the Susitna River. Thalweg profiles, gradient, extent of backwater, and substrate composition were collected. Cross-section profiles, illustrating channel characteristic and wetted surface area as a response to stage changes were developed (ADF&G 1984e).

Aquatic habitats were characterized and classified for 172 specific areas in the Talkeetna to Devil Canyon segment of the Susitna River in 1983. Emphasis was placed on the transformation of specific areas from on habitat type to another in response to incremental decreases in main stem discharges from 23,000 cfs to 5,100 cfs (Trihey Associates and UAF 1985).

In order to characterize use of the Susitna River by spawning salmon, spawner abundance, distribution, and habitat utilization were studied:

- Spawning distribution of adult salmon was studied in the 1980s using multiple methods. This work is some of the only information available on spawning distribution for the drainage, but is more than 25 years old. Work may have underestimated both the number of spawners and number of spawning locations due to gear limitations and turbidity of the water. Less is known regarding distribution and number of spawners for turbid portions of the watershed than for clear water areas. Spawning locations of Chinook, chum, and coho salmon were studied using radio telemetry, but only a limited number of tags were put out and fish were tagged only at Talkeetna (RM 103) and Curry (RM 120) stations (ADF&G 1983a; ADF&G 1984i; ADF&G 1984j).
- Utilization of slough spawning habitat along the mainstem river was studied in 1981 and 1982, providing data that were used to evaluate accessibility and quality of habitat in these areas. Mainstem flows at which the selected sloughs were accessible to salmon were identified. A relative value was assigned to each slough, based on the observed

utilization in 1981 and 1982 (ADF&G 1984h).This is some of the only information on how salmon spawning could be affected by the project; however, only nine sloughs were studied (and none in the lower river were studied) and data used to perform analyses are more than 25 years old.

Specific information needed

- Digitized and orthorectified imagery of areas of the lower and middle Susitna River captured in the 1980s.
- Stream channel habitat classification and delineations from 1980s.
- Digitized and orthorectified imagery and LIDAR data of lower and middle Susitna River from present day.
- A comparison of habitat types based on historic and current aerial imagery is required to evaluate the need for further basin wide spawning distribution studies.
- A geodatabase containing the current known spawning distribution and habitat utilization of all five species of salmon including recent telemetry studies, aerial survey index streams, and other spawning ground monitoring programs.
- If possible, present-day channel geometry for the study sites used in the 1980s APA Project.
- Acoustic 3d bathymetry data for important main channel habitats. Descriptions of the full longitudinal extent and abundance of spawners by habitat type.
- The available quantity of habitat and the habitat response to changes in flow under the proposed Watana Project configuration.

AS-3: Sockeye salmon spawning distribution and habitat utilization

Rationale

Sockeye salmon were identified as an indicator species in the 1980s APA Project instream flow study because they are a dominant species that spawns in side channel and side slough habitats (ADF&G 1984i; Trihey & Associates and Entrix 1985a). Information on current sockeye salmon spawning distribution and habitat utilization is needed to document biological baseline conditions. Specific distribution of spawning and proportion of habitats currently being utilized would assist assessment of potential project impacts due to changes in flow and contribute to development of habitat versus flow relationships, components of the instream flow study.

Available and relevant information

In the Yentna river, considerable uncertainty is associated with the Bendix sonar escapement estimate and productivity of the sockeye stock (Fair et al. 2010). Preliminary population estimates (Yanusz et al. 2007), which included the number of adult salmon counted through weirs at lakes in the Yentna River drainage upstream of the sonar site, revealed the Bendix sonar counts using fishwheel captures for species apportionment was significantly underestimating sockeye salmon passage in the Yentna River. Deployment of a DIDSON resulted in substantially more fish targets being counted than with the Bendix sonar, but the improved sonar technology could not resolve species apportionment issues. This became evident when escapements counted through weirs at two lakes (Chelatna and Judd) in the Yentna River drainage exceeded the Bendix passage estimate for the entire river. In addition, mark-recapture population estimates for the Susitna drainage corroborated the fact that the Bendix sonar passage estimates were significantly biased low (Yanusz et al. 2007).

ADF&G and Cook Inlet Aquaculture Association (CIAA) recently completed a 3-year (2006–2008) comprehensive sockeye salmon study in the Susitna River drainage. Abundance estimates were generated by capture-recapture methods using passive integrated transponder (PIT) tags in 2006. Sockeye salmon abundance for the Susitna River drainage above Sunshine and in the Yentna were estimated at 107,000 fish and 311,197 fish, respectively (Yanusz et al. 2007). In 2008 using similar methods, the total abundance estimate for spawning adult sockeye in the entire Susitna River was 359,540 fish with 80 percent migrating up the Yentna (Yanusz et al. 2011). All three years of the study involved placing radio transmitters in sockeye salmon and tracking fish to their terminal locations. Much of the tracking was with fixed receivers on key tributaries and from aerial surveys. A small fraction of the terminal locations of radio-tagged sockeye were in the Talkeetna to Devil Canyon segment of the middle Susitna. Due to the size of the area covered and the frequency of surveys, final fates of the tagged fish are estimated to be within one-half mile at best of the fish's true spawning location (Yanusz et al. 2011).

Specific information needed

- Locations of sockeye salmon spawning in main-stem, side sloughs, and side channels of the middle and portions of lower Susitna determined to be most sensitive to likely project effects.
- GIS layers from the radio telemetry studies conducted by ADF&G in 2006, 2007, and 2008 (Yanusz et al. 2007, 2011).
- Evaluation of 2006, 2007, and 2008 sockeye salmon telemetry results in the context of habitat utilization findings of the 1980s APA studies.

AS-4: Chinook salmon abundance and distribution in the upper Susitna reach

Rationale

Abundance and distribution of adult and juvenile Chinook salmon above Devil Canyon and the proposed Watana dam site is poorly understood. Chinook salmon spawning distribution in the reach above Devil Canyon is needed to determine the direct impact of the dam, which may preclude fish passage. While Devil Canyon is an impediment to Chinook migration, it may not prevent passage under all flow conditions. Advances in sonar and radio telemetry technology since the 1980s provide new tools to accurately quantify the habitat available to be utilized by spawning Chinook in the reach above Devil Canyon and in the reach above the proposed dam site.

Available and relevant information

Prior to 1982, Devil Canyon was thought to provide a barrier to upstream migration of all salmon (Acres 1982). Subsequent studies conducted by ADF&G, however, reported that a few Chinook salmon (20–45 individuals) were observed in small tributaries upstream of the Canyon (ADF&G 1983a, ADF&G 1984a). In 1984 Chinook spawning was documented above Devil Canyon at Chinook Creek (RM 156.8 *n*=15) and Fog Creek (RM 176.7 *n*=2) (ADF&G 1985a). In 2003 ADF&G conducted electrofishing in the upper Susitna above Watana Canyon. Juvenile Chinook salmon were observed in Kosina Creek[3] (RM 201) and as far upstream as the mouth of the Oshetna River[4] (RM 225) (ADF&G 2011c). No adults have been observed in these tributaries, but the presence of rearing juveniles suggests the possibility of adult spawners this far upstream.

Specific information needed

- Abundance and spawning distribution of adult Chinook salmon spawners above Devil Canyon.

AS-5: Chinook salmon spawning distribution and habitat utilization in the middle and lower Susitna reaches

Rationale

Based on the 1980s studies, it is believed that Susitna Chinook salmon spawn exclusively in clearwater tributaries (ADF&G 1983b, Harza-Ebasco 1985). In other systems, Chinook spawn in mainstem habitat (ADF&G 1983a). Data to support the finding that Chinook spawn exclusively in clearwater tributaries are more than 25 years old, and are questionable due to the sampling constraints in the main channel and limitations of the 1980s APA Project Chinook telemetry study.

Available and relevant information

Adult Chinook salmon have been documented throughout the Talkeetna to Devil Canyon segment and as far upstream as RM 176.7 (ADF&G 1985a). Chinook salmon were observed in tributary mouths and tributaries in upper Devil Canyon. During the 1980s APA Project studies, all known and suspected Chinook salmon spawning areas in the Susitna River drainage upstream of the Chulitna River confluence (RM 98.6) were surveyed twice between July 15 and August 9. The surveys were conducted by helicopter and where possible on foot.

In 1983, there was no specific sampling for Chinook salmon spawning in the Susitna River main channel. General observations in 1983 by the crews assigned to main channel stations at RM 80, 103 and 120 and at Gold Creek (RM 136.7) provided no evidence that Chinook salmon spawned in the Susitna River main channel. A total of 35 sloughs between RM 98.6 and 161.0 were routinely surveyed for salmon escapements between July 25 and October 11, 1983. Twenty streams were likewise surveyed in this reach between July 15 and October 8, 1983. In 1983 Chinook salmon were found in 11 streams above RM 98.6. A total of 4,432 Chinook salmon were enumerated in the peak survey counts of these streams. The majority (97.8 percent) of these counts were recorded at Indian River (RM 138.6) and Portage Creek (RM 148.9)

In 1983, aerial escapement surveys were conducted at designated Chinook salmon spawning index streams in the Susitna River drainage, some streams had been surveyed since 1977 (ADF&G 1984a). Since 1983, escapement estimation has continuously documented

[3] Anadromous Waters Catalog (AWC) No. 247-41-10200-2810
[4] AWC No. 247-41-10200-2880

abundance for some stocks and additional work has been completed to address specific management concerns (Oslund and Ivey 2010). Radio transmitters were placed on Chinook salmon at RM 103 in 1981 and 1982. Results did not contribute to the understanding habitat utilization with majority of the few fish tagged tracked to tributaries below the tagging location (ADF&G 1984a). Radio telemetry studies of Susitna salmon stocks conducted by ADF&G since 2006 have not included Chinook salmon.

Specific information needed

- Spawning locations and habitat utilization in the middle river main stem, side sloughs, and side channels and portions of the lower river where determined to be highly or moderately sensitive to likely project effects.
- Investigation of main channel spawning for Chinook salmon in the middle and portions of the lower Susitna reaches.

AS-6: Coho Salmon spawning distribution and habitat utilization

Rationale

Information on current coho salmon spawning distribution and habitat utilization is needed to better document biological baseline conditions. Specific distribution of spawning and proportion of habitats currently being utilized will assist assessment of potential project impacts due to changes in flow and contribute to understanding the relationship of flow and the availability of habitat, components of the instream flow study (IF-1).

Available and relevant information

During spawning ground surveys in 1981–1983, over 99 percent of the coho salmon counted were observed in streams (ADF&G 1984a, Jennings 1984). Few coho salmon were observed spawning in mainstem and slough habitats (ADF&G 1981a, 1984a; ADF&G 1982a, Jennings and Consultants 1984). Slough spawning and stream spawning salmon were suggested to be separate stocks. However, coho migration in the Susitna River appears to not be segregated by spawning habitat type (ADF&G 1984a, Jennings 1984).

Recent concerns regarding coho stock status in the Susitna River have prompted new state funding for abundance estimates. In 2009, ADF&G initiated a four-year (2010 to 2012) radio telemetry study of coho salmon in the lower river. The objective of the study is to estimate drainage-wide escapement and distribution. Radio-tagged fish were tracked by fixed stations and by aerial surveys. Results from 2009 (contrary to the findings of the 1980s APA Project studies), a significant number of coho salmon were tracked to mainstem and side channel habitats where there were assumed to spawn (Merizon et al. 2010). Results from 2010 remain unpublished. Objectives for the 2011 season will include ground-based tracking, which will provide more precise locations of spawning salmon and their associated habitats (Merizon 2011, pers. comm.).

Specific information needed

- Spawning locations and habitat utilization of coho salmon in main stem, side sloughs and side channels of the Susitna River.

- GIS layers from the radio telemetry studies conducted by ADF&G in 2008, 2009, and 2010 (Merizon et al. 2010).
- Evaluation of 2008, 2009, 2010 coho salmon telemetry results in the context of habitat utilization findings of the 1980s APA studies.

AS-7: Chum Salmon spawning distribution and habitat utilization

Rationale

Chum salmon were a primary indicator species for the 1980s APA Project instream flow studies due to their utilization of main stem and side channel habitats. New technologies and data collections may provide better understanding on habitat utilization for Chum salmon in the Susitna. Information on current chum salmon spawning distribution and habitat utilization is needed to document biological baseline conditions. Specific distribution of spawning and proportion of habitats currently being utilized are required to assess potential project impacts due to changes in flow. This information also contributes to development of habitat versus flow relationships, components of the instream flow study.

Available and Relevant Information

In 1983, fishwheels were used to tag chum salmon at Sunshine (RM 80), Talkeetna (RM 103), and Curry (RM 120) stations. Recaptures made at upstream sampling locations were documented and released (ADF&G 1984a). Adult salmon escapements to Sunshine (RM 80), Talkeetna (RM 103), and Curry (RM 120) stations were calculated using tag/recapture population estimation techniques.

Chum salmon peak index counts in streams above RM 98.6 were: 241 fish in 1981, 1,737 fish in 1982, and 1,500 fish in 1983. In 1982 and 1983 more than 95 percent of the chum salmon counted during peak spawner surveys were observed in three streams: Indian River, Fourth of July Creek, and Portage Creek. About 93 percent of the 10,570 chum salmon counted during peak index surveys were observed in stream or slough habitats (Jennings 1984).

In 2008, chum salmon stock status was brought before the Alaska Board of Fisheries and the Matanuska-Susitna Borough issued a resolution to ADF&G to declare Susitna River chum salmon a stock of concern, enumerate escapement, and set escapement goals. In response, the Alaska State Legislature established funding for the Cook Inlet Salmon Task Force to examine conservation and allocation issues (Merizon et al. 2010). In 2009, ADF&G initiated a four-year (2010–2012) study to apply radio transmitters to chum salmon in the lower river. The objective of the study is to estimate drainage wide escapement and distribution. Radio tagged fish were tracked by fixed stations and by aerial surveys. Results from 2009 are published (Merizon et al. 2010). Results from 2010 remain unpublished. Objectives for the 2011 season will include ground-based tracking, which will provide more precise locations of spawning salmon and their associated habitats (Merizon, 2011, pers. comm.).

Specific information needed

- Spawning locations and habitat utilization in middle and portions of the lower river main stem, side sloughs, and side channels where determined to be highly or moderately sensitive to likely project effects.

- GIS layers from the radio telemetry studies conducted by ADF&G in 2008, 2009, and 2010 (Merizon et al. 2010).
- Evaluation of 2008, 2009, 2010 chum salmon telemetry results in the context of habitat utilization findings of the 1980s APA studies.

AS-8: Pink salmon spawning distribution and habitat utilization

Rationale

Pink salmon were a primary indicator species for the 1980s APA Project instream flow studies due to their utilization of main stem and side channel habitats. New technologies and data collections may provide better understanding on habitat utilization for pink salmon in the Susitna. Information on current pink salmon spawning distribution and habitat utilization is needed to document biological baseline conditions. Specific distribution of spawning and proportion of habitats currently being utilized will be important to assess sensitivity of pink salmon to changes in flow resulting from the project, depending where they spawn in the system. This information also contributes to the understanding of habitat versus flow relationships, components of the instream flow study (IF-1).

Available and Relevant Information

No pink salmon were observed spawning in the mainstem of the Susitna River above RM 98.6 between 1981 and 1983 (ADF&G 1984a).

Specific information needed

- Absence or presence of spawning locations and habitat utilization in middle river and portions of the lower river main stem, side sloughs, and side channels where determined to be highly or moderately sensitive to likely project effects.

AS-9: Genetic baselines for the middle river Susitna Chinook salmon

Rationale

Population genetic baselines for adult salmon in the Susitna River are incomplete. Identification of salmon stocks in the Susitna drainage during the 1980s was reliant upon what is now considered primitive and imprecise methods such as scale pattern analysis (Cross and Goshert 1988). Modern day genetic methodologies can provide more robust and statistically defensible allocations of stock contributions. They can also help describe baseline genetic structure and complexity of sub-stocks within the basin. Baseline information on stock diversity within the Susitna River Basin is important for identification of sub-stock structure, measuring productivity and monitoring long-term project impacts. Chinook stocks in the middle river have the highest propensity to be affected by the project.

Available and relevant information

Genetic methods are now widely used in Alaska to estimate stock composition of mixture samples. Advances in the development of genetic markers and statistical models have occurred recently and genotyping technologies have been developing at a rapid rate (Habicht et al. 2008). Sampling of baseline population genetics defines stock-specific salmon distributions and apportions their significance in commercial, sport, and subsistence fisheries.

Sockeye salmon - Genetic stock identification of upper Cook Inlet sockeye salmon stocks has been refined since the early 1990s and has been used to estimate the stock composition in commercial fisheries since 2005 (Barclay et al. 2010). Data gathered from these studies are starting to be used to reconstruct estimates of the total return of adult salmon by brood year for the major sockeye stocks in UCI, which will improve understanding of stock productivity (Habicht et al. 2008).

Chinook salmon - On the Kenai River, genetic stock identification for Chinook salmon is being evaluated as a method to provide estimates of annual abundance for discrete stock components independent of sonar estimates (Eskelin and Miller 2010). A similar genetic approach is being employed for sockeye salmon in the Susitna River watershed, using fishwheels at Susitna Station in conjunction with weirs at Judd, Shell, Chelatna, and Larson Lakes (Willette, pers. comm. 2011).

Few collections have been made of adult Chinook on Susitna River spawning grounds. The ADF&G is currently in the second year of a three year study to develop Chinook baselines for Northern Cook Inlet[5] and Western Cook Inlet[6]. This study will benefit Chinook salmon stock identification in the Susitna, and is anticipated to be first reported in 2012.

Chum salmon - A few adult chum salmon baseline samples have been collected in Cook Inlet as part of the Western Alaska Salmon Stock Identification Project (WASSIP). The objective of this program is to characterize western Alaska and Asian chum stocks for fishery management and allocation purposes. Cook Inlet as a whole is treated as a single reporting group. The March 2009 technical document for WASSIP identifies a very limited collection of chum salmon the Susitna drainage (Jasper et al. 2009). New genetic markers for chum salmon are being developed (Seeb et al. 2011), which may provide better resolution to future chum salmon stock identification projects. Tissue samples for future genetic analysis were collected in conjunction with chum and coho radio telemetry studies (Merizon et al. 2010). No funds are presently allocated to perform genetic analysis on these samples. In other watersheds, there has been a miss match observed between the results from radio telemetry studies and genetic stock identification (Habicht, pers. comm. 2011). It has not been resolved if this is a result of sampling error or telemetry tags affecting homing and further investigation is recommended.

Coho salmon - Very little genetic baseline information has been collected for coho salmon in the Susitna drainage. A few opportunistic collections have been made however none of the samples have been analyzed (Habicht, pers. comm. 2011).

Pink salmon - Very little genetic baseline information has been collected for pink salmon in the Susitna drainage. A few opportunistic collections have been made however none of the samples have been analyzed (Habicht, pers. comm. 2011).

Specific information needed

- Inventory of Chinook salmon spawning stocks in current collections at the ADF&G and USFWS conservation genetics laboratories.

[5] AKSSF project 45864
[6] AKSSF project 44517

- Identification of relevant unanalyzed collections.
- Identification of previously unsampled Susitna Chinook spawning populations in the middle river reach of the Susitna.
- Analysis of existing genetic markers and identification of the need for new markers to provide the resolution needed to obtain resolution of sub-stock structure in the Susitna.

5 Resident and Rearing Fish

The Susitna River basin provides habitat for resident fish, those spending their entire life cycle within the river; it also provides habitat for anadromous rearing fish, those that spend time in the river only in immature life stages before moving to saltwater. The Susitna River drainage is home to 19 documented species of anadromous and resident freshwater fish (Table 5.1), though two additional undocumented species may also live in the river (Pacific lamprey and Alaska blackfish).

Resident and rearing fish are important to commercial, sport, and subsistence fisheries in the Susitna River basin. Sport fisheries occur in the Susitna River basin for Pacific salmon, Arctic grayling, Dolly Varden, rainbow trout, burbot, northern pike, and salmon (see also Section 5). Pacific salmon rearing in the Susitna River basin supports commercial fisheries (see also Section 4). Pacific salmon species, Dolly Varden, rainbow trout, lake trout, eulachon, whitefish, and burbot support subsistence and personal use fisheries in the Susitna River basin (Fall and Foster 1987). Non-key species (those not important to a fishery) can be important to aquatic food chains as either predatory or prey species, and thus are covered in this analysis; non-key species covered here include round whitefish, longnose sucker, Bering cisco, threespine stickleback, and sculpins.

Resident and rearing anadromous fish in the Susitna River drainage were examined in detail during the early 1980s, mostly by the ADF&G in support of APA's 1980s Project. Their results are published in multiple reports from each study year. Accomplishments of the Susitna Hydroelectric Aquatic Studies Program 1980 to 1984 include:

- Relative abundance and distribution of 19 species of resident and rearing anadromous fish
- Dominant age classes for most of those species
- Sex ratios for most species
- Population estimates for Arctic grayling in the upper Susitna River tributaries
- Outmigration timing for most species of juvenile salmon
- Movements of selected species of resident adult fish in the Susitna River
- Identification of spawning habitats of certain species
- Identification of overwintering habitats of certain species

Additional resident and rearing fish studies were proposed in the 1985 Plan of Aquatic Studies; however, the project was terminated prior to the initiation of any studies. Issues related to resident and rearing fish are as follows:

- Lower river juvenile rearing and resident fish studies
- Outmigrant studies on the middle river

- Outmigrant studies on the lower river
- Winter studies of resident and juvenile anadromous fishes

Because of the cancellation of the project, these studies were not completed. Since that time, little work has been done on the resident and rearing anadromous fish in the Susitna River drainage.

Table 5.1 Common names, scientific names, life history strategies, and Susitna usage of fish and potential fish species within the lower, middle, and upper Susitna River, based on sampling during the 1980s

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

[a]A = anadromous
[b]M_1 = marine
F = freshwater
O=overwintering
R=rearing
P=present
M_2 = migration
S=spawning
U=unknown

The fishes listed in Table 5.1 represent those documented and likely to occur within the Susitna basin. Information on resident freshwater and anadromous fishes gathered during the 1980s APA project, as well as any studies conducted since then have been evaluated. Potential data gap topics are listed in Section 5.17. Except where noted, information below regarding resident and rearing fish is from 1980s APA studies (ADF&G 1981b, 1982).

5.1 Dolly Varden

Dolly Varden were also present in all reaches of the Susitna River drainage during the 1980s. Based upon limited sampling conducted in the 1980s, Dolly Varden were more abundant in the middle and lower river compared to the proposed impoundment zone and relative to other fish species. Dolly Varden in the Susitna River drainage were assumed to have a resident freshwater life history (FERC 1984b).

5.2 Humpback Whitefish

Humpback whitefish were captured in all reaches of the Susitna River drainage during the 1980s; though they were most prevalent in the lower Susitna River. Humpback whitefish in the Susitna drainage are a species complex consisting of Alaska whitefish, Lake Whitefish, and humpback whitefish. They can only be distinguished by examining gill rakers. During the 1980s, all three types were classified as humpback whitefish and it is unclear what proportion of the population each group represents.

5.3 Round Whitefish

Round whitefish were also captured each reach of the Susitna River drainage during the 1980s, although they were more prevalent in the middle river than the lower river.

5.4 Burbot

Burbot are a resident freshwater fish that were also captured in the lower, middle, and upper Susitna River drainage during the 1980s. They were captured at all sampling locations on the upper river during 1981 and all but one location on the lower and middle river. Spawning locations and timing have not been identified.

5.5 Longnose Sucker

Longnose sucker are a resident freshwater species that were widely distributed in the lower, middle, and upper Susitna River during the 1980s. They appear to be associated with mainstem sites in the upper river (as well as both tributary and mainstem locations in the lower and middle Susitna drainage.

5.6 Sculpin

Sculpin were widely distributed in the lower, middle, and upper Susitna River during the 1980s. Up to three species of sculpin (Pacific staghorn sculpin, coastrange sculpin, and slimy sculpin) may have been present and were classified under the genus Cottus. Of these three species, the

Pacific staghorn sculpin is the only marine species, though it often enters freshwater. Due to the difficulty in properly identifying sculpin species, they were classified together.

5.7 Eulachon

Eulachon are anadromous fish that may have been the most abundant species in the lower Susitna River (Vincent-Lang and Queral 1984). They are found in the lower river only (up to approximately RM 50 [Little Willow Creek]). Eulachon begin their upstream spawning migration sometime in May and continue into June with population estimates in the millions of fish.

5.8 Bering Cisco

Bering cisco are an anadromous species present in the lower and middle Susitna River during the 1980s, although they were more abundant in the lower river than the middle river. The Susitna River represents the southern extent of the range for Bering cisco and may provide some specific habitat for them.

5.9 Threespine Stickleback

Threespine stickleback can assume either a resident freshwater or anadromous life history and were widespread and abundant in the lower and middle Susitna River during the 1980s studies. They were not found in the upper Susitna River drainage; however, their preferred habitat was not sampled and they may exist in some of the unsampled ponds in the proposed impoundment zone.

5.10 Arctic Lamprey

Arctic lamprey were the only lamprey present in the 1980s fish surveys of the lower and middle Susitna River and they were not abundant. They were assumed to be a mix of the anadromous and resident freshwater forms based on length analysis. Arctic lamprey habitat requirements and life histories are poorly understood, so it is difficult to identify where current populations might be found or how the proposed project might affect rearing and raising.

5.11 Pacific Lamprey

Pacific lamprey could be present in the Susitna River since it is within their range. However, none were captured during the 1980s APA Project studies. They have been captured in neighboring rivers, such as the Chuit River (Nemeth et al. 2010).

5.12 Pacific Salmon

Pacific salmon (all five species) were captured in the lower and middle Susitna River during the 1980s. Juvenile Chinook salmon are the only anadromous species known to rear in the upper Susitna River and tributaries (Fog Creek, Kosina Creek, and the Oshetna River). The extent of their presence in the upper river has been poorly studied. Coho salmon were found in the lower and middle Susitna River during the 1980s. They usually out migrated to sea as age 1+ or age 2+ fish. Chum salmon were also present in the middle and lower River. Because the chum outmigrated to sea within a few months of emergence, little is known about their environmental dependence on the Susitna River. Sockeye salmon were also found in the middle and lower River. Most age 0+ sockeye salmon outmigrate from the middle river. It has not been determined whether they rear in the lower river or if they go to sea at age 0+. Pink salmon were found in the middle and lower River during the 1980s. However, since they outmigrate soon after emergence, and like the chum salmon little is known about their environmental requirements in the Susitna River.

5.13 Rainbow Trout

Rainbow trout (assumed to be a resident freshwater species within the Susitna River) were widely distributed throughout the lower and middle Susitna River during the 1980s and are important for sport fishing. Criteria for the determination of life history status were not described in the studies, though studies on rainbow trout movements, age, and size continued into the early 1990s (Rutz 1992, 1993). While much is known regarding certain aspects of their life history, environmental parameters in association with their habitats still needs to be studied.

5.14 Lake Trout

Lake trout, while not captured in the mainstem of the Susitna River, were captured in one lake within the upper Susitna drainage that was to be inundated by the 1980s project. This lake will likely not be inundated by the proposed project, and it is unknown if they exist in any lakes or ponds proposed to be inundated.

5.15 Northern Pike

Northern pike are an invasive resident freshwater species within the Susitna drainage. During the 1980s studies they were only captured incidentally. By the 1990s, however, they were found throughout most of the system (Rutz 1999). It is unknown if northern pike are present in the upper Susitna River. Their spread and the fact that salmonids are a preferred prey are likely implicated in the destruction of populations of salmon in many streams. A sport fishery for northern pike also exists within the Susitna River drainage.

5.16 Alaska Blackfish

Alaska blackfish have also been illegally introduced to the Susitna basin. It is not certain that they exist in the mainstem or tributaries of the Susitna River, since their preferred habitat is not present in the mainstem.

5.17 Potential Data Gap Topics

RR-1: Resident and rearing fish within the proposed impoundment zone

Rationale

Arctic grayling, Dolly Varden, humpback whitefish, round whitefish, burbot, longnose sucker, juvenile Chinook salmon, and cottids are known to occur in tributaries of the upper Susitna River located within the potential impoundment zone. Lake trout may be present in lakes within the proposed impoundment zone. Abundance of resident and rearing fish potentially impacted by the impoundment zone relative to other drainages and species-specific influence of the impoundment on their survival and propagation is poorly understood. Updated information is needed in order to assess impacts to resident and rearing fish in the impoundment zone, either because information has not been collected to date, or because most existing data are from 1980s APA Project studies and are over 25 years old.

Available and Relevant Information

Arctic grayling - Arctic grayling are likely the most abundant fish species in the proposed impoundment zone. The populations of Arctic grayling most likely to be affected by inundation in the upper Susitna drainage would be those that assume a fluvial (occurring in rivers) life history, with juveniles rearing in clearwater pools and adults present in larger streams. These populations of Arctic grayling may be severely impacted by changes in water levels due to drawdown of the reservoir during operations.

Arctic grayling are present in all three reaches of the Susitna River. While they were widely distributed in the upper Susitna River during the 1980s APA Project studies, they were not as abundant in the middle and lower Susitna River. ADF&G estimated in the 1980s that Arctic grayling populations in tributary streams would likely experience the greatest impact of any population, due to their location within the potential impoundment zone (Table 5.2).

Arctic grayling were collected in the upper Susitna River, from RM 173.9 (Fog Creek) to RM 226.9 (the Oshetna River) during the summer of 1981 and from Cheechako Creek to the Oshetna River during 1982 (ADF&G 1981b, 1982). The upper Susitna River itself was not sampled, only tributaries and two lakes to be inundated. Arctic grayling were captured in all habitat types (main stem, side channel, side slough, upland slough, tributary, and tributary mouth, see 9.1 for complete descriptions) on the upper Susitna during 1981 (ADF&G 1981b). Of the 11 sites sampled in 1982, Arctic grayling were captured in all but Chinook Creek (located below the proposed Watana Dam site; ADF&G 1982). Other analysis completed based on this work included scales-based age and age-length analyses; and sex composition. Spawning is believed to occur under the river ice in late April or early May, though the exact timing has not been documented (ADF&G 1981b). During 1982, spawning was documented in four tributary locations in late May (ADF&G 1982). Juvenile Arctic grayling were observed in 1982 in all eight major tributaries sampled, as well as some mainstem sloughs. Characteristics of the habitat were similar in each tributary: low water velocity, shallow depth, and abundant cover (ADF&G 1982).

Mark-recapture studies for Arctic grayling were carried out in tributary streams in the upper Susitna River to determine population estimates during 1981 and 1982. Based on these studies, population estimates were made for the various tributaries (Table 5.2; ADF&G 1981b, 1982). Population estimates of adult Arctic grayling in the proposed impoundment zone ranged from 13,750 to 14,174 fish, based on scales and otolith analysis, respectively (ADF&G 1984b, 1984c). While some Arctic grayling migrated between tributaries using the mainstem Susitna as a migratory corridor, the majority remained in their original stream of capture (ADF&G 1981b, 1982).

Table 5.2 Arctic grayling population estimates with 95% confidence intervals, in tributaries to the upper Susitna River based on mark-recapture studies during June–September 1981 and 1982

Tributary	Population Estimate 1981	95% Confidence Interval 1981	Population Estimate 1982	95% Confidence Interval 1982
Oshetna	2,017	1,525–2,976	2,426	1,483–4,085
Goose	1,327	1,016–1,913	949	509–1,943
Jay	1,089	868–1,462	1,592	903–3,071
Kosina	2,787	2,228–3,720	5,544	3,792–8,543
Deadman	979	604–2,575	734	394–1,502
Tsusena	1,000	743–1,530	—	—
Fog	176	115–369	—	—
Watana	—	—	3,925	1,880–6,973

Source: ADF&G 1981b, 1982

Dolly Varden - Available information on the distribution and relative abundance of Dolly Varden in the proposed impoundment zone is limited to two studies from the 1980s APA Project that found Dolly Varden presence in tributaries to the upper Susitna River. Because only large tributaries were sampled for fish, and because the sampling was targeted toward Arctic grayling, the distribution of Dolly Varden was inadequately documented and remains poorly understood.

One Dolly Varden was collected in the upper Susitna River resident fish study during 1981. This male fish, taken from the mouth of Fog Creek, measured 235mm in fork length. Previously, the only known occurrence of Dolly Varden in the upper Susitna River was from Lake Louise (ADF&G 1981b). During 1982, Dolly Varden were observed in Cheechako, Devil, Watana, Jay, and upper Deadman creeks (ADF&G 1982).

Round whitefish locations - There is little information available regarding round whitefish spawning, overwintering, and rearing habitats. Information is also lacking with regard to the round whitefish's relationships to various abiotic and biotic parameters, such as water temperature, discharge, substrate, large woody debris, undercut bank, and macroinvertebrate communities in the proposed impoundment zone. Round whitefish were not specifically targeted in the 1980s studies and as such critical habitats were not identified.

Both juvenile and adult round whitefish were captured in the upper Susitna River and Jay Creek in 1981. Age, sex, reproductive condition, and length were assessed. A small number of fish were fish were tagged in the mark-recapture study and none were recaptured (ADF&G 1981b). In 1982, round whitefish were again captured in the mainstem upper Susitna River (ADF&G 1982).

Burbot - Burbot were characterized during the 1980s APA Project studies of the impoundment zone. However, minimal effort was given to classifying their habitats. Burbot are believed to spawn within glacial rivers during midwinter. Burbot were investigated in the upper Susitna River during 1981 and 1982. They were collected at all habitat locations sampled around tributary confluences within the mainstem Susitna River (ADF&G 1981b) and all seven upper Susitna River mainstem habitat locations sampled (ADF&G 1982).

Burbot were analyzed for age and sex composition. Spawning is believed to occur in March on the upper Susitna River (ADF&G 1981b). Spawning habitats have not been identified.

Of the 23 burbot tagged during the 1981 mark-recapture study, none were recaptured (ADF&G 1981b). Sixty-nine burbot were tagged during 1982 and three of them were recaptured near their tagging location. Additionally, four of the burbot tagged in the 1981 study were recovered in the 1982 study at their original point of capture (ADF&G 1982).

Juvenile Chinook - Juvenile Chinook have been found to occur in tributaries located in the proposed impoundment zone. Their abundance and distribution throughout the zone, however, have not been identified. The presence and distribution of juvenile Chinook salmon provides an indication of the extent of Chinook spawning in the upper Susitna River and when used in conjunction with adult Chinook salmon surveys will provide information for impact analysis. During 2003, ADF&G conducted stream fish surveys in some of the tributaries in the upper Susitna River to identify those streams important for anadromous fish. Juvenile Chinook salmon were captured in Fog Creek, Kosina Creek, and the Oshetna River (Johnson 2010).

Longnose sucker - Longnose suckers were also captured in the upper Susitna River basin; they were found in all locations sampled except Fog and Tsusena creeks (ADF&G 1981b). Fish were caught at the confluence of tributary streams with the Susitna River, and in mainstem sloughs (ADF&G 1981b). During 1982, longnose suckers were again captured at upper Susitna River mainstem sites (ADF&G 1982). Most were captured at the Watana Creek mouth. Fish in spawning condition were captured at the Watana Creek mainstem site during May and June 1982; by late June they were in post-spawning condition (ADF&G 1982).

Cottids – Sculpin were captured in the upper Susitna River during the 1981 resident fish study. They were all assumed to be slimy sculpin (ADF&G 1981b).

Lake trout - During the 1980s APA Project studies, lake trout were present in two lakes sampled near the proposed impoundment zone for the Watana Project. To date, lakes within the proposed impoundment zone for the Watana Project have not been sampled; it is unknown whether lake trout are present. Lake trout were captured in two lakes examined during 1981; all lake trout captured were within 100 feet of the shoreline and in less than 6 feet of water. Age, sex, reproductive condition, and length were assessed. During mid August, both pre- and postspawning fish were observed in Sally Lake, suggesting spawning had occurred (ADF&G 1981b). During 1982 sampling, lake trout were caught again (ADF&G 1982). A small number of lake trout were tagged during the mark-recapture studies in both years, but no conclusions could be drawn because of the low number recaptured. Whereas the current plan does not include the inundation of lakes previously sampled in the 1980s, it is possible that fish communities among lakes in the basin are similar and that lake trout exist in other lakes in the proposed impoundment zone.

Specific information needed:

- Population estimates of adult Arctic grayling and Dolly Varden in selected tributaries within the proposed impoundment zone.
- Spawning migration timing of Arctic grayling using the proposed impoundment zone.

- Relative abundance and distribution of Dolly Varden, lake trout, and juvenile Chinook in the impoundment zone.
- Physical parameters (e.g., water temperatures, velocity, and substrate size) round whitefish, longnose sucker, and burbot habitats within the impoundment zone.

RR-2: Resident and rearing fish along the access and transmission corridor

Rationale

The transmission and access corridors are yet to be proposed for the Watana Project; this work was performed for the 1980s APA Project, but data are more than 25 years old and the footprint of the project may differ. Current information on aquatic conditions and fish species within the corridor is needed in order to assess project impacts. Construction of a transmission and access corridor could impact fish passage and water quality, and increase sport fishing pressure through better access to fishing sites and boat launches. Identification of fish species within the corridor is important to consider with regard to mitigation of project impacts.

Available and relevant information

Studies from the 1980s were conducted on fish characterization and distribution in streams along the then-proposed access and transmission corridor. The access and transmission corridor for the Susitna-Watana Hydroelectric Project, however, has not been identified, though it may make use of some or all of the same corridors proposed in the 1980s. Consequently, an updated characterization study may be needed.

Specific information needed

- Identification presence and/or absence of resident and juvenile anadromous fish species, distribution, life stages, habitat characteristics, and abundance.
- Inventory of physical habitat characteristics, fish use, and sensitive habitats at corridor stream crossing sites.
- Summary of fish species presence, distribution, life stages, habitat characteristics, and abundance within the subject water body.

RR-3: Resident fish movement within the middle Susitna River

Rationale

Understanding the movements/migrations of various resident species (e.g., longnose sucker, Dolly Varden, Arctic grayling, rainbow trout, burbot, and round whitefish) will identify which habitats are utilized by each species at different life stages and various seasons. This information will enable determination of flows necessary to maintain access to tributary streams and other habitats important for different life stages of fish species.

Available and relevant information

Mark-recapture studies were performed on resident freshwater and some anadromous fish species during the 1980s (ADF&G 1984b, 1984c). Most of the studies had so few recaptures, that little to nothing could be definitively stated regarding fish movements.

Based on 1981 and 1982 radio telemetry studies on rainbow trout, the trout's preferred overwintering habitats are sloughs and side channels in the mainstem Susitna River that exhibit slow to moderate water velocities (0.2 to 3.0 feet per second [ft/sec]) and without under-ice slush. Rainbow trout were located on most substrates; however, silt and sand were not preferred. They were also observed during the winter to be in areas with elevated specific conductance (greater than 200 micro-ohms per centimeter [µohm/cm]) and water temperatures above 0.5°Celsius (C), indicating groundwater upwelling areas (ADF&G 1983b).

A radio tagging effort of rainbow trout in 1983 gave insight into their movements and adequately documented their movements in the middle Susitna River. A majority of these fish were captured at tributary mouths on the mainstem of the Susitna River. Most of the fish moved downstream after tagging (an average of 6.9 miles); however, some moved up the river also (an average of 2.4 miles). The majority of the downstream movement occurred after September 1, possibly indicating a move to overwintering habitats. (ADF&G 1984b)

Burbot are thought to occupy the turbid waters of the mainstem Susitna River and spawn and rear in reaches directly influenced by the mainstem. Radio tagging of 20 burbot over the course of three years demonstrated that instream migrations begin in September and last until March. It is believed that few burbot spawn in the middle Susitna River (ADF&G 1984c).

Mark and recapture studies on Arctic grayling in the middle Susitna River indicate that they spawn in tributary habitat. Recaptures of Arctic grayling indicated that a strong spring migration occurs from the mainstem to tributary streams. Also, that there was limited summer movement as indicated by recaptures of tagging Arctic grayling in the same areas of their original capture. Most Arctic grayling returned to the mainstem of the Susitna River by October. Little is known regarding Arctic grayling distribution during the winter (ADF&G 1984a).

A mark-recapture study was also performed on round whitefish and demonstrated that they moved little in the middle Susitna River. During 1981 and 1982, round whitefish exhibited a fall movement, and in 1983 they exhibited downstream summer movements (ADF&G 1984c).

Mark-recapture data on humpback whitefish are limited, but appear to indicate a spawning or overwinter movement upstream. They likely return to the lower river to overwinter after spawning (ADF&G 1984c).

A mark-recapture study was also performed on longnose suckers during the early 1980s. These data suggest that longnose suckers do not move far from where they were tagged. Movements indicate an upstream migration in the spring and a downstream migration in the fall (ADF&G 1984c).

Mark-recapture studies performed on Dolly Varden indicate an upstream spring and summer movement. Clear Creek, although outside of the project area, is thought to be an important tributary for Dolly Varden production (ADF&G 1984c).

Specific information needed

- Information on migration timing and movements of resident species in the middle Susitna.

RR-4: Eulachon synthesis document

Rationale

Cook Inlet eulachon are a major prey item for Cook Inlet beluga whales (*Delphinapterus leucas;* CIBW) and are part of the designated critical habitat for the whales. A significant, but unknown portion of Cook Inlet eulachon originate in the Susitna River; the National Marine Fisheries Service (NMFS) identified this species as a primary constituent element (PCE) essential for the conservation and recovery of CIBW in its designation of critical habitat for the whales.[7] Personal use, subsistence, commercial, and recreational fisheries exist in the Susitna River and delta for eulachon (NMFS 2008). While the commercial fishery is limited to 100,000 pounds of eulachon a year, other fisheries may not be accurately recorded. The eulachon personal use fishery harvests between 4,400 and 10,000 lbs per year over the past decade in the Cook Inlet; however, that number may be underreported. No records are kept on the eulachon subsistence fishery (NMFS 2008).

While 1980s APA Project studies focused on eulachon run timing, spawning habitat characteristics, age composition, and sex ratios, little is known regarding population estimates or larval outmigration. Data on population size and outmigration timing is critical to quantifying the potential impacts of the Watana Project. A significant effort to study eulachon was made during the 1980s APA Project studies; a synthesis of existing information on Susitna River eulachon may help determine whether sufficient information exists in order to evaluate impacts of the Watana Project.

Available and relevant information

Between 1982 and 1983, ADF&G conducted studies to determine the relationship between naturally occurring discharges and temperatures on eulachon spawning. These studies indicated that eulachon were likely the most abundant fish in the Susitna River. They also indicate that two runs of eulachon enter the Susitna River with no correlation to temperature, mainstem discharge (Vincent-Lang and Queral 1984), or Cook Inlet tide levels (ADF&G 1983a). Eulachon spawning occurred over a variety of hydraulic and substrate conditions from the mouth of the Susitna (RM 0) to RM 50.3 (Vincent-Lang and Queral 1984). The majority of each run of eulachon spawned below RM 28.1 (ADF&G 1983a). Most eulachon spawned within 5 days of entering the Susitna River in both 1982 and 1983 (ADF&G 1984g).

Eulachon did not spawn in clearwater tributaries or sloughs associated with the mainstem in either year of the study. They did, however, spawn in the Yentna River, a glacial tributary to the Susitna, but the extent of spawning was not determined. In both 1982 and 1983, male eulachon ripened earlier than females and remained in spawning condition longer (ADF&G 1984b). In 1982, the majority of both first- and second-run eulachon were from age 3 fish and the minority were age 4 fish (ADF&G 1983a). First-run eulachon were generally smaller in length and weight than second-run eulachon. Male eulachon outnumbered female eulachon in 94.7 percent of samples. Male eulachon spawned over a multiday period, whereas female eulachon generally spawned within a single day. Males remained in the river for days

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postspawning before either outmigrating or dying, whereas females either died or outmigrated immediately after spawning. Spawning was determined to take place near cut banks and where the bottom composition included unconsolidated sands and gravels, and riffle zones or bars with relatively moderate velocity (ADF&G 1983a). In both years, eulachon escapement was estimated at several hundred thousand fish for the first run and several million fish for the second run (ADF&G 1984b). Vincent-Lang and Queral (1984) concluded that based on eulachon spawning sites studied, similar habitat would be available under increased or decreased mainstem flow.

Eulachon appeared to use water velocity for upstream orientation during their upstream spawning migration. They were seldom observed in areas of low water velocity (less than 0.3 ft/sec), and the majority of upstream eulachon migration appeared to occur along banks with velocities ranging from 0.3 to 3.0 ft/sec. The habitat requirements for eulachon spawning appeared to be broad; thus, a large portion of the lower Susitna River was available for them as spawning habitat. Spawning occurred during 1982 along the mainstem Susitna River and associated side channels, but gravel bars and riffle zones with moderate velocities were most commonly used. The mean water depth occurring at spawning sites was 1.1 to 3.1 feet and ranged from 0.3 to 4.3 feet. The mean water column velocity at spawning sites was 0.6 to 1.9 ft/sec and ranged from 0.0 to 3.2 ft/sec. The most commonly used spawning substrate was silt and sand intermixed with some gravel. Water temperature at the time of spawning ranged from 3.0 to 9.5°C. The above data were collected over the course of one season and were considered preliminary and to be interpreted with caution (ADF&G 1983a).

While studies were conducted during the 1980s on adult eulachon, no studies were conducted on eulachon larval outmigration.

Specific information needed

- Synthesis of existing information on Susitna River eulachon.

RR-5: Northern pike

Rationale

The Northern pike's activity in the Susitna River is poorly understood. Understanding the distribution and abundance of Northern pike in the mainstem Susitna River is imperative to quantifying the impacts of the proposed project.

Available and relevant information

In the early 1950s, a pilot illegally transported Northern pike from Minto Flats, in the Yukon drainage, to Bulchitna Lake in the Yentna River drainage (Southcentral Alaska Northern Pike Control Committee [SANPCC] 2010). Several floods allowed for access to the Susitna River drainage from the Yentna River drainage (SANPCC 2010), and since then Northern pike have established themselves in most of the Susitna River drainage (Rutz 1996). More than half of the Susitna River drainage area contains Northern pike habitat (SANPCC 2010).

One Northern pike was caught incidentally during the resident fish study in the 1980s. The pike was a 9-year-old female, 715mm long, at Kroto Slough mouth (RM 30.1; ADF&G 1981b).

Rutz conducted studies on northern pike in the lower Susitna River basin during the 1990s (1996, 1999). In 1994 and 1995, he sampled 14 lakes and two tributaries of the Susitna River to assess seasonal migrations and distributions; age and size compositions; and food habits (Rutz 1996). During 1996 and 1997, four tributaries of the Susitna River were assessed for movements, mean length, availability of food items, and stomach contents for Northern pike (Rutz 1999). In all years studied, the greatest movement of Northern pike was 8 miles (13 kilometers), while the least movement was less than 1 mile (1 kilometer). By radiotagging Northern pike, Rutz showed that they remained in the same drainage they were tagged in; however, they did move between lakes and streams within those drainages. Salmonids were the major prey item of northern pike when available (Rutz 1996, 1999).

According to traditional ecological knowledge, the Susitna River may act as a source population for Northern pike. In his thesis, Carter interviewed fishermen who have captured Northern pike swimming and doing well in the upper Cook Inlet. Because these fish can survive in salt water, they could potentially be spreading to other drainages from the Susitna River (2009).

Specific information needed

- Improved information on distribution, age composition, movements, relative abundance, habitat requirements for overwintering, spawning, and rearing.

RR-6: Middle river young-of-the-year sockeye from outmigration and rearing

Rationale

Age 0+ sockeye comprise a very small portion of the annual return to the Susitna River, though there is spawning occurring in the middle river, which has limited rearing habitat for sockeye salmon. The proportion of age 0+ fish outmigrating directly from the middle river, to those proportion of age 0+ fish rearing in the lower river is unknown. This information is important due to the impact that proposed lower flows of the project may have on rearing habitat, since reduction in flow regime in a reading habitat increases mortality rates among young of the year.

Available and relevant information

Outmigration trap data collected between 1982 and 1984 at the Talkeetna Station demonstrated that large numbers of age 0+ sockeye outmigrated from the middle Susitna River. Scale analysis from returning adult salmon indicates that age 0+ sockeye represents only 6.4 percent of the returning adult population. It was concluded that the majority of age 0+ sockeye from the middle Susitna River either rear in the lower Susitna River or have a low survival rate in the ocean (ADF&G 1985b).

Specific information needed

- Rearing locations in the lower river.
- Determining whether those sockeye rearing in the lower river originate in the middle or lower river.
- Outmigration age and destination of young-of-the-year sockeye from the middle river.

RR-7: Juvenile Pacific salmon density estimates in mainstem and tributaries of the Susitna River

Rationale

A relative measure of juvenile salmon abundance in the mainstem and tributaries of the middle Susitna River will contribute to the general understanding of productivity. This measurement may provide a benchmark for evaluation of whether changes to the flow regime would have measurable effects on rearing salmon populations.

Available and relevant information

Population estimates of juvenile salmon were generated for the middle river for two species of Pacific salmon during the 1980s. The population of chum salmon estimated in the middle river during 1984 was 2,039,000 fry (Schmidt et al. 1985). A population estimate for age 0+ sockeye salmon fry in the middle river was 309,000 in 1985 using the Schaefer method, which was very similar to the population estimate calculated using the Petersen method for the same species and time period (305,000; 95 percent CI = 265,000 – 352,000; Roth, Gray et al. 1986). Population estimates for the other Pacific salmon species were not determined during the previous study effort.

Specific information needed

- Density estimates for all species of juvenile salmonids in the mainstem of the middle and lower portions of the lower Susitna River where determined to be highly or moderately sensitive to likely project effects relative to tributary streams.

RR-8: Peak outmigration timing for Pacific salmon

Rationale

An understanding of whether potential changes in the river's thermal regime will alter the outmigration timing for Pacific salmon will be necessary to assess the environmental impact of the project.

Available and relevant information

Studies from the 1980s established outmigration timing from the middle Susitna River for all species of juvenile Pacific salmon except pink salmon. The peak of juvenile sockeye salmon outmigration occurred prior to July 8 during both 1982 and 1983. Since rearing habitat for juvenile sockeye salmon is limited in the middle Susitna River, it is uncertain whether the outmigrating juvenile sockeye salmon from the middle Susitna River, rear in the lower Susitna River or outmigrate to sea at age 0+. Peak outmigration for juvenile chum salmon also occurs before mid-July in both 1982 and 1983. Peak outmigration for juvenile coho salmon occurred from mid- to late August during 1982 and 1983. Peak outmigration for juvenile Chinook salmon from the middle Susitna River occurred during mid- to late June and mid- to late August during 1982 and 1983 (ADF&G 1984c).

Specific information needed

- Determination of whether outmigration timing of juvenile Pacific salmon has altered since the 1980s.

RR-9: Ambient water quality parameters, substrate size, and water velocity of active redds

Rationale

An understanding of ambient water quality parameters, substrate size, and velocity of incubating salmon in redds is important to determine the baseline characteristics of redds in the middle Susitna River. This information will aid in determining the alteration of spawning habitat due to the project in the middle Susitna River. The determination of the ways in which the project would affect groundwater upwelling and hydraulic conductivity will be needed. This topic encompasses both resident and rearing fish and water quality.

Available and relevant information

Incubation, defined as the period in time between fertilization and complete yolk sac absorption, in the Susitna River begins in July with Chinook salmon. Pink salmon follow Chinook and spawn in mid to late August. Chum and sockeye salmon spawn in late August to early September. Coho salmon spawn last in tributaries during September (Jennings 1984). Jennings states that incubation habitat in the middle river may be limited for the species that spawn in the mainstem (1984). Dissolved oxygen (DO), water velocity, temperature, substrate, and streamflow were studied in the Susitna River and compared to primary literature to determine preproject conditions in the 1980s. For dissolved oxygen, the Susitna sloughs were generally within the accepted range for proper incubation. Sufficient intragravel velocity is important so that wastes are washed away from the embryos and DO is delivered to them. Intragravel velocity was not studied in incubation sites during the 1980s. Temperature is important for the incubating eggs to ensure proper closure of the blastopore. Once this is closed, embryos are less sensitive to temperature (Jennings 1984).

Substrate sizes needed for proper incubation vary by species. It must allow for the exchange of DO and metabolic wastes. Chum and sockeye salmon use substrate between 1 and 10 inches in diameter. Chinook salmon use substrate between 3 and 10 inches in diameter. Pink salmon use substrate between ⅛ and 5 inches in diameter, Coho salmon use substrate between ⅛ and 3 inches in diameter (Jennings 1984).

Nothing is known about the scouring effects of high stream flow and the impacts scouring would have on incubating salmon embryos in the Susitna River. Low stream flows, however, have been shown to lead to desiccation, low oxygen levels, high temperatures, and freezing (Jennings 1984). During the winter of 1983 to 1984, it was found that freezing and dewatering of salmon redds was the largest cause of chum salmon mortality in the middle Susitna River (Vining et al. 1985). Dewatering and thus freezing of redds occurred most frequently in side channels and least frequently in sloughs (Vining et al. 1985).

Specific information needed

- Ambient water quality, substrate size, temperature and velocity data from salmon redds of all species incubating in the middle and relevant areas of the lower Susitna River in conjunction with habitat suitability studies conducted for the instream flow study effort.

RR-10: Environmental requirements of rearing juvenile coho salmon in the Susitna River

Rationale

The habitat requirements of juvenile coho in the Susitna River are poorly understood, and an improved understanding is necessary to determine how the Susitna-Watana Hydroelectric Project would alter their habitats. In particular, stream margins, side sloughs, and slough habitats are likely to be modified in the middle river due to changes in stream discharge. It is important to understand the relative importance of these habitat types to rearing juvenile coho (and possibly Chinook) salmon.

Available and relevant information

Work done during the 1980s began to address these issues (Jennings 1984) but remains incomplete.

Specific information needed

- Better understanding of the types of habitat used in the Susitna River by juvenile coho.
- Better understanding of the relationship between habitat and various abiotic (e.g., velocity, undercut bank, substrate size, and water quality) and biotic (e.g., macroinvertebrate assemblages) factors.

RR-11: Resident and rearing fish habitat requirements in the middle and lower Susitna River

Rationale

While spawning locations and physical characteristics of spawning habitats of some resident and (non-salmon) rearing fish in the Susitna River were identified and evaluated during 1980s APA Project studies, habitat requirements for several species in the middle and lower Susitna River are poorly understood. Arctic grayling, burbot and Dolly Varden were considered an evaluation species during the 1980s APA Project study effort. However, these data are over 25 years old and current information on their spawning habitats is needed to support the instream flow study. Less effort was devoted to study of habitat requirements for other non-salmon species during the 1908s APA studies. This information is needed in order to assess project impacts to resident and rearing fish.

Available and relevant information

Bering cisco - Because the Bering cisco population in the Susitna River is at the southern extent of its range, habitat use within the Susitna River may differ from previous studies within other drainages. In addition, migration and spawning timing may vary due to differences in water temperatures. While Bering cisco are not a PCE species for beluga whales (see also Section 10.1), they are abundant in the upper Cook Inlet and have been documented as a food source for beluga whales (NMFS 2008).

Bering cisco were sampled in conjunction with the 1980 to 1981 resident fish studies. They were collected within the mainstem Susitna River from RM 30.1 to RM 100.8. Large numbers of Bering cisco were located from RM 74.3 to RM 79 (near the confluence with

Montana Creek), apparently on their fall spawning migration. Age, sex, and lengths were assessed. Spawning appeared to peak the second week in October; physical characteristics of three sites with spawning were analyzed (ADF&G 1981b).

Bering cisco were also sampled in conjunction with the adult anadromous fish studies in 1981 and 1982. Fish were sampled by fishwheels at the Susitna (RM 26), the Yentna (RM 4), the Sunshine (RM 80), the Talkeetna (RM 104), and Curry (RM 120) stations. Age and length were assessed. The majority of Bering cisco were captured on the east bank of the river. Five spawning sites and probable spawning sites were located between RM 7.0 and 98.5 in 1981 and 1982. In both years, spawning occurred around mid-October (ADF&G 1983a).

Dolly Varden - Dolly Varden were considered an evaluation species during the 1980s efforts. Dolly Varden were collected during the resident fish study in the mainstem middle and lower Susitna River between 1980 and 1981. While they were present in the mainstem, they were captured most frequently at tributary mouths, with the greatest catch occurring at the mouth of Portage Creek (RM 148.8) during June. Sexually mature Dolly Varden were found in September and October. Spawning behavior was observed in October in upper Indian Creek. Of the 59 Dolly Varden tagged in the mark-recapture study, none were recaptured, and no conclusions can be made about their movements and migrations based on this study (ADF&G 1981b).

Arctic lamprey - Arctic lamprey were captured during the 1980 to 1981 resident fish study of the lower and middle Susitna River. Arctic lamprey were captured between RM 10.1 and RM 101.4 between November 1980 and September 1981. Larger Arctic lamprey were captured downstream of RM 40.6 and were assumed to be anadromous (ADF&G 1981b). The DEIS speculated that approximately 30 percent of Susitna River Arctic lamprey were anadromous based on length frequency analyses (FERC 1984b). Neither age classification nor sex composition studies were performed (ADF&G 1981b). During 1982, one potential Arctic lamprey spawning site was identified at Birch Creek mouth (RM 89.2).

Longnose sucker - Longnose suckers were captured in the mainstem middle and lower Susitna River during the early 1980s. They were collected in mid May at the mouth of the Deshka River (RM 40.6) and Cache Creek Slough (RM 95.5). Juvenile longnose suckers were found throughout the system below Curry (RM 120.7). Lengths were assessed; only a few fish (n=15) were examined to determined age and sex, so those data were deemed insufficient and were not included. Of the 350 fish tagged during the mark-recapture study, only three were recaptured and the movements of those fish were not extensive; therefore, no conclusions could be made about longnose sucker movements/migrations in the Susitna River (ADF&G 1981b). Two possible spawning locations for longnose suckers were identified during 1982, one at Sunshine Slough and the other at the mouth of Trapper Creek (ADF&G 1983b).

Arctic grayling - As of 1982, Arctic grayling spawning had not been observed on the Susitna River (ADF&G 1983b). It was assumed to occur in clear water tributaries between May and mid-June (ADF&G 1983b).

Burbot - Because burbot are considered winter spawners, spawning has not been documented in the lower or middle Susitna River. Therefore, the exact period of spawning is unknown. Spawning is assumed to occur during late January and February at the mouth of the Deshka River (RM 40.6). Preferred spawning habitat characteristics of burbot in the Susitna River are unknown. Preliminary studies in areas of high milling by burbot occurred during the winter in 1982/1983 and concluded that burbot tend to mill in areas of ice cover with low to moderate velocities (0.1–4.0 ft/sec) and with moderately high specific conductance (70–150 µohm/cm). The relatively high specific conductance may be an indication of upwelling (ADF&G 1983b).

Round whitefish - In the Susitna River, round whitefish may use both mainstem and clear water tributaries for spawning. After spawning, it is presumed that round whitefish move into their over wintering locations; however, due to low winter catches, those overwintering locations could not be determined. It was presumed that round whitefish overwinter in the mainstem and associated side channel habitats (ADF&G 1983a).

After winter, they return to their summering habitats consisting mostly of tributaries upstream of the mouths and the mainstem for summer rearing habitats. Juvenile round whitefish were most commonly captured rearing in clear water sloughs in the middle Susitna River. Turbidity (under 120 nephelometric turbidity units [NTUs]) did not appear to exclude round whitefish from rearing habitat. Little is known of the summer habitat characteristics for juvenile and adult round whitefish (ADF&G 1983b).

Humpback whitefish - The Susitna River is assumed to be home to both anadromous and resident humpback whitefish. Little is known of the spawning behavior or habitat of humpback whitefish or the outmigration timing of juvenile humpback whitefish or their habitat requirements while in the Susitna River. Their outmigration timing is assumed to occur in August (ADF&G 1983a, 1983b).

Specific information needed

- Habitat use by species, life stage, and season in the areas of the Susitna River determined to be highly sensitive to likely project effects: characterization of Bering cisco, Dolly Varden, Arctic lamprey, and longnose sucker spawning and rearing timing and locations; Bering cisco outmigration timing; Dolly Varden, Arctic lamprey, and longnose sucker overwintering locations.
- Biotic (e.g., macroinvertebrate assemblages) and abiotic (e.g., velocity, water temperature, and turbidity) factors associated with habitats identified above.
- Arctic grayling and burbot spawning locations.
- Abiotic variables at Arctic grayling and burbot spawning locations (e.g., velocity, water temperatures, upwelling zones, and substrate size).
- Round whitefish and humpback whitefish spawning, rearing, and overwintering locations.
- Abiotic variables at round whitefish and humpback whitefish spawning, rearing, and overwintering sites (e.g., turbidity, substrate size, velocity, and water temperatures).

RR-12: Data rescue needs for resident and rearing fish

Rationale

Detailed information regarding resident and rearing fish sampling locations from year to year, fish distribution and relative abundance at those locations, fish life stage information from sampling locations, available water quality and hydrologic data from sampling locations, and all spawning, rearing, and overwintering locations by species would be needed for impact analysis.

Available site specific relevant information

Studies conducted on the Susitna Hydroelectric Program during the 1980s contain a wealth of information. Table 5.3 presents relevant information needed and the studies in which these data are available.

Specific information needed

- Yearly sampling locations.
- Fish distribution.
- Fish relative abundance at each sampling location.
- Life stage information for each species at each location.
- Water quality data for each location.
- Hydrologic data for each location.
- Specific habitat (i.e., spawning, rearing, or overwinter) locations for each species.

Table 5.3 Data needed by report

	Sampling Locations	Fish Distribution	Relative Abundance	Life Stage at Sampling	Water Quality Data	Hydrologic Data	Habitat Type
ADF&G 1981a	X	X	X	—	—	—	—
ADF&G 1981b	X	X	X	—	—	—	—
ADF&G 1982	X	X	X	X	X	X	X
ADF&G 1983a	X	X	X	X	X	X	X
ADF&G 1983b	X	X	X	X	X	X	X
ADF&G 1984a	X	—	—	—	—	—	—
ADF&G 1984b	X	X	X	X	X	X	X
ADF&G 1984c	X	X	X	—	X	X	X
ADF&G 1985	X	X	X	X	—	—	X
Jennings 1984	X	—	—	X	X	X	X
Roth et al. 1986	X	X	X	X	—	—	—
Rutz 1992, 1993, 1996, and 1999	X	X	X	X	—	—	—
Schmidt et al. 1985	X	X	X	X	—	—	—
Vincent-Lang and Queral 1984	X	X	X	X	X	X	X
Vinning et al. 1985	X	X	X	X	X	X	X

6 Macroinvertebrates and Periphyton

Effects of the project on macroinvertebrates and periphyton will be directly tied to changes in water quality and physical habitat (e.g. changes in temperature, dissolved oxygen, turbidity, sediment load). Gaps in water quality and sediment load information are discussed in other sections of the gap analysis and will not be restated here. In summary, while the water quality and sediment load studies of the 1980s APA Project were detailed in scope and geographic coverage, it is likely that conditions in the Susitna River have changed since the time of the studies, resulting in a necessity to perform sampling to determine current baseline conditions.

Macroinvertebrate and periphyton studies should be repeated and expanded during the next phase of data gathering for the Susitna-Watana Hydroelectric Project. Previous studies have focused on limited geographic extent, although the temporal extent and variety of methods (drift and benthic) were somewhat robust. At least two years of current benthic and drift data should be gathered to characterize annual variability. Sampling should be related to possible habitat changes due to the proposed project and should be co-located with periphyton and fish sampling efforts in select side channel, slough and woody debris habitats. Benthic and drift sampling should be conducted at the mouths of tributary streams to estimate the relative contribution of tributaries to mainstem macroinvertebrate drift. Following are recommendations for fulfilling these needs.

MP-1: Update baseline macroinvertebrate datasets

Rationale

Baseline macroinvertebrate data are useful to assess post-project changes in aquatic resources. Susitna River anadromous and resident fish species rely on macroinvertebrates as a primary food source. Overwintering species rely on invertebrate availability in upwelling areas and resident fish feed on drifting invertebrates from upstream. Changes in sediment transport, temperatures, and timing of flow would be expected to produce changes in the invertebrate population both downstream and upstream of the proposed dam site as compared to the baseline condition. Aside from immediate construction impacts, longer-term changes upstream of the dam site would convert the habitat from lotic to lentic, creating a shift in invertebrate population from those that prefer fast-moving, cooler, and high gradient waters (e.g., Ephemeroptera, Plecoptera, Trichoptera) in those waters to the more planktonic taxa (e.g., Copepoda, Cladocera, Rotifera, Oligochaeta). Downstream of the dam site, streambanks, channel edges, side channel and slough habitats would likely be affected by a reduction of flow during the summer, changes in temperature of water releases, and the increase in groundwater influences which can exhibit lower DO levels, higher TDS, etc.). These effects could change the timing of instar growth and taxa emergence and could change the taxa richness at the site altogether. The current baseline condition needs to be established in key habitats that may be affected by the project.

Available and relevant information

As part of the 1980s APA Project studies, ADF&G sampled for invertebrates in side channel and slough habitats peripheral to the Susitna River (ADF&G 1985c). Samples were collected from May through October in three side channel sites and one side slough site between River

Mile 129 and 142. Water velocity and substrate type were correlated with the behavioral type (swimmers, burrowers, clingers) of the invertebrates, however no functional feeding type analysis was performed. Invertebrate diversity was calculated for riffle, run and pool habitats, and curves were developed for utilization, preference, and/or suitability. A full reporting of the identified macroinvertebrates is available for review and comparison. It is possible to develop functional feeding type analysis using the sample data from this early study, however the length of time since sample collection occurred and the lack of associated specific habitat information in some cases (e.g., amount of woody debris) would create difficulties in performing a full functional analysis to establish a current baseline condition.

Inquiries with USGS, ADF&G, UAA (Environment and National Resources Institute (ENRI) and other knowledgeable sources indicate no additional macroinvertebrate sampling has been conducted in the Susitna River since the original project investigations, although some studies have been conducted on tributaries downstream of the proposed Watana Dam site.

Specific information needed

- Updated understanding of benthic macroinvertebrate community composition among mainstream Susitna River habitats where determined to be most sensitive to likely project effects, including stream margins and undercut banks, woody debris and debris dams, mid-channel, side channel, sloughs; and brown water and clear water tributary streams. Comparisons among tributaries and the mainstem Susitna can provide insight into the relative productivity among these stream systems. Macroinvertebrate communities can be used to assess post-project changes in water quality and physical habitats.
- Macroinvertebrate drift in the mainstem near representative streambanks and mid-channel areas. Invertebrate drift in side channels, and near the mouths of clear-water, and brown water tributary streams along with stream discharge at these sites.

MP-2: Updated baseline information on primary productivity, transported and benthic organic matter

Rationale

Measures of the major food sources in aquatic ecosystems are needed for permitting purposes and to assess post-project changes in aquatic resources. Periphyton (algae), along with organic matter in transport and on the stream bed area at the base of the aquatic food chain and are the major food sources for invertebrates that feed anadromous and resident fish species. Periphyton growth is directly related to photoperiod, water temperature, turbidity and available nutrients in the system. As described in previous studies, the Susitna River is relatively oligotrophic, limited for nutrients (specifically phosphorous and nitrogen), and is inhibited by high turbidity concentration that can impede ambient light penetration. This parameter is important to monitor and studies should be expanded for the next phase of this project.

Available and relevant information

During the 1980s APA Project studies, water quality information was collected at Denali, Cantwell (Vee Canyon), Gold Creek, Sunshine, and Susitna Station on the Susitna River, and also on the Chulitna River and Talkeetna River (Harza-Ebasco 1985d). Algal communities were sampled and analyzed for chlorophyll-a periodically at Susitna Station from 1978–1980; results were low (1.2 mg/m^3 or lower) and indicated algal abundance was most likely reduced by the filtering of ambient light to the substrate by high concentrations of turbidity.

The abundance of algae as chlorophyll-a has been measured in some tributary streams. Periphytic chlorophyll-a ranged from 30 to 40 mg/m^2 in samples collected in the lower reaches of Montana Creek (Davis et al. 2006). In comparison, chlorophyll-a was less than 5 mg/m^2 in Whiskers Creek, a small brown-water tributary to the middle reach of the Susitna River (Davis and Davis 2009).

Inquiries with USGS, ADF&G, UAA (ENRI), and other knowledgeable sources indicate no additional periphyton sampling has been conducted in the Susitna River since the original project investigations, although some studies have been conducted on tributaries downstream of the proposed Watana Dam site.

Specific information needed

- Algal samples collected and analyzed for chlorophyll-a and ash-free-dry-mass (AFDM) concentrations. To characterize annual variability, sampling should occur once a year for two years, during the spring, summer, and late summer after water levels recede and clarity is improved. Sample sites should be stratified above and below the proposed dam site and across the channel, and should be co-located with the macroinvertebrate, instream flow, water quality and fisheries studies to correlate invertebrate functional feeding groups with habitat types.

7 Water Quality

Water quality impacts were noted as possible effects due to construction and operation of the Watana Dam under the 1980s APA Project (FERC 1984a). The final design and operations criteria may be different than what was originally proposed during the earlier stage of the project; however, effects are likely to be similar. The timing and magnitude of changes resulting from project construction and operation would need to be evaluated for each water quality parameter that plays an important role in aquatic life, drinking water, industrial uses, etc. A robust data set is most important where project effects are likely to change the baseline condition, and some data needs are outlined below as a result of these project impact evaluations.

Water quality conditions in the Susitna River watershed are influenced by fast flow, cool temperatures, and high turbidity resulting from upstream glacial meltwater. Water quality and hydrologic conditions are naturally different upstream of the confluence of the Susitna River with the Chulitna, and Talkeetna rivers (RM 104 to 95) from those in downstream areas. Sediment loads from the Chulitna River may be 15 times greater than those from the Susitna River (Bredthauer and Drage 1982), although both contribute similar amounts of flow below the confluence.

7.1 Potential Data Gap Topics

WQ-1: Update baseline for turbidity, TSS, TDS, pH Dissolved Oxygen, temperature, metals, nutrients, organics, bacteria and other parameters

Rationale

Studies in the mid-1980s extensively characterized the baseline conditions of water quality parameters in the project area, yet the effects of climate change and shifting of hydrologic patterns over the last decades result in a need to collect current baseline data. Current water quality conditions for turbidity, total suspended solids (TSS), total dissolved solids (TDS), pH, DO, temperature, metals, nutrients, organics, bacteria and other parameters should be established.

Aquatic ecosystem health is primarily driven by the ability of the water quality parameters to support aquatic life. Fish, macroinvertebrates, bacteria and algae all respond directly to the temperature, dissolved oxygen and pH of the ambient waters in the habitat, and changes to the status quo can disrupt the balance in these systems. The formation of a reservoir can increase the surface area and water temperatures. However, thermocline formation can cause differences in temperature, dissolved oxygen, and nutrient concentrations with depth. Water quality downstream can therefore vary depending upon withdrawal location. Natural background turbidity and TSS loads can be high in this system, especially during summer months in the Susitna River, and in Susitna River waters downstream of the confluence with the Chulitna River. Proposed changes in timing and magnitude of freshwater input to the middle Susitna River as a result of Watana Dam construction could cause a number of water quality changes downstream, most notably by changing water temperature immediately downstream of the dam, and by increasing the influence of the glacial-silt laden Chulitna River waters downstream of its confluence with the Susitna River. Immediately downstream, when flows are reduced due to water storage, the Susitna will be more heavily influenced by the quality in the groundwater upwelling and tributaries than in the current condition, which may affect aquatic life in the system. Changes in flow patterns could also result in the redistribution or resuspension of metals or organics in the substrates of these waters, and previous documentation indicates lentic environments can cause leaching of ions or precipitation of metals, adsorbed nutrients, particulate and dissolved organic matter, and deposition of inorganic particles, significantly changing the water quality behind the dam. Current baseline information on all of these parameters is necessary to assess possible project effects during and after construction.

Available and relevant information

In 1983, data were collected between May and October in the Susitna River, side channel habitats, side sloughs, upland sloughs and tributary habitats (Seagren and Wilkey 1985. Between 1984 and 1985, the ADF&G collected continuous surface and intragravel temperature at select locations in the Susitna River and sidechannel habitats; some water quality parameters such as turbidity were added to analyses. Water quality conditions were found to be similar amongst habitats, however conditions in all habitats appeared to be directly influenced by discharge in the mainstem Susitna.

In July 1984 though May 1985, ADF&G identified upwelling and seepage areas in the Susitna River and selected sites for surface and intragravel temperature monitoring (Seagren and Wilkey 1985). The intent of the study was also to identify natural upwelling locations to enhance mitigation options for post-construction activities.

In the early 80s, the USGS and R&M Consultants began collecting water quality information at Denali, Cantwell (Vee Canyon), Gold Creek, Sunshine, and Susitna Station on the Susitna River, and also on the Chulitna River and Talkeetna River (Harza Ebasco 1985b). Samples were collected throughout the year, and were lumped into subsets of data by breakup, summer, and winter for analysis. A suite of ambient and laboratory-analyzed parameters were collected; a summary is provided below:

Temperature - Results indicted the Susitna River primarily froze at 0°C in the winter with some limited upwelling areas occurring, while many of the side sloughs remained open with a contribution of groundwater upwelling of approximately 3 to 5°C. During the summer, these side sloughs would become warmer, but during the winter it appeared the groundwater upwelling was the primary driver that kept the sloughs from freezing over. Water temperatures generally increase as the river travels downstream, however cooler temperatures can be observed just downstream of the Chulitna and Talkeetna confluences. Water temperatures in the Susitna River and its major tributaries have been summarized by Kyle and Brabets (2001) as part of the USGS NAWQA program. Water temperatures generally are above 4°C from May through September. Maximum daily water temperatures peak during July reach near 12 to 13°C at Gold Creek, and Susitna Station, but near 10°C at Sunshine. Maximum daily water temperatures are generally less than 10°C in the Chulitna River, and from 10 to 12°C in the Yentna River. Daily range in Susitna River water temperatures is low, with daily July minimum values near 8 to 10°C.

TSS and turbidity - Summer flows contained high amounts of TSS and turbidity due to glacial meltwater effect, and this effect was more pronounced after the Chulitna River confluence; the Chulitna also contains glacial meltwater with high concentrations of glacial flour. Susitna River turbidity at Gold Creek reached 200 NTU during the summer, but was less than 1 NTU during the winter. In the winter, waters ran clearer and were influenced more by groundwater conditions and precipitation.

Dissolved oxygen - DO was high in the Susitna drainage, generally ranging from a low of 80 percent to supersaturated conditions (over 100 percent).

Nutrients: carbon, silica, nitrogen, and phosphorous - Results indicated that nitrogen and phosphorous are the limiting factors in the Susitna's relatively oligotrophic system, and simulated studies performed using a modeling program called DYRESM on the similar Eklutna Lake drainage indicated phosphorous would likely be the primary limiting factor if the Watana Dam was built.

Major ions - Bicarbonate, sulfate, chloride, and the dissolved fractions of calcium, magnesium, sodium and potassium results were low to moderate in concentration. Waters are generally hard (more calcium and magnesium concentration) in the winter and soft in the summer, and waters tended to become softer from upstream to downstream areas.

pH - pH was relatively normal to slightly acidic range. Infrequent pH occurrences near 6.0, yet this is common in Alaskan waters due to the surrounding reducing conditions that can occur in tundra environments.

Alkalinity - All alkalinity results were above minimum Alaska water quality standard concentration of 20 mg/L CaCO3 (ADEC 2003), although some results are near the standard, indicating a possible difficulty in those conditions for adequate buffering against low pH conditions.

Metals - Sampling results were below the limits for antimony, boron, gold, platinum, tin, radium, zirconium and dissolved molybdenum; results above the limits for aluminum, cadmium, copper, manganese, mercury, zinc, dissolved bismuth, total iron, total lead, and total nickel.

Cholorphyll-a - Water samples collected at Susitna Station from 1978–1980 were analyzed for chlorophyll-a. Results were low (1.2 milligrams per cubic meter [mg/m^3] or lower); primary productivity is most likely reduced by the filtering of ambient light to the substrate by high concentrations of turbidity. However, this sampling method did not account for benthic periphytic algae.

In late winter and spring, turbidities are low and algal growth and consequent macroinvertebrate production may be high. As sediment concentrations increase, scouring removes the majority of algal production in these habitats and, with light penetration decreasing to <0.15m, primary production becomes limited. In autumn, a second algal bloom typically occurs as stream flows moderate and turbidities fall below 20 NTU (Richardson and Milner 2005).

Bacteria - Fecal coliform, total coliform, and fecal streptococci were collected at Susitna Station and in the Talkeetna River. Most results were low, although summer levels were higher than winter levels due to breakup and precipitation event runoff.

Miscellaneous - Samples indicated that pesticides, herbicides, uranium, and gross alpha radioactivity were below levels of concern. Total organic carbon and chemical oxygen demand were also assessed as part of the study.

In 1985, the APA and ADF&G began a long-term water quality monitoring program for water temperature, turbidity, suspended sediment settleable solids, total dissolved gas, dissolved oxygen and pH. Although heavy metals and organic nitrogen and phosphorus were not included in the suite of analysis, the long-term monitoring plan in place at the time indicated these were necessary prior to project construction.

Specific information needed

- Ambient conditions (temperature, pH, DO, specific conductivity) in side channel and slough areas that may provide overwintering habitat or otherwise support aquatic life through critical time periods with groundwater upwelling. Water temperature and flows in the mainstem and major tributaries so that estimates of reduction of mainsteam flow on water temperature can be estimated. Differences in specific conductivity can be used to indicate the presence and dominance of groundwater discharge.
- Full suite of water quality parameters bulleted above, including ambient parameters, fecal coliform, metals (add meHg and selenium), major ions (hardness), alkalinity, nutrients (i NH4-N, Nitrate+nitrite-N, total P, total dissolved-P and orthophosphate) and organics (DOC), in the mainstem and side channel areas just upstream of the Watana Dam site based on the simulations performed on Eklutna Lake.
- Repeat of the water quality monitoring study performed by the U.S. Geological Survey (USGS) and R&M consultants at key locations co-located with the instream flow studies in mainchannel, side channel and slough habitat to adequately document current conditions during significant hydrologic events; over the last few decades; it is possible that conditions have changed as a result of climate change, glacial meltwater rate change, alterations in river morphology or groundwater influence, etc.
- Data of such frequency and spatial distribution to adequately assess the baseline for TSS and temperature, as these would likely be the two primary water quality parameters exhibiting the most change from the baseline condition under the assumed construction and operating plans; continuous monitoring strategy and locations for study should be collective decisions to be made with the instream flow and fisheries groups.

WQ-2: Temperature, TSS, and dissolved gas model for middle and lower Susitna

Rationale

The understanding of potential downstream Project effects for water quality parameters is limited by the lack of information on the likely operational regimes and how measurable and/or significant the effects will be at points downstream. A model that incorporates parameters of flow, temperature, TSS, and dissolved gas is needed to predict the potential magnitude and geographic extent of detectable downstream effects. An understanding of water quality conditions at various downstream control points would provide an improved basis for impact analysis and mitigation. The model outputs could be presented on a GIS platform where it could be used interactively during the development of study plans. Such a presentation would allow interested parties to see how river conditions vary in various parts of the watershed. Use of a formal model could also help to determine the locations of needed sampling stations for the WQ-1 task.

Available and relevant information

Specific information needed

- A hydrologic model that can incorporate likely Project operational flow regimes and predict downstream effects of temperature, TSS, and dissolved gas at various downstream control points.

8 Hydrology, Ice, Sediment, Geomorphology, and Climate

Hydrology and water resources form the basis for energy supply and ecological conditions in the Susitna River. Mean flows, low flows, and peak floods are affected by project operations; in turn, this affects sediment transport, freeze-up, break-up, and groundwater, all of which sustain channel form and fish habitat downstream of the proposed Watana Dam site.

Geomorphology studies are closely linked to fish habitat studies and hazard studies in the middle and lower rivers. Sediment transport is dependent on flow rates and sediment supply, both of which would be altered by the proposed project. Woody debris is arguably a habitat rather than geomorphic study, though it is outlined briefly below.

Climate is not affected by the project, but plays an important role in water supply, particularly as it pertains to glaciers, snowmelt, and temperature. Understanding climatic influences on streamflow over the historical period allows us to better define the natural variability of the system, as well as the uncertainty associated with future water supply for both energy and environmental flows.

8.1 Potential Data Gap Topics

HG-1: Streamflow synthesis (USGS)

Rationale

Only two gages (Talkeetna River at Talkeetna and Susitna River at Gold Creek) are still active in the Susitna watershed. However, 14 gages were operated in the basin at different times, especially during the 1980s study period, to define the seasonal distribution of flow throughout the watershed. Currently, the last 25 years of record are missing from all but two areas. These last 25 years have primarily occurred in a climatically “warm” phase, while many of the records prior occurred in a climatically “cool” phase. An accurate determination of natural seasonal flow ranges should include records distributed evenly among climatic phases.

Available and relevant information

Flow records from USGS gages in the Susitna watershed at different time periods are available, and the USGS is currently contracted to complete this potential data gap.

Specific information needed

- A statistically derived flow record, including mean daily, mean monthly, mean annual and flow peaks, from 1949–2011 for gages other than Gold Creek and Talkeetna, including:
  - Susitna at Watana
  - Chulitna near the confluence
  - Susitna at Talkeetna
  - Susitna at Sunshine
  - Yentna near the confluence

- Susitna at Susitna Station

HG-2: Middle and lower river ice studies

Rationale

Ice formation and breakup is important to navigation, winter travel, flood hazards, river morphology, and fish habitat. The proposed project has the potential to affect ice formation and breakup below the project site. It was estimated that at Talkeetna, up to 80 percent of the frazil ice in the Susitna was generated upstream in the rapids of the upper and middle Susitna River. Frazil ice build-up causes the ice cover to progress in most parts of the river, thus a decrease in the volume of available frazil ice would delay freeze up. The storage of snowmelt peaks behind the dam could also delay breakup.

Available and relevant information

R&M Consultants conducted several years' worth of ice observations on the lower and middle rivers between 1980 and 1985. These observations were compiled in six documents: *Ice Observations 1980–1981* (1981), *Ice Observations 1981–1982* (1982a), *Susitna River Ice Study 1982–1983* (1983), *Susitna River Ice Study 1983–1984* (1984), *Susitna River Ice Study 1984–1985* (1985), and *Susitna River Freeze-up Final Report* (1986). R&M's 1980-to-1981 study includes a thorough review of ice observations to date, including USGS, National Weather Service, and Alaska Railroad observations of ice thickness prior to 1980. The 1980 and 1981 focus was to describe ice cover progression during freeze-up from Portage Creek (Devil Canyon) to Talkeetna, and break-up in the spring along the same reach using aerial reconnaissance and selected measurements. Freeze-up and break-up were correlated with climatic and weather conditions in the basin.

Between 1982 and 1983, R&M began to focus on ice processes thought to be important to river morphology and habitat maintenance, including staging (intermittent increases in water surface elevation as ice cover progresses), ice cover in sloughs, ice jams, and sediment transport. R&M also collected observations of freeze-up and break-up in the lower river, the reach between Cook Inlet and Talkeetna, and placed a time-lapse camera in Devil Canyon to capture observations. R&M concluded in 1984 that ice processes are the dominant control on channel morphology in the middle river reach between Devil Canyon and the Chulitna confluence, while downstream of the confluence, ice processes are secondary to open-water processes. Ice jams create higher river stages than open-water flooding in the middle river reach, and appear to control the formation of side channels and sloughs that provide the most valuable fish habitat in the reach.

The 1984-to-1985 ice observations focused on the lower river. R&M established cross-sections and surveyed them throughout the winter to relate ice processes and river morphology. R&M also studied the relationship between tidal processes and ice bridge formation at the mouth of the river. Caution was advised in drawing general conclusions as this was a very mild and dry fall. In the years prior, ice cover formation and progression in the lower river were heavily influenced by frazil ice contributed from the rapids in Vee, Watana, and Devil Canyons. During freeze-up in 1984–1985, the dominant frazil ice contributions at the confluence tended to be from the Chulitna and Talkeetna Rivers rather than the middle and upper Susitna, although relative contribution of frazil ice changed dramatically as freeze-up progressed. R&M also measured the porosity of slush ice on the Susitna River throughout the freeze-up period. Slush ice porosities were significantly lower in the lower Susitna River than published values, which they attributed to the up-to-200-mile distance that the frazil traveled downstream.

In 1984, Harza-Ebasco Joint Venture conducted a numerical simulation of ice cover progression before and after the project on the middle river (Harza-Ebasco 1984b). The simulation was calibrated to R&M's previous observations of ice formation for the pre-project condition, and relied on temperature modeling results for the post-project condition. Harza-Ebasco predicted that freeze-up would be delayed by up to 6 weeks in the lower Susitna River because the upper basin would not be contributing frazil ice during early freeze-up. They also predicted that a reach below Devil Canyon dam would never form an ice cover because of the elevated temperature of the water released from the reservoir.

Specific information needed

- Additional middle and lower river baseline data, where relevant, is needed to understand the potential effects of the current Susitna-Watana Hydroelectric Project proposal on fish habitat as a result of changing ice regimes.

  Existing studies highlight the importance of frazil-ice production in middle and upper Susitna rapids to ice cover progression on the lower river. However, these do not quantify the relative contribution of frazil and slush ice from the reach above Watana versus Devil Canyon and below. The rapids in Devil Canyon are well-suited to producing frazil ice, but they are also at a lower elevation than rapids near Denali, Vee, and Watana and thus typically produce frazil later. Middle River ice studies should focus on the relative timing and contribution of frazil production upstream and downstream of Watana.
- Increased understanding of the relationship between ice processes and slough and side channel formation on the lower river to the extent relevant to anticipated project effects.

  Most detailed lower river observations took place during an unusually mild, dry fall. R&M's five years of observation have shown that ice cover formation varies dramatically with climate. Additional observations of ice cover formation should be undertaken with the goal of understanding how ice processes affect side channel and slough habitat on the lower river.
- Understanding of the relative contribution of upper Susitna basin to the snowmelt peak.

  The relationship between streamflow, climate, and breakup processes on the middle and lower river should also be derived as much as possible from existing data.

HG-3: Slough groundwater/surface water studies

Rationale

Along alluvial rivers, subsurface flow and upwelling in the floodplain is directly related to the stage of the river. Where the floodplain is broad, the stage of the river may affect flow in side sloughs miles from the river. Understanding the connection between river stage and upwelling water in sloughs is necessary to evaluate the effects of changing flow stages during project operations. The 1985 Aquatic Plan of Study (Harza-Ebasco 1984a) stated that studies to date were inconclusive regarding the effects of river stage changes on slough hydrology.

Available and relevant information

R&M conducted slough hydrology studies from 1980 to 1982 (R&M 1982b) and collaborated with Harza-Ebasco to conduct additional slough studies in 1983 and 1984 (Harza-Ebasco and R&M 1984). The goal of these studies was to determine the sources of slough inflow at different river discharges. R&M studied four sloughs in detail, all of them between Talkeetna and Devil Canyon. They concluded that although the sloughs had roughly similar geometry in relation to the mainstem, each slough was unique in terms of relative contributions of tributary inflow, lateral subsurface flow from the mainstem, and other groundwater. These contributions also varied seasonally—in the winter, ice cover in the main channel increased river stage over open-water conditions for the same discharge, leading to increased groundwater levels in the sloughs.

Each slough was separated form the mainstem by a gravel berm, but the frequency of berm overtopping flows was different for each slough. R&M completed a slough water balance study in 1985 for three middle river sloughs. Each slough had somewhat different inputs, but the consistent characteristic among them was that the water level was strongly related to mainstem discharge at water levels below berm overtopping.

ADF&G identified 19 sloughs and side channels important to spawning on the lower river (1985), and determined the mainstem discharges necessary to breach each one. Typically, the lower river sloughs were breached at more frequent flows that the middle river sloughs. ADF&G did not attempt to quantify the groundwater contribution to these sloughs.

Specific information needed

- Existing slough studies indicate that each slough has a unique relationship to mainstem water levels. Year-round information is available only for middle river sloughs. The importance of groundwater contribution to lower river sloughs, especially in the winter, could be useful depending on the relative sensitivity of these areas to likely effects of the Project. As mentioned in the ice data gap (HG-2), additional winter observations are needed to determine the relationship between ice processes and slough occurrence on the lower river.

HG-4: Middle and lower river change analysis

Rationale

Several reaches of the Susitna River are dynamic, with shifting channels and islands. Some shift seasonally, while other reaches appear to change slowly over many years. Flow, sediment transport, and ice all affect the form of the river. An understanding of the historical range of channel forms, trends toward degradation or aggradation, and bank stability is necessary before being able to evaluate the effects of the proposed project.

Maintenance of side channel and slough habitat for fish in the middle river (between the dam site and Talkeetna) was identified during the 80s as a key concern in mitigating the environmental effects of the proposed project. The natural condition and evolution of slough and side channel habitat needs to be understood before the effects of the dam operation or the potential for mitigation can be discussed. Previous studies indicate that sloughs and side channels were evolving through a trend of main channel degradation in the middle reach.

This is based on aerial photo analysis of the middle river between 1949 and 1982. It is unknown whether this degradation has continued, stopped, or whether aggradation has occurred over the last 25 years.

The Chulitna River supplies a large amount of the sediment to the Susitna River, and its confluence is an especially complex and unstable location that is likely to be susceptible to change under project conditions. Detailed morphology studies of the confluence area and below have not been undertaken

Available and relevant information

R&M conducted a River Morphology analysis in 1982 that included the lower 149 miles of the Susitna River, from Devil Canyon to Cook Inlet (1984b). The report divides theses 149 miles into 9 reaches, and for each reach describes channel pattern, local geology, channel processes, and a comparison between 1951 and 1980 photography to assess channel stability. The analysis also contains a summary of potential post-project changes for each reach. More detailed information is available for the reaches between Devil Canyon and Talkeetna than for lower river reaches, and the lower river reaches are significantly longer (20 to 42 miles instead of 4 to 10 miles).

The 1985 report *Geomorphic Change in the Middle Susitna River since 1949* details changes in channel morphology between 1949 and 1982 (Lebelle et al. 1985). AEIDC compared aerial photography from 1949, 1977 to 1978, and 1982, focusing especially on middle river sloughs. The study concluded that the middle Susitna River has undergone slow degradation (lowering of the main channel) since 1949, and that side channels and sloughs are evolving to be progressively higher from the main channel. The report did not mention the influence of ice processes on maintaining these sloughs. AEIDC also concluded that the middle Susitna River is primarily a transport reach, where sediment transported into the reach is transported out of the reach with little storage.

Harza-Ebasco conducted a *Middle River Sedimentation Study and Stability Analysis* (Harza-Ebasco 1985) to evaluate potential effects of reservoir operations on the morphology of the middle river, especially sloughs and side channels, and the potential for armoring or silting-over of bed materials. This study concluded that some reaches would likely aggrade and others degrade, depending on tributary input. The study also concluded that sloughs would be breached less often and may silt in. This study did not take into account the effect of ice processes on slough breaching and flushing.

R&M conducted a reconnaissance survey of channel features, water depth, and velocity in Devil Canyon reach in 1981 (R&M 1981b). An observer was lowered into the canyon on a rope in the spring and conducted the survey perched on massive ice shelves that were anchored to the canyon wall. The observer reported approximate channel characteristics, and developed a map of the canyon that was not apparently captured on microfiche.

Instream flow and fish habitat studies also contain narrative information and cross-section surveys that are useful in characterizing channel morphology in the lower river. ADF&G (ADF&G 1985) conducted side channel and slough habitat studies and related these to mainstem conditions.

ADF&G (Mouw 2011) is conducting a study of river morphology and vegetation along the middle Susitna River. The study investigates the contribution of vegetation and moderate flood flows to channel form.

Specific information needed

- An updated representative change analysis for the river between Devil Canyon and Cook Inlet with current aerial imagery. The analysis could focus on reaches that were identified as unstable (Chulitna confluence, Delta Islands from RM 61 to 42), and middle river slough reaches.
- Repeat cross-section measurements to verify whether degradation in the middle river has continued, increased, or reversed during the 30 years since the original studies.
- Analysis to identify sloughs or side channels that have been created or disappeared since the original mapping took place. Special emphasis should be place on determining the extent of change to study sites utilized in the 1980s for habitat and instream flow analysis.

HG-5: Chulitna confluence and lower river sediment transport and aggradation study

Rationale

The Chulitna River supplies 10–30 times more bedload than the Susitna River above Talkeetna. The influx of sediment causes the Susitna River to abruptly change planform from a single channel to a broad multi-channel braidplain. With lower post-project summer peak discharges, bedload transport may decrease below the confluence and throughout the lower river. Aggradation near Talkeetna may push the Susitna River toward Talkeetna, may increase flood elevations at Talkeetna, and may affect tributary and side channel access throughout the lower river.

Available and relevant information

The USGS conducted sediment transport studies along the Susitna River, Chulitna River, Talkeetna River, and Yentna River between 1980 and 1985 (Knott and Lipscomb 1983, 1985; Knott et al. 1986). These studies are summarized in Open File Report 87-229 (Knott et al. 1987). The USGS characterized seasonal sediment loads, and computed flow vs. sediment transport for each site for suspended sediment and bedload. Suspended load relationships were linear-logarithmic and divided into silt-clay load and sand load, each with different exponents for each sampling site. Only a few sites were sampled in the winter months, however, and winter relationships between streamflow and suspended sediment transport were weak. Bedload transport did not increase linearly with discharge at the all sites. The authors hypothesized that the Chulitna and Talkeetna Rivers, for which the bedload/flow relationships are different for different flows, tend to have more transport capacity than sediment supply. Sediment in storage is rapidly exhausted during the rising limb of the hydrograph in the spring, after which there is a lag before additional sediment is moved from upstream to replenish storage areas. Computed relationships corresponded well to measurements taken during low to moderate discharges, but not to measurements taken during and after storms. An estimate of mean annual bedload and suspended load transport is provided, with the understanding that the estimates may not capture the true transport of bedload during and after high flow events, particularly at Chulitna, Talkeetna, and Sunshine Station.

Realizing the complexity of the sediment transport problem at the Chulitna River confluence, APA commissioned the Iowa Institute of Hydraulic Research to develop a quasi-steady, one-dimensional flow numerical model of sediment transport for the 14-mile reach of the Susitna River from the Chulitna confluence downstream to Sunshine Station (Holly 1985). The model was based on sediment transport data from 1981 and 1982, as the following years of data collection had not yet been completed. The topography was derived from 28 cross-sections (approximately 1 every ½ mile) measured by R&M and aerial photography (Ashton and R&M 1985). The model was still in development as of the writing of the report in 1985, and the companion report referenced in Hoffman (1985) was not found in the Susitna documentation.

The *Reservoir and River Sedimentation Final Report* (Harza-Ebasco 1984a) does not mention the numerical model, but uses the preliminary sediment-discharge rating curves developed by the USGS in 1984 to predict a general trend toward aggradation downstream of the confluence.

Specific information needed

- Updated estimates and measurements of sediment transport during summer high flows at the Chulitna, Talkeetna, and Susitna Rivers to refine the sediment-discharge rating curve.
- Evaluation of existing sediment transport and storage regimes in reaches downstream of Sunshine Station in order to identify those reaches most vulnerable to upstream changes in sediment supply and transport.

HG-6: Large woody debris recruitment and transport

Rationale

Little is known of the role of large woody debris (LWD) in the morphology and aquatic biology of braided, glacial rivers. LWD likely plays an important role in island formation and stabilization, as well as side channel and slough avulsion and bank erosion. If the project increases or decreases bank erosion along forested floodplains, the supply of large woody debris will increase or decrease. An assessment of the sources of LWD and their role in channel form and aquatic habitat is needed.

Available and relevant information

High-resolution aerial photography from previous studies can be used to identify reaches where LWD accumulates in channel. Draft studies by ADF&G (Mouw 2011) identify middle Susitna River riparian vegetation classes.

Specific information needed

- Information regarding the sources of LWD (forested banks along the river with evidence of tree recruitment), locations of LWD in the river channel where appropriate, and relationship of LWD to channel or slough habitat.

HG-7 Climate change and variability

Rationale

Since the original studies in the 1980s, the influence of large scale warm/cool cycles such as the Pacific Decadal Oscillation (PDO) and El Niño Southern Oscillation (ENSO) on streamflow have been recognized. These cycles have been studied in Southeast Alaska, in non-glacial, temperate, small basins, but have not been studied in the Susitna watershed, which includes both glacial and non-glacial tributaries and several climatic zones. PDO and ENSO are related to long term (several years to decades) climate anomalies, which produce higher or lower than average streamflow. Understanding the distribution of these anomalies is the historical record in necessary in accurately evaluating future water supply above and below the dam for energy and environmental purposes. Climate warming introduces further uncertainty into water supply above and below the proposed dam for the life of the project.

Available and relevant information

No studies have been done to identify climate trends in the Susitna River specifically; however most of the necessary data already is available. USGS streamflow records from multiple decades exist in the basin. The forthcoming synthesized flows will increase the period of record. PDO indices are available from the University of Washington, and ENSO indices are available from the Climate Data Center.

The U.S. Air Force (USAF; Cherry 2010) conducted studies relating climate indices to streamflow in Southeast Alaska specifically to assess whether water supply predictions could improve existing hydropower operations. The studies indicated that several dams had been constructed after several relatively wet decades, and that water (and energy) supply had been over predicted. PDO and ENSO both were significantly related to streamflow.

Specific information needed

- Synthesis of long-term streamflow records from HG-1 to derive the relationship between long-term climate cycles and seasonal water supply above and below the proposed dam.

HG-8: Glacial contribution to streamflow in the Susitna Basin

Rationale

Glaciers in the Susitna Basin were receding during the historical period leading up to the 1980s studies. The studies found that glaciers at the heads of Susitna and McLaren Rivers are temperate, surge-type glaciers that have been decreasing in volume, sometimes very rapidly during surges. It was estimated that 3 to 15 percent of the streamflow in the Susitna Basin above the proposed dam was derived from glacial meltwater. Although continued glacial melt will increase flows into the reservoir, once glacial storage has decreased beyond a certain point, flows will decrease, especially in late summer. The same is true for the Chulitna and Yentna Rivers.

Available and relevant information

R&M in cooperation with the University of Alaska, Fairbanks (UAF; R&M and Harrison 1981) conducted the first glacial studies for the 1980s APA Project. R&M characterized the upper Susitna Basin glaciers, conducted a mass-balance study, and estimated glacial meltwater contribution to the upper Susitna River was on the order of 10 to 15 percent. Harrison et al. 1983 conducted reconnaissance studies, concluding that the Susitna Basin glaciers were temperate and exhibited pulse or surge behaviors. They identified that Eureka Glacier was on the drainage divide and could retreat so that all of Eureka Glacier flowed into a different basin. They also identified problems of estimating long-term sediment transport downstream from episodically surging glaciers.

Clarke (1986) completed his Masters thesis at UAF on glacial mass-balance studies in the Susitna Basin. He concluded that while glaciers covered about 5 percent of the watershed area contributing to the Susitna River at Watana, glacial runoff produced about 15 percent of the volume of water. Clarke refined the original estimate by R&M of 13 percent glacial meltwater contribution to the streamflow at Gold Creek (R&M Consultants and Harrision 1981) by looking at additional headwaters glaciers. He estimated that the contribution of glacial melt (water not replenished by precipitation) averaged about 3 percent over the period of record between 1949 and 1982. These values still have significant error associated with topographic estimates of the glacier surfaces for different time periods.

Clarke (1991) describes the surge behavior of the Susitna, West Fork, and East Fork Glaciers (all draining into the upper Susitna River) and the resulting pulses of meltwater and sediment discharges into the Susitna River. The glaciers are all temperate and exhibited rapid thinning surges approximately every 50 years. Following this paper, Harrison et al. (1994) described the 1987-to-1988 surge of the West Fork Glacier in the upper Susitna Basin.

The USGS Benchmark Glacier studies indicate that since the 1980s, Gulkana Glacier (which drains the Alaska Range to the east of the Susitna Basin has undergone a more rapid loss of volume than it had the previous 30 years (USGS 2008). It is likely that the upper Susitna glaciers have likewise undergone more rapid melting than during the study period of 1949 to 1983.

Specific information needed

- An updated estimate of the glacial meltwater contribution to streamflow in the Susitna River, and the likely trend of glacially derived streamflow for the next century.

HG-9: Hydrology and Geomorphology Data Rescue

Aerial imagery is available for various reaches of the river since 1982. This imagery would be useful in characterizing recent changes in channel morphology.

Linework depicting channel banks and islands are available from several studies. This linework would need to be digitized to be of most use in characterizing channel change since the 1980s.

9 Instream Flow

Flow quantity and timing of water in the Susitna River are needs of its aquatic resources, as well as being important to power generation, energy benefits, and economic feasibility of the proposed Susitna-Watana Hydroelectric Project. This analysis summarizes knowledge related to instream flow needs of Susitna River aquatic resources, and identifies gaps in existing information that would need to be filled in order to assess impacts of the proposed project.

The purpose of instream flow studies is to develop flow-habitat relationships that can be used by decision makers, along with other information, to balance the proposed hydroelectric project flow needs with the needs of the instream resources. Resident and anadromous fish are the primary aquatic resources of interest in the Susitna River.

9.1 Potential Data Gap Topics

IF-1: Instream Flow Study

Rationale

Habitat versus flow relationships are necessary to model project effects on selected species/lifestages affected by alterations in mainstem discharge. Although instream flow and associated studies undertaken for the 1980s APA Project were extensive, the studies' scope and objectives may require revision due to changes in government policies and regulations, changes in the status of certain fish populations, physical and environmental changes in the Susitna River, differences in configuration/design between the APA Project and the proposed Susitna-Watana Hydroelectric Project, and improvement in study methods and technology.

While many of the decisions and much of the thinking that went into the APA Project instream flow study may still be relevant today and should be used to the greatest extent possible, a new instream flow study will be required for the following reasons:

- APA Project instream flow study focused on the middle section of the river, with much less attention to the lower river, below Talkeetna, or the upper river above Devil Canyon.
- The study only directly evaluated flow habitat relationships for chum salmon spawning in sloughs and Chinook juvenile in side channels (direct study of a wider range of evaluation species/lifestages and channel type combinations may be required).
- The population status of some species may have changed, which could result in a different prioritization of evaluation species today.
- Habitat suitability criteria used in the APA Project instream flow study for chum spawning and Chinook juvenile may or may not be adequate today.
- Assumptions then about the sensitivity of different habitat types to flow changes and subsequent prioritization of habitat types may not be adopted today.
- The listing of the CIBW as endangered and designation of critical habitat in the lowermost reach of the Susitna River may affect prioritization of species and may require an understanding of the effects of the proposed Project on beluga mud-flat habitat at the mouth of the river.

- Advances in data collection technologies permit the collection of more data in more detail than could be collected in the early 1980s.
- The proposed Susitna-Watana Hydroelectric Project configuration is different than the APA Project configuration.
- Stakeholder interests and concerns have likely changed.
- Advances in computer technology permit the analysis of much larger data bases and many more variables in ways not possible in the early 1980s.

Available and relevant information

Instream flow studies of the Susitna were conducted by the APA for the previous hydroelectric project (FERC No. 7114) proposed in the early 1980s (herein referred to as the APA Project).

The 1980s APA Project instream flow study efforts focused on establishing the relationships between physical variables, fluvial processes and fish resources in the middle Susitna River. Faced with the complexity of the number of environmental variables involved and the number of species of fish which inhabit the middle Susitna River, it was deemed necessary to focus only on the most important physical variables and carefully identified fish resources which were most sensitive to project-related changes (Trihey & Associates and Entrix 1985b).

An instream flow study is a multi-faceted undertaking that requires information and data from many sources and disciplines, including: stakeholder and resource agency collaboration; fish biology, and population; channel structure and substrate; habitat needs by species; habitat typing and distribution; hydraulics; hydrology; fluvial geomorphology; water quality; and water temperature; among others.

Considering the above required data and information needs, this instream flow gap analysis addresses the following major study elements of an instream flow study.

- Study methods
- Baseline or reference conditions
- Geographic extent of study
- Major channel/habitat types
- Selected evaluation species/lifestages
- Species/lifestage longitudinal distribution and utilization of major channel/habitat types
- Seasonal timing of utilization of evaluation species/lifestages
- Habitat suitability criteria for evaluation species/lifestages
- Macrohabitat variables affected by flow alterations
- Hydrologic record for with-project and without-project

A substantial body of excellent and well documented information relevant to several of these elements is available in the environmental baseline study reports prepared for licensing of the APA Project. These reports are collectively referred as the Instream Flow Relationships reports (IFRR).

Instream flow study methods

The only instream flow studies known to have been conducted on the Susitna River were those conducted in the 1980s for licensing the APA Project. These studies are documented in the IFRR and FERC licensing documents. Table 9.1 is a summary of the IFRR primary instream flow study methods for the APA Project. There are "sub-methods" not listed. A rigorous analysis of the IFRR and associated reports would be necessary to understand the full breadth of the methods and results and determine the current value and applicability of the IFRR studies to an instream flow analysis of the proposed Project.

One methodology applied in the APA Project instream flow study is the Physical Habitat Simulation (PHABSIM) component of the Instream Flow Incremental Methodology (IFIM). IFIM is one of the most widely used instream flow methods in the world for assessing the effects of flow manipulation on river habitats (Bovee et al. 1998). The PHABSIM component was a key methodology applied in the IFRR. Because of the size and geomorphic and hydraulic complexity of the Susitna, other methods, in combination with the PHABSIM, were required to adequately characterize and model habitat flow relationships. Other methods included upstream passage studies for anadromous salmonids and wetted surface area/habitat studies of sloughs and off-channel habitats. APA Project instream flow methods and elements of the studies for each species/lifestage are presented in Table 9.1.

Table 9.1 Summary of IFRR instream flow study methods

Evaluation Species and Lifestage		Type and Elements of Study				
Evaluation Species	**Evaluation Lifestage**	**Channel Type If PHABSIM Conducted**	**Passage Study or Assessment**	**Wetted Surface Area/Habitat**	**Used Surrogate Species Shown**	**Incomplete Study or No Specific Instream Flow Study Conducted**
Chum	Adult Passage		X	—	—	—
	Spawning	Side slough and Side channel	—	—	—	—
	Incubation	Side slough and Side channel	—	—	—	—
	Juvenile Rearing	—	—	—	—	X
Chinook	Adult Passage	—	X	—	Chum	
	Spawning	—	—	—	—	X
	Juvenile Rearing	Side channel only	—	—	—	—
Sockeye	Adult Passage		X	—	Chum	—
	Spawning	Side slough and Side channel	—	—	Chum	—
	Juvenile Rearing	—	—	X	—	—
Coho	Adult Passage	—	X	—	Chum	—

Evaluation Species and Lifestage		**Type and Elements of Study**				
Evaluation Species	**Evaluation Lifestage**	**Channel Type If PHABSIM Conducted**	**Passage Study or Assessment**	**Wetted Surface Area/Habitat**	**Used Surrogate Species Shown**	**Incomplete Study or No Specific Instream Flow Study Conducted**
	Spawning	—	—	Tributary mouth	—	—
	Juvenile Rearing	—	—	Tributary mouth	—	—
Pink	Adult Passage	—	X	—	Chum	—
	Spawning	—	—	—	—	X
	Juvenile Rearing	—	—	—	—	X
Rainbow Trout	Adult	—	X	—	Chum	—
	Spawning	—	—	—	—	X
	Juvenile Rearing	—	—	—	—	X
Dolly Varden	Adult	—	X	—	Chum	
	Spawning	—	—	—	—	X
	Juvenile Rearing	—	—	—	—	X
Arctic Grayling	Adult Rearing	—	X	—	Chum	—
	Spawning	—	—	—	—	X
	Juvenile Rearing	—	—	—	—	X
Burbot	Adult Rearing	—	X	—	Chum	—
	Spawning	—	—	—	—	X
	Juvenile Rearing	—	—	—	—	X

Source: Trihey & Associates and Entrix 1985b

Baseline or reference conditions

Baselines serve as the benchmarks for developing and evaluating flow alternatives. They establish the reference points against which comparisons are made. Instream flow studies using IFIM usually intend the baseline to represent existing conditions of hydrology, water use and management, prevailing thermal regimes, and water quality (Bovee et al. 1998). For a developed project, the baseline can be either with the project in place or pre-project. For a developed project, pre-project baseline conditions must be modeled.

Baseline conditions for the 1980s APA Project would likely be the existing condition; i.e., without project. Baseline information for evaluating instream flow study results would include time series data (empirical, modeled, or a combination) of hydrology, temperature, and water quality. The period of record for these variables will depend on the availability of existing data and the reliability of model extrapolation to unmeasured periods.

The geomorphic baseline is different than time-series baselines. The geomorphic baseline refers to watershed characteristics, land use, and water management practices that affect the structure, pattern, and stability of the river channel and floodplain (Bovee et al. 1998). Whether the existing channel morphology will remain the same, or at least be in "dynamic equilibrium," once the proposed action has occurred is a significant question in an instream flow study (Bovee 1982). Instream flow versus habitat relationships developed for today's river assumes that similar relationships will persist for the period of time the project is in place, within a reasonably defined range of variability.

Baselines for evaluating instream flow study results were not specifically addressed in the 1980s APA Project report series. Final identification and selection of specific baselines or reference conditions would be done in collaboration with stakeholders primarily during the planning stage and scoping stage of the instream flow study. The question of how and to what extent potential project induced changes in geomorphology affect flow/habitat predictions will also need to be addressed during the planning and scoping phases.

Geographic extent of the instream flow study

The Watana instream flow study would be a project impact study, as defined by Bovee (1982), in which the riverine project impact is confined to the portion of the river system likely affected by the proposed activity.

The 1980s APA Project IFRR studies focused on the middle river from the proposed Devil Canyon Dam at RM 150 downstream to the confluence with the Talkeetna River at RM 103 (Trihey & Associates and Entrix 1985b). APA's reasoning for the lower boundary just above Talkeetna was the assumption that cumulative flow from downstream tributaries, primarily the Chulitna, Talkeetna, Kashwitna, and the Yentna, rivers, would sufficiently buffer the effects of the proposed project on habitat in the lower river.

The *Susitna Hydroelectric Project Aquatic Plan of Study – Fiscal Year 1985* (Harza-Ebasco et al. 1984a) states that:

> …resource management agencies have questioned the lack of focus on the lower river. The agencies are concerned that, even though with-project physical changes may be relatively small, there is little quantitative support to justify the conclusions that project-related impacts to the lower river fisheries resources would not be significant. Project-related impacts could be greater than projected either because the fish and/or their habitats in the lower river are more sensitive to expected physical changes or the fish are much more abundant so relatively small environmental changes could have a larger net effect on fish populations.
>
> The final decision on geographic extent of the instream flow study for the Watana Project will be made in collaboration with stakeholders and will be based on study needs. Existing information for defining the lower study area boundary includes

the 1980s APA Project report series, current technical reports on use of the lower Susitna by species of interest, and the knowledge of agency experts and others on occurrence and use of the lower river by species of concern. Also needed is a general understanding of predicted with-project hydrology in the lower river.

Major channel types

Much of the Susitna River in the study area is an extremely complex network of channels, each with a different channel/flow response to changes in mainstem discharge. While each channel is unique, they can be grouped into different channel types with similar characteristics in both morphology and general hydraulic response/sensitivity to changes in mainstem discharge. Each channel type also has similarities in species/lifestage utilization. The APA Project instream flow study was designed specifically to analyze the various channel types in the study area. The process for identifying and prioritizing major channel types involved extensive and detailed field data collection, analysis, and documentation of the hydraulic and hydrologic relationships between the major channel types and mainstem discharge.

Specific areas were categorized into one of the following seven basic channel types based upon their instantaneous hydraulic and morphologic characteristics (Harza-Ebasco 1985).

Mainstem - By definition most sensitive to changes in main stem discharge since habitat conditions in terms of surface area, depth, and velocity vary continuously with discharge.

Side channels - Less sensitive but are directly affected by mainstem discharge sufficiently great to breach the upstream ends of the channels. In general, side channels convey mainstem water more than 50 percent of the time during the summer, open water season.

Tributary mouth - Habitats occur at the confluence of the tributaries with the mainstem. The aerial extent of this habitat type is dependent not only upon mainstem discharge but also on tributary discharge. To some extent both mainstem and tributary discharge will affect the specific location of this habitat type.

Side sloughs - Less responsive to mainstem discharge changes in that mainstem discharges sufficiently great to breach the upstream ends occur less than 50 percent of the time during the open water season. However, at lower discharge levels, the mainstem discharge may affect slough habitat conditions, particularly at the mouths, through backwater effects. Mainstem discharge less than that sufficient to breach the upstream end may also affect habitat conditions through the influence on groundwater upwelling.

Upland sloughs - Relatively insensitive to mainstem discharge. The major effects on upland sloughs by changes in mainstem discharge are changes in surface area, velocity, and depth due to backwater effects. Changes in mainstem discharge generally will not affect discharge or water quality parameters in the upland slough.

Tributaries - Although continuous with the mainstem, are not affected by changes in mainstem discharge. Habitat conditions in tributaries are dependent only upon tributary discharge. Similarly, habitat conditions in lakes and streams within the basin are unaffected by changes in mainstem discharge. In some cases, the lakes or ponds are completely independent of the mainstem with no interconnecting body of water. In other cases, outlet streams from the lakes or ponds do provide a surface water connection with the mainstem.

Lakes and ponds - Not studied in the middle river IFRR for reasons described under Tributaries, above.

Channel type designations in the APA study appear to be valid and appropriate, although the extent of change over the past 25 years is unknown.

Selected species/lifestages

There are several reasons why it is necessary to identify and select evaluation species/lifestages. The primary reasons are to: a) focus the study on species of key importance; b) avoid an analysis overload where possible without sacrificing needed information; and c) avoid analysis of species of lesser importance or that are only marginally affected by the project.

Most approaches to selecting the species/lifestages for evaluation in an instream flow study agree on the following criteria, where appropriate.

- Commercial, sport, or subsistence value.
- Endangered Species Act (ESA) or species of special concern, (example Board of Fisheries stocks of concern)
- Critical species/lifestage (species/lifestage particularly sensitive to changes in flow such as non-mobile or limited mobility lifestages).
- Prey base species, including both fish and macroinvertebrates, utilized by commercial, subsistence, and sport fish.
- Prey base species that are identified as in a critical habitat designation under the ESA. Prey base species for the listed CIBW would include, but may not be limited, to salmon and eulachon.
- Key ecological species.

Target species in the APA Project instream flow study were selected after initial baseline studies and impact assessments had identified the dominant species and the potential impacts on available habitats throughout the year. Species were selected on the basis of the following criteria (Trihey & Associates and Entrix 1985a, 1985b):

- High human use value
- Dominance in the ecosystem
- Sensitivity to project impacts

The following are excerpts from Harza-Ebasco that provide the “thinking” behind the selection of evaluation (target) species.

Since the greatest changes in downstream habitats were expected in the reach from Devil Canyon to Talkeetna, fish using that portion of the river were considered to be the most sensitive to project effects.

Because of the differences in their seasonal habitat requirements, the 1980s APA instream flow team determined that not all fish species or life stages would be equally affected by the proposed project. In the middle river, chum and sockeye salmon spawning, incubation, and early rearing in sloughs and juvenile Chinook salmon rearing in the mainstem appear to be most vulnerable because of their dependence on these habitats.

Chum salmon were designated primary over sockeye because they are the most dominant species in the middle river.

Spawning and incubation life stages for Chinook and coho salmon occur in tributaries. This habitat type will not be affected by the project. Much of the Chinook rearing occurs in tributaries (again, not affected by the project) and in turbid mainstem side channels.

Coho rearing occurs in tributaries and upland sloughs, both of which should not be affected.

Chum spawning and incubation occurs in both tributaries and side sloughs. It is only those that spawn in the sloughs that will be potentially affected.

Sockeye salmon in the middle river only spawn in sloughs. Spawning in these areas is considered atypical because this species generally spawns in streams that have nearby access to a lake for rearing. No such lakes exist in the middle Susitna River, however, the few sockeye that do spawn in the middle river are able to utilize upland sloughs for rearing.

While some pink salmon spawn in slough habitats in the middle river, most of these fish utilize tributary habitats. Mitigation measures proposed to maintain chum salmon productivity will allow sockeye and pink salmon to be maintained as well. Maintenance of Chinook rearing habitat will provide sufficient habitat for less numerous resident species with similar life stage requirements.

In conclusion, two principal species/habitat combinations were selected to evaluate the response of habitat to changes in flow and the subsequent effects on fish. These species/habitat combinations are juvenile Chinook salmon rearing in side channel habitats during the summer, and adult chum salmon spawning in side slough habitat during the summer and chum embryo incubation during early winter months. Juvenile Chinook overwintering in side sloughs will also be discussed to a greater extent than other species habitat combinations. These two species/habitat combinations form the focus of the flow selection and mitigation planning process. (see Exhibit B and Exhibit E, Chapter 2, Section 3). Effects of an altered flow regime on other species will also be discussed. (1985)

The 1980s APA Project instream flow study selected evaluation species and prioritization are presented in summary Table 9.2. Only chum salmon spawning and Chinook juvenile were modeled in the instream flow study.

Table 9.2 Summary of selection and prioritization of evaluation species for the APA Project Instream Flow Study

Species	Returning Adults	Spawning Adults	Embryos and pre-emergent fry	Rearing juveniles	Out-migrant juveniles	Adults	Juveniles
Chum	S	P	P	S	S	—	—
Chinook	S			P	S	—	—
Sockeye	S	S	S	S	S	—	—
Coho	S	—	—	S	S	—	—
Pink	S	S	S		S	—	—
Arctic grayling	—	—	—	—	—	S	S
Rainbow trout	—	—	—	—	—	S	S
Dolly Varden	—	—	—	—	—	S	S
Burbot	—	—	—	—	—	S	S

Source: Harza-Ebasco 1985
P = Primary priority species/lifestage S = Secondary priority species/lifestage

Species/lifestage longitudinal distribution and utilization of major channel types

The longitudinal distribution of evaluation species/lifestages and utilization of major channel/habitat types is necessary information for an instream flow study. This is particularly necessary for a study area as large and complex as the Susitna study area. Different instream flow methods or method variations will be applied based on the species/channel type combination. Field studies may be conducted differently and data may be analyzed differently depending on the species/habitat combination and the longitudinal location of the study site relative to the dam and the amount of side flow accretion that enters between the dam and the study site. For instream flow decision making, where and what habitat types are utilized by different species is important information.

The primary source of information on species/lifestage longitudinal distribution and utilization of major channel types in the Talkeetna to Devil Canyon (middle river) is found primarily in *IFRR Technical Report 1—Fish Resources and Habitats of the Susitna Basin* (Jennings 1984).

IFRR Technical Report 1 summarized the available information on the fishery resources and habitats of the Susitna River. The report was based primarily on existing reports and analyses generated by other 1980s APA Project studies. The objective of the report was to synthesize and summarize information to describe the biology, relative abundance, and seasonal habitat utilization of important fishery resources of the Susitna River, with a focus on the middle river.

The document provides 172 pages of detailed information. Because of the detail and the large number of species/lifestages, large number of habitat types, and the complex relationships between the two, a summary of longitudinal distribution and habitat type utilization is not possible in this gap analysis.

Information from 1980s APA Project studies on species presence and utilization of major habitat types should be reviewed and updated with current data. More recent studies by ADF&G, utilizing advances in capture and tracking technology, should be incorporated into the data base.

For the proposed Project instream flow study species distribution and habitat utilization studies may need to be extended into the upper and lower river sections.

Seasonal timing of utilization by evaluation species/lifestage

The temporal variation or periodicity of a species/lifestage in the use of different sections of the river, channel types, and habitat types is necessary information for an instream flow study. How seasonal alterations in discharge potentially affect selected evaluation species/lifestages will depend to a large part on the seasonal timing of habitat use. Inclusion of temporal variation in habitat usage is particularly important in the Susitna River because of the large number of species/lifestages and their widely variable timing of use and selection of different channel/habitat types.

The 1980s studies also covered seasonal timing and utilization of major habitat types by evaluation species/lifestages was also extensively for salmon species (ADF&G 1985). Seasonal timing of lifestages for the five salmon species included adult migration, spawning, incubation, rearing, and outmigration. Seasonal timing of other species/lifestages was reported in FERC Exhibit E, Chapter 3 (Harza-Ebasco 1985).

Information from APA 1980s APA Project studies on seasonal timing evaluation species/lifestage should be reviewed and updated with current data. More recent studies by ADFA&G, utilizing advances in capture and tracking technology, should be incorporated into the data base.

For the proposed Project instream flow study seasonal timing information on evaluation species may need to be extended into the upper and lower river sections.

Determine habitat suitability criteria for evaluation species/lifestages

Habitat suitability criteria (HSC) are needed for evaluation species if a flow versus habitat model (Physical Habitat Simulation System or River2D) is a selected instream flow methodology for that species/lifestage. The process of developing HSC for a specific instream flow study can range from a literature and professional judgment based HSC with low or no field effort and minimal time and cost to a higher effort and higher cost site-specific field study. Lower field effort does not necessarily mean the HSC is more or less valid for a specific study. According to Bovee (1998), “Category I Criteria [lower intensity] are as valid in an application of IFIM as data-based criteria, if they are supported by a consensus of opinion among the stakeholders.”

The primary documents regarding HSC for the 1980s APA Project instream flow study are: Chapter 9 of *ADFG Technical Report 3 - Habitat Suitability Criteria for Chinook, coho, and Pink Salmon Spawning in Tributaries of the Middle Susitna River* (Vincent-Lang and Queral 1984); *ADF&G Technical Report 7—Resident and Juvenile Anadromous Fish Investigations*

(Schmidt et al. 1985); and Volume II of the *Draft Instream Flow Relationships Repor*t (Harza-Ebasco 1985).

The species/lifestages for which HSC were developed in the 1985 1980s APA Project studies were Chinook spawning and juvenile; chum spawning and incubation; sockeye spawning and juvenile; coho spawning and juvenile; pink spawning; rainbow adult and spawning; Arctic grayling adult, spawning, and juvenile; and burbot spawning. Site specific HSC (HSC development that included Susitna River field studies) are limited to Chinook spawning and juvenile and chum spawning and incubation. HSC for Chinook spawning were developed in tributaries only, juvenile Chinook were developed in side channels exclusively, chum spawning and incubation HSC were developed in sloughs exclusively. Note that the development of HSC for a specific species/lifestage did not necessarily mean that a flow/habitat model was developed for that species.

As shown in Table 9.3, the methods of HSC development for the Susitna Instream Flow Study varied widely between species/lifestages. The greatest effort in HSC development was for Chinook juvenile and chum spawning. At the other end of the methods spectrum were HSC developed from very minimal data for lower priority species.

Table 9.3 is a summary of HSC developed in the 1985 APA Project fisheries investigations. This is not intended to be a rigorous analysis of the HSC development reported in the 1980s APA Project instream flow report series.

Methods of development and rationale for HSC used in the 1980s APA Project instream flow study need to be thoroughly reviewed and analyzed by AEA, resource agencies, and stakeholders. The need for new or revised HSC and how the new or revised HSC will be developed will based on overall study goals and objectives, species/lifestage prioritization, and a collaborative process with resource agencies and stakeholders. HSC developed on other river systems since 1985 could be applied to the Susitna as could the expert opinion of fisheries biologists knowledgeable about habitat requirements of species/lifestages in the Susitna River.

Table 9.3 Summary of HSC developed in the 1985 APA Project fisheries investigations

Species	Lifestage	Microhabitat HSC Developed Using		
		Susitna River Observations; Data from Other Streams/ Professional Opinion	Only Previous Studies on Other Rivers and/or Professional Opinion	HSC Not Developed
Chum	Adult Passage	—	X	—
	Spawning	X	—	—
	Juvenile Rearing	—	—	X
Chinook	Adult Passage	—	—	X
	Spawning	X	—	—
	Juvenile Rearing	X	—	—
Sockeye	Adult Passage		X	—
	Spawning	X	—	—
	Juvenile Rearing	X	—	—
Coho	Adult Passage	—	—	X
	Spawning	—	X	—
	Juvenile Rearing	—	X	—
Pink	Adult Passage	—		X
	Spawning	—	X	
	Juvenile Rearing	—	—	X
Rainbow Trout	Adult	Minimal information	—	—
	Spawning	Minimal information	—	—
	Juvenile Rearing	—	—	X
Dolly Varden	Adult	—	—	X
	Spawning	—	—	X
	Juvenile Rearing	—	—	X
Arctic Grayling	Adult Rearing	Minimal information	—	—
	Spawning	Minimal information	—	—
	Juvenile Rearing	Minimal information	—	—
Burbot	Adult Rearing	—	—	X
	Spawning	Minimal information	—	—
	Juvenile Rearing	—	—	X

Sources: Vincent-Lang and Queral 1984; Schmidt et al. 1985; Trihey & Associates and Entrix 1985b.

Macrohabitat variables affected by flow alterations

The relationship between an aquatic organism and its environment exists at several scales, generally referred to as the microhabitat, mesohabitat, macrohabitat, and watershed scale. Incremental instream flow type models generally operate at the microhabitat and mesohabitat scales. However, habitat at the microhabitat and mesohabitat scales is subdominant to macrohabitat. According to Bovee (1998):

> Macrohabitat is the set of abiotic conditions such as hydrology, channel morphology, thermal regime, chemical properties, or other characteristics in a segment of river that define suitability for use by organisms….During the problem identification phase [of an IFIM] we must determine potential responses of the four major macrohabitat classes (flow regime, channel structure, thermal regime, and water quality) to an ongoing or proposed change in the land or water use.

The major macrohabitat classes were considered in the APA Project instream flow study, particularly Volume II of the *Draft Instream Flow Relationships Report* (Trihey & Associates and Entrix 1985a). Levels of discharge, suspended sediment, turbidity, ice over, and temperature with and with-out the project were cursorily estimated. Although potential effects were discussed, effects of these factors on mesohabitat and microhabitat may not have been incorporated into the flow-habitat model as may be necessary.

An important macrohabitat variable that was not addressed in the APA Project instream flow study is channel equilibrium. The question of whether the existing channel morphology will remain the same, or at least be in "dynamic equilibrium", once the proposed action has occurred is a significant question in an instream flow study. Instream flow versus habitat relationships developed for today's river assumes that similar relationships will persist for the period of time the project is in place, within a reasonably defined range of variability. In the case of the proposed Project instream flow study the question is whether the river is currently in a state of equilibrium or disequilibrium. If it is in a state of disequilibrium, will the state be exacerbated or reversed as a result of the project?

If it is exacerbated or reversed, the impact of the project cannot be assessed without estimating a post project channel configuration (Bovee et al. 1998). The same holds true if the river is currently in a state of equilibrium and shifts to disequilibrium for a significant period of time with the project in place.

Although macrohabitat effects were raised in Volume II of the *Draft Instream Flow Relationships Report* (Trihey & Associates and Entrix 1985a), the discussion focused on temperature and ice formation. While not explicit, the statement in the report also applies to the macrohabitat variable of channel structure. The document states: "The application of aggregate habitat response curves to mainstem discharge involves the assumption that conditions under which they were modeled remain the same. If, however, factors not incorporated in the model become significant under altered discharges in a with-project condition then their application may not be appropriate".

The extent to which the 1980s APA Project and existing fisheries and instream flow information is applicable to licensing studies for the proposed Susitna-Watana Hydroelectric Project will vary depending on the information type. Information that will help support study decisions for the proposed project instream flow studies (such as selection of study methods, selection of evaluation species, or geographic extent of the study area) is probably most useable. Data type information such as site specific physical measurements of survey points or velocity measurements at pin-point locations in the river at a specific discharge are probably least useable because of likely physical changes in the river.

The expert critical thinking of numerous knowledgeable professionals that is reflected in the 1980s APA Project Report Series is also a source of valuable information directly applicable to the development of an instream flow plan of study for the proposed Project.

What information is still applicable, what information needs to be updated, and what information is no longer valid are questions that cannot be answered without an in-depth review and analysis of the voluminous reports and supporting data in collaboration with the resource agencies and stakeholders. A screening process should be undertaken to first determine whether existing conditions are satisfactory and then whether or not they will remain if the flow or sediment load is changed. Before proceeding with an instream flow study, the following questions should be at least considered and accounted for, if not answered.

- What is the potential for temperature to become more of a determinant of habitat suitability (i.e. dominant over the microhabitat variables of depth, velocity, and substrate) at different locations in the river?
- What is the potential for water quality (i.e., DO, TSS) to become more of a determinant of habitat suitability at different locations in the river?
- What is the potential for changes in sediment load (i.e., smothering of benthic biological activity or bed armoring) to be the dominant determinant of habitat suitability at different locations in the river?
- What is the potential for icing to become more of a determinant of habitat suitability at different locations in the river?
- What is the potential for major changes in channel morphology due to the project?
- What is the potential for changes in flow to restrict access by desired species to previously available sections of the river and what is the potential for changes in flow to improve access by undesired species to previously unavailable sections of the river?

These questions should be evaluated in collaboration between AEA, resource agencies, and stakeholders.

Specific information needed

- Instream flow in the lower river to the extent determined to be important below Talkeetna, and the upper river above Devil Canyon
- Instream flow needs for key species and life stages identified through the licensing process
- Current abundance, distribution, and evaluation priority of species in the project area

- Assessment of the adequacy of habitat suitability criteria used in the 1980s APA Project instream flow study for chum spawning and Chinook juvenile for applicability to Susitna-Watana Hydroelectric Project
- Analysis of the suitability of the 1980s study sites for re-use in future study – site change analysis.
- Determination whether the assumptions about the sensitivity of different habitat types to flow changes remain adequate, and whether subsequent prioritization of habitat types remain applicable to the current project
- Impacts of CIBW listing as endangered under the ESA, and the designation of Critical Habitat in the lowermost reach of the Susitna River, on the prioritization of species
- Determination whether the differences between data collected using 1980s technology and that which could be collected using current technology are sufficiently significant to warrant additional studies
- Comparison of the 1980s APA Project configuration and the Susitna-Watana Hydroelectric Project configuration for impacts to instream flow
- Understanding of current stakeholder interests and concerns

10 Marine Mammals

All marine mammals are afforded protection under the Marine Mammal Protection Act (MMPA); additionally, CIBWs are classified as endangered under the ESA. Critical habitat has been designated for the CIBW that includes the Susitna River area. Four other marine mammal species are documented in the upper inlet: harbor seal (*Phoca vitulina*), harbor porpoise (*Phocoena phocoena*), killer whale (*Orcinus orca*), and Steller sea lion (*Eumetopias jubatus*). The Cook Inlet distinct population segment (DPS) of the beluga whale is the most abundant marine mammal in upper Cook Inlet and, specifically, in Susitna delta area. Harbor seals also frequently occur in the delta. Harbor porpoises and killer whales have been sighted in upper Cook Inlet, although their occurrence there is considered rare. The Steller sea lion is unlikely to occur in upper Cook Inlet, because sightings there are also rare. This analysis summarizes knowledge related to marine mammal use of the Susitna River, its mouth, and delta, for use in identifying potential impacts of the proposed Susitna-Watana Hydroelectric Project.

10.1 Cook Inlet Beluga Whales

Five stocks of beluga whale occur in Alaskan waters: Cook Inlet; Bristol Bay; eastern Bering Sea; eastern Chukchi Sea; and Beaufort Sea (Allen and Angliss 2010). The Cook Inlet stock is an isolated population likely confined to Cook Inlet throughout the year (Rugh et al. 2000; Hobbs et al. 2006; Hobbs and Shelden 2008; Hobbs et al. 2008; NMFS 2008). The estimated abundance for the CIBW was 340 individuals in 2010 (Shelden et al. 2010).

Aerial surveys of CIBWs were carried out in 1982 and 1983 as part of the original licensing effort (Harza-Ebasco 1985), confirming the summer aggregation of belugas at the Susitna Delta also documented by more recent surveys (NMFS 2008; Shelden et al. 2010). A time series of data from annual aerial surveys of CIBWs exists for the period between 1993 and 2010 (NMFS 2008; Shelden et al. 2010). Surveys are conducted at the peak of seasonal use of the study area during June and July to support annual abundance estimates. Additional surveys are conducted in August to document presence of calves.

10.1.1 Listing Status

On April 20, 2007, following the completion of a Status Review and Extinction Assessment of CIBWs (Hobbs et al. 2006; Hobbs and Shelden 2008), NMFS published a proposed rule to list the Cook Inlet DPS as an endangered species under the ESA[8]. NMFS extended the final determination date on the listing for an additional 6 months on April 22, 2008[9]. On October 22, 2008, NMFS listed the CIBW as an endangered species under the ESA[10] . Section 7 of the ESA requires that Federal agencies must ensure they do not fund, authorize, or carry out any actions (e.g., issuance of FERC license) that will:

- Jeopardize the continued existence of the listed species
- Destroy or adversely modify designated critical habitat

[8] 72 Federal Register (FR) 19854
[9] 73 FR 21578
[10] 73 FR 62919

10.1.2 Species Occurrence

Aerial surveys conducted since 1993 have consistently documented high use of Knik Arm, Turnagain Arm, Chickaloon Bay, and the Susitna River delta areas of the upper inlet (NMFS 2008). Satellite tagging data further support the high use of these areas by belugas (Hobbs et al. 2005).

Several factors likely influence beluga whale distribution in Cook Inlet. Prey availability, predator avoidance, sea-ice cover and other environmental factors, reproduction, sex and age class, and human activities play an important role in beluga seasonal distribution within Cook Inlet (Rugh et al. 2000; NMFS 2008). Seasonal movement and density patterns as well as site fidelity appear to be closely linked to prey availability, coinciding with seasonal salmon and eulachon concentrations (Moore et al. 2000). CIBWs forage intensely during the summer when prey availability is high and locally concentrated near river mouths (Huntington 2000; Moore et al. 2000). This seasonal feeding is presumably important in providing energy storage and reserves for the winter. Availability of prey species appears to be the most influential environmental variable affecting Cook Inlet whale distribution and relative abundance (Moore et al. 2000). The patterns and timing of eulachon and salmon runs have a strong influence on beluga whale feeding behavior and their movement during the spring and summer (Nemeth et al. 2007; NMFS 2008). The presence of prey species may account for the seasonal change in beluga group size and composition (Moore et al. 2000). Belugas frequent areas near coastal mud flats and river mouths in Cook Inlet from spring through fall (Goetz et al. 2007; NMFS 2008). Beluga whales tend to concentrate at rivers and bays in upper Cook Inlet during summer and fall, then disperse to waters in the mid-inlet during winter and spring (NMFS 2008).

CIBWs exhibit site fidelity to distinct summer concentration areas and are reliably found annually in these areas (Seaman, Frost et al. 1986), typically near river mouths and associated shallow, warm, and low-salinity waters (Moore et al. 2000). Aerial surveys conducted in late April and early May reported beluga whales in the upper inlet as eulachon runs reached the Susitna and Twentymile rivers (NMFS 2008). During the summer, beluga whales are frequently observed along Susitna Flats, gathering at the Susitna and Little Susitna rivers and other small streams on the western side of Cook Inlet, following runs of eulachon, Chinook salmon, and coho salmon (Hobbs and Shelden 2008; NMFS 2008; Allen and Angliss 2010). In late summer and fall, beluga whales aggregate near the mouths of streams on the western side of the inlet south from Susitna Flats to Chinitna (NMFS 2008).

CIBWs appear to calve primarily in the Susitna Flats portion of upper Cook Inlet (Huntington 2000). Calves represented 7–8 percent of whales observed in the Susitna Flats area during various surveys, including aerial and boat-based surveys (Funk et al. 2005; McGuire et al. 2008; McGuire et al. 2009). However, during 2009 photo-identification surveys, 63 percent of whale groups photographed in Knik Arm contained neonates, compared with 47 percent of groups in Susitna, indicating there may be more than one nursery area in upper Cook Inlet (McGuire et al. 2011).

The traditional ecological knowledge (TEK) of Alaska Natives and NMFS aerial survey data document a historical contraction of the summer range of CIBWs (Huntington 2000; NMFS 2008; Rugh et al. 2010; Carter and Nielsen 2011). While belugas were once abundant and frequently sighted in the lower inlet during summer, they are now primarily concentrated in the upper half of the inlet (Rugh et al. 2010). Potential explanations for the range contraction include:

- Habitat change;
- Predator avoidance; or
- Use of spatially limited optimal habitat by a remnant population.

The first indication of a possible recovery may be reoccupation of more peripheral habitats (Rugh et al. 2010).

Large groups of belugas arrive at the Susitna River mouth in the spring during eulachon runs in May and June, and suggesting that Cook Inlet beluga whale distribution is associated with the seasonal presence of prey species (Calkins 1984; Hazard 1988; Nemeth et al. 2007; NMFS 2008). Eulachon runs in the Susitna River number in the several hundred thousand individuals during May, with several million fish present in June (Calkins 1989). Eulachon filled the stomach of one beluga whale harvested at the Susitna delta in 1998 (NMFS 2008), suggesting the importance of Susitna River spring eulachon runs to CIBWs. In summer, as runs of eulachon decline in abundance, belugas begin feeding heavily on Pacific salmon (NMFS 2008).

10.1.3 Critical Habitat

Critical habitat was designated for CIBWs by the NMFS on April 11, 2011[11]. The critical habitat area includes upper Cook Inlet from the upper end of Knik and Turnagain arms to an area south of Kalgin Island, Kachemak Bay, and nearshore areas extending from Tuxedni Bay to Kamishak Bay[12] (Figure 10.1). Proposed critical habitat for the Cook Inlet beluga whale is present in lower reach and mouth of the Susitna River. The lower Susitna River, mouth, and delta are located in Area 1 of the designated critical habitat.

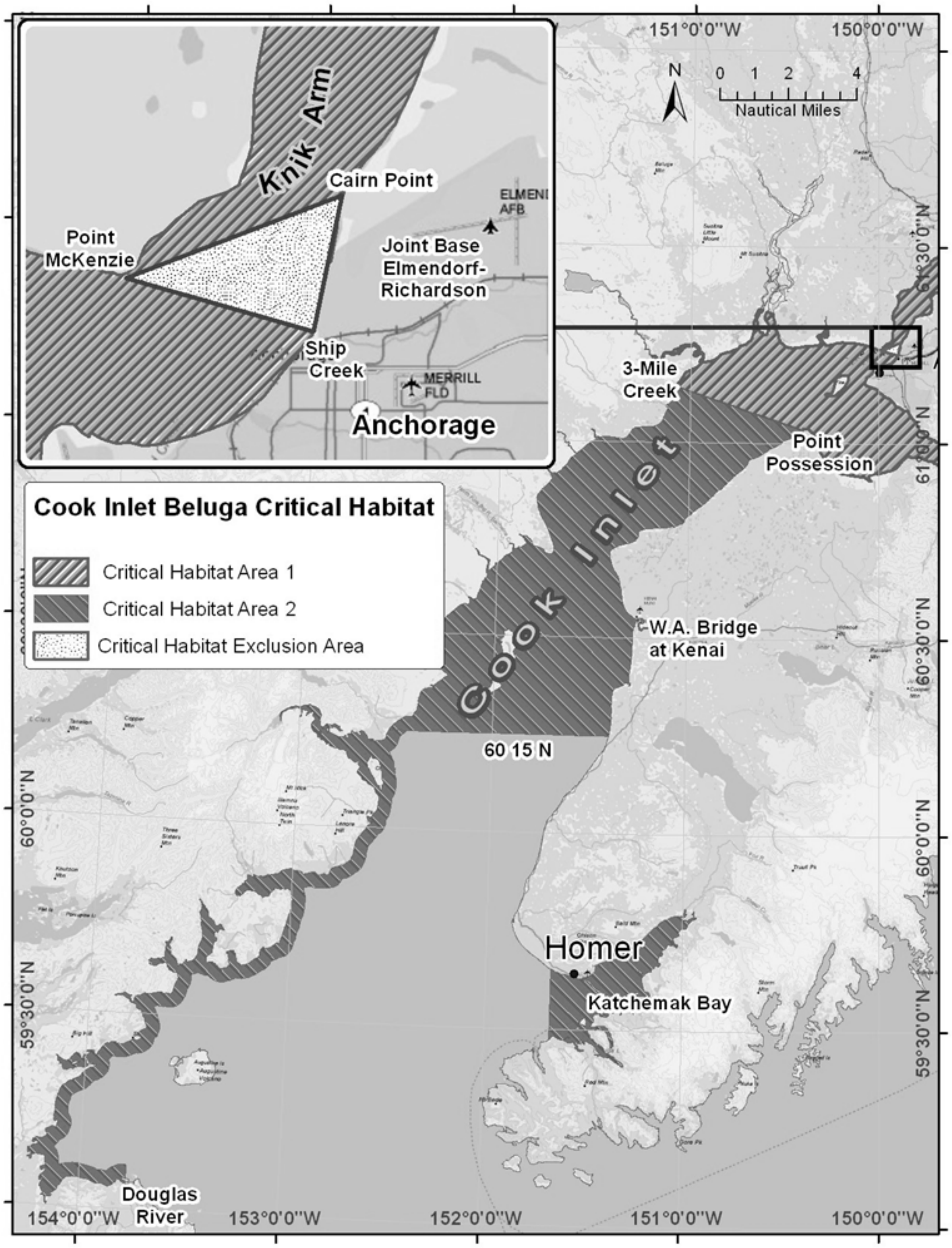
NMFS identified five PCEs in the final ruling that are essential to the conservation of CIBWs[13]:

- **PCE 1** – Intertidal and subtidal water of Cook Inlet with depths <30 feet (mean low lower water) and within 5 miles of high and medium flow anadromous fish streams
- **PCE 2** – Primary prey species consisting of four species of Pacific salmon (Chinook, sockeye, chum, and coho), eulachon, Pacific cod (*Gadus macrocephalus*), walleye pollock (*Theragra chalcogramma*), saffron cod (*Eleginus gracilis*), and yellowfin sole (*Limanda aspera*)
- **PCE 3** – Waters free of toxins or other agents of a type or amount harmful to CIBWs
- **PCE 4** – Unrestricted passage within or between the critical habitat areas
- **PCE 5** – Waters with in-water noise below levels resulting in the abandonment of critical habitat areas by CIBWs

Although PCEs 1–5 are present in the lower Susitna River and its mouth, only PCEs 1 and 2 could potentially be directly affected by the proposed hydroelectric project. Potential effects of the Watana Project on Cook Inlet beluga whale critical habitat are described below.

[11] 76 FR 20180
[12] 76 FR 20180
[13] 76 FR 20180

Figure 10.1 Cook Inlet beluga whale critical habitat



Source: http://www.fakr.noaa.gov/newsreleases/images/cibelugachmap.jpg

10.1.4 Habitat use in the Susitna River area

Available information indicates that the Susitna River mouth and delta are vital habitats for the Cook Inlet beluga whale. The lower reach of the Susitna River lies within critical habitat Area 1[14]. Area 1 critical habitat contains shallow tidal flats, river mouths, or estuarine areas, and is important as foraging and calving habitat[15]. These habitats may also serve other biological needs, such as molting or escape from predators (Shelden et al. 2003).

Area 1 critical habitat has the highest concentrations of belugas from spring through fall as well as the greatest potential for adverse impact from anthropogenic threats[16]. Intensive summer feeding by belugas occurs in the Susitna delta area. Risk from harm from anthropogenic factors in Area 1 is increased by the fact that whales occur here in high densities[17].

Though belugas are known to enter Cook Inlet area streams, information on their distribution and occurrence of is limited[18]. The NMFS (NMFS 2008) identified beluga "feeding hotspots" in Cook Inlet as the Susitna and Little Susitna rivers, Knik Arm from Eagle Bay to the Eklutna River, the Ivan River, the Theodore River, the Lewis River, the Chickaloon River, and Chickaloon Bay. Whales may gather in estuaries or river mouths in order to carry out biologically important, such as:

- Calving or breeding, because warm water may facilitate thermoregulation in neonates and/or adults (Calkins 1989; Moore et al. 2000; NMFS 2008)
- Feeding in spring when blubber resources are lowest (Calkins 1989; NMFS 2008)
- Escaping predators (Shelden et al. 2003; NMFS 2008)
- Sheltering during storms (Calkins 1984; Huntington 2000)

HDR (2010) reviewed CIBW presence upriver of the mouths of various tributaries of Cook Inlet. Whales were found to be present upriver in spring, summer, and autumn (approximately April–September). Documented presence of whales upriver was confirmed for the Susitna River, Kenai River, Twentymile River, Placer River, Knik River, and Beluga River (as far upriver as Beluga Lake at RM 30. Bird Creek, Chickaloon River, Glacier Creek, Fox River, Ivan River, Lewis River, Little Susitna River, McArthur River, and Theodore River (HDR 2010).

Tags applied to adult salmon migrating up the Susitna River at RM 20, 22 and 80 during the 1980s APA Project Aquatic Studies Program were recovered in January 1986 from the stomach of a male beluga whale found stranded in Turnagain Arm (Calkins 1989). Since it is unlikely that a spawning adult salmon would migrate up to 80 miles downstream to exit the river, and belugas are not known to feed on dead or dying fish, (Calkins 1989) the whale may have taken the salmon upriver. In spite of this, crews manning fish-tagging stations along the Susitna River did not see whales upstream of RM 3 (Calkins 1989).

Traditional hunting areas for beluga whales included upriver feeding locations in the Susitna, Little Susitna, Ivan, Theodore, and Lewis rivers (Calkins 1989). According to traditional

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[14] 76 FR 20180
[15] 76 FR 20180
[16] 76 FR 20180
[17] 76 FR 20180
[18] 76 FR 20180

ecological knowledge, CIBWs are known to ascend the Susitna River at least as far as the power lines near RM 5 and occasionally as far as RM 30 to 40 (Huntington 2000).

Whales have also been observed above tidewater in seven other Cook Inlet streams, including the nearby Beluga River, Kenai River, and streams entering both Knik and Turnagain Arms (HDR 2010), indicating a pattern of frequenting upriver habitats.

10.1.5 Potential effects on critical habitat

PCE 1 - Areas of shallow mudflats surrounding and within the Susitna River mouth and delta are part of critical habitat PCE 1. If maintenance of these mudflats is dependant on the sediment output of the Susitna River, possible changes in sediment-loading at the river mouth due to the project could affect PCE 1.

Shallow mudflat habitats have been shown to correlate highly with beluga whale presence (Goetz et al. 2007). CIBWs frequent deeper waters during the winter, and shallower areas during summer and autumn. Sediment discharged by glacial tributaries makes up the majority of substrate, as well as rain, snowmelt runoff, and the Alaska Coastal Current (Schumacher et al. 1989). Possible functions of shallow habitats:

- Concentrate prey, increasing availability to belugas (NMFS 2008)
- Provide predator escape habitat (NMFS 2008)
- Provide optimal conditions for molting, calving, and nurturing young

Shallow areas may serve to concentrate fish, with the result that belugas may preferentially use areas with favorable bathymetry over areas with greater prey concentrations (NMFS 2008). For example, belugas do not often feed at the Kenai River mouth although salmon return there in high concentrations (NMFS 2008). Belugas gather at the edge of the Susitna River delta at lower tides to feed on salmon holding in this area before they migrate upstream at higher tides, and belugas have been reported to block channel entrances to the river delta in order to feed (Huntington 2000).

Data needs for assessing potential impacts to this PCE will be fulfilled under data gaps identified under Hydrology, Ice, Sediment, Geomorphology, and Climate, Section 8.

PCE 2 - PCE 2 consists of the following primary prey species for beluga whales: Chinook, sockeye, chum, and coho salmon; eulachon; Pacific cod; walleye pollock; saffron cod; and yellowfin sole. All of these species, except yellowfin sole, have been caught offshore of the Susitna Delta (Moulton 1997). Occurrence of marine fish species in the mouth and lower (tidal) reaches of the river are unknown. Chinook, sockeye, chum and coho salmon; and eulachon spawn in the Susitna River (Harza-Ebasco 1985). Concentrations of saffron cod in the shallow nearshore areas may create a valuable prey source for belugas during spring (NMFS 2008).

Pacific salmon (Chinook, sockeye, chum, and coho), Pacific eulachon, Pacific cod, walleye pollock, saffron cod, and yellowfin sole constitute were identified as the most important food sources for CIBWs through research and TEK[19]. Stomach sampling indicates the above species make up the majority of prey consumed by weight during the ice-free season. A hydroelectric

[19] 76 FR 20180

project that could potentially affect fish stocks spawning in the Susitna River or using habitat in its mouth or delta could impact Cook Inlet beluga whale critical habitat PCE 2. More information is needed on Susitna River anadromous PCE 2 species (Chinook, sockeye, chum, and coho salmon; and eulachon)[20]. Estimates of the occurrence of marine PCE 2 species (Pacific cod, walleye Pollock, saffron cod, and yellowfin sole)[21] in the Susitna River mouth and delta are needed.

What little data are available on fish abundance and occurrence in the Susitna River delta and mouth are over five years old, and come from studies not designed to determine impacts from a hydroelectric project. More information on fish abundance and occurrence is needed in order to assess the project's possible impacts to PCE 2. However, data needs for assessing potential impacts to this PCE will be fulfilled under data gaps identified under Adult Salmon (Section 4) and Resident and Rearing Fish (Section 5).

PCE 3 - PCE 3 consists of waters free of toxins or other agents of a type or amount harmful to CIBWs. Potential for effects on beluga whale critical habitat from the project exists since the project has potential to affect water quality and contaminant-loading of sediment of the Susitna River. Upper Cook Inlet has been designated a Category 3 water body, or a water for which there is insufficient or no data to determine whether any designated use would be impaired; therefore, there are no identified water quality concerns or total maximum daily loads for Cook Inlet. Water quality of the river mouth and contaminant-loading of sediment at the mouth are unknown. More information is needed in order to assess the project's possible impacts to PCE 3. However, data needs for assessing impacts to this PCE will be fulfilled under data gaps identified under Water Quality, Section 7.

PCE 4 - Changes in water levels could prevent belugas from accessing estuarine and upriver habitats in the Susitna River necessary for their survival. Potential for effects on beluga whale critical habitat from the project exists since the project has potential to affect water quality and contaminant-loading of sediment of the Susitna River. If waters become too shallow, whales may not physically be able to enter them. Belugas have been documented traveling in large, tightly packed groups in both the east and west tributaries of the Susitna River, thought to be pursuing fish (Rugh et al. 2000). Belugas may use bathymetric features such as river banks and shallow mud flats in order to increase their hunting success. Changes in water levels could affect feeding success.

PCE 5 - Noise levels in critical habitat areas are not expected to be affected by the project since no noise impacts are expected at the river mouth/delta, as the proposed dam would be more than 120 miles upriver.

10.2 Harbor Seal

The Gulf of Alaska stock of harbor seals, which includes Cook Inlet seals, is not classified as a strategic or depleted stock and is not listed under the ESA (Allen and Angliss 2010). New genetic information on harbor seals in Alaska which indicates the current division of Alaskan

[20] 76 FR 20180
[21] 76 FR 20180

harbor seals into the Southeast Alaska, Gulf of Alaska, and Bering Sea stocks needs to be reassessed. The most recent population estimate for this stock was 45,975 (Allen and Angliss 2010).

Harbor seals are more abundant in lower Cook Inlet than in the upper inlet, but they also occur in upper Cook Inlet throughout the year. A traditional haulout site is located near the West Forelands, although harbor seals have also been reported to haulout intermittently near the Susitna River delta and in Turnagain Arm at Chickaloon Bay (Nemeth et al. 2007).

In Cook Inlet, harbor seals are year-round residents; they move into the upper inlet in summer, coinciding with movements of their anadromous fish prey such as eulachon and salmon. Harbor seals occasionally forage near river mouths during summer and fall salmon runs when fish aggregate there typically in large numbers. During salmon runs, seals have been observed in upper Cook Inlet in the Susitna River and are believed to enter other Cook Inlet rivers (e.g., Shelden et al. 2008; Shelden, Rugh, et al. 2009; Shelden, Goetz, et al. 2009). Harbor seals were seen at the Susitna Delta during offshore surveys from May through October 2006 (Nemeth et al. 2007). Harbor seals were seen in 71 different events, totaling 130 individual seals. Harbor seals were sighted during all months of the study period, with two-thirds of sightings occurring in May and June. Harbor seals were seen on 72 occasions during offshore surveys, for a total of 130 individual harbor seals. The most seals sighted were in the mouth or delta of the Susitna River during June, with seals sighted adjacent to, or hauled out on the mudflats. The most common group size was one or two individuals, however, on June 2, a group of 48 were observed; eight of the seals in this large group in the water adjacent to the mudflats and the remaining 40 were hauled out on the edge of the mudflats. Sightings declined steeply in July with only four sightings in the Susitna Flats area. From July through October, harbor seals were rarely seen in the Susitna Flats area (Nemeth et al. 2007). During winter, seals are absent from the upper inlet and have likely moved into the lower inlet.

10.3 Harbor Porpoise

Harbor porpoise found in Cook Inlet are part of the Gulf of Alaska stock. The Gulf of Alaska stock of harbor porpoise is not listed as depleted under the MMPA; this stock is also not listed as threatened or endangered under the ESA (Allen and Angliss 2010).

Harbor porpoises were commonly seen (May through October) in nearshore monitoring near the Chuit River mouth south of the Susitna delta from April through October 2006; they were seen occasionally (in May, June, and August) during offshore surveys from May through October 2006 (Nemeth et al. 2007). Acoustic monitoring for beluga whales has also detected harbor porpoise occurrence at the Beluga River, which empties on to the Susitna Flats south of the Susitna River (e.g., Small 2010).

10.4 Killer Whale

NMFS recognizes five killer whale stocks in Alaskan waters (Allen and Angliss 2010):

- Eastern North Pacific Alaska Resident
- Eastern North Pacific Northern Resident
- Gulf of Alaska, Aleutian Islands, and Bering Sea Transient

- AT1 Transient
- West Coast Transient

For upper Cook Inlet, the only killer whale stock documented above Kalgin Island is the Gulf of Alaska Transient stock (part of the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock). Individuals of the Southern Alaska Resident stock (part of the Eastern North Pacific Alaska Resident stock) are frequently found in the lower inlet, but it is unclear how far up the inlet they swim—very unlikely above Kalgin Island. Whales sighted in Cook Inlet belong to the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient or Eastern North Pacific Alaska resident stocks. None of the stocks in Alaskan waters is classified as a strategic or depleted stock; none is listed under the ESA (Allen and Angliss 2010).

Killer whales have been sighted throughout Cook Inlet (Shelden et al. 2003; NMFS 2008). Occurrence of this species in Cook Inlet is sporadic. Sightings are more common in lower Cook Inlet and the Gulf of Alaska, and the number of killer whales using the upper Inlet appears to be small (Shelden et al. 2003; NMFS 2008). No killer whales were sighted during recent marine mammal studies in Knik Arm (Markowitz et al. 2005; Funk et al. 2005; Ireland, McKendrick, et al. 2005; Ireland, Funk, et al. 2005) or during Port of Anchorage (POA) marine mammal monitoring efforts (ICRC 2009, 2010). Additionally, killer whales were not seen during offshore surveys between the Susitna delta and the Chuit River from May through October, 2006 (Nemeth et al. 2007). Killer whales have been reported in Turnagain and Knik arms, between Fire Island and Tyonek, and near the mouth of the Susitna River (Shelden et al. 2003; NMFS 2008). Killer whales were most recently reported in Turnagain Arm on September 11, 2009 (Matkin 2009, pers. comm.).

10.5 Steller Sea Lion

Individuals observed in Cook Inlet are part of the western U.S. stock. The western U.S. stock of Steller sea lion is listed as "endangered" under the ESA[22] and is, therefore, designated as "depleted" under the MMPA. As a result, the stock is classified as a strategic stock.

Steller sea lions occur in lower, rather than upper, Cook Inlet. Steller sea lions are rarely sighted north of Nikiski. Haul-outs and rookeries are located near Cook Inlet at Gore Point, Elizabeth Island, Perl Island, and Chugach Island (NMFS 2008). Steller sea lion critical habitat has been established at locations in the southern portion of lower Cook Inlet (NMFS 2008). No Steller sea lion rookeries or haul-outs are located in the vicinity of the Susitna River delta. No sightings were reported during recent studies of marine mammals in Knik Arm (Markowitz et al. 2005; Funk et al. 2005; Ireland, McKendrick et al. 2005). A single adult male was sighted in 1999 in the Susitna Flats area (Eagleton 2009, pers. comm.). Monitors observed a single, adult Steller sea lion in June 2009 near the POA construction area (ICRC 2009, 2010). Additionally, Steller sea lions were not seen during offshore surveys between the Susitna delta and the Chuit River from May through October 2006 (Nemeth et al. 2007).

[22] 62 FR 30772

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