Revised Study Plan

Susitna-Watana Hydroelectric Project

FERC No. 14241

ALASKA ENERGY AUTHORITY

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LIST OF ACRONYMS AND SCIENTIFIC LABELS

Abbreviation	Definition
µg	microgram
µg/L	micrograms per liter
µg/m^3	microgram per cubic meter
µL	microliter(s)
^{14}C	Carbon 14
AAC	Alaska Administrative Code
ac-ft	acre-feet
ACHP	Advisory Council on Historic Preservation
Active floodplain	The flat valley floor constructed by a river during lateral channel migration and deposition of sediment under current climate conditions.
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
Adfluvial	Fish that spend a part of their life cycle in lakes and return to rivers and streams to spawn.
ADNR	Alaska Department of Natural Resources
ADOT&PF	Alaska Department of Transportation and Public Facilities
ADOTPFCR	ADOT Central Region Planning
ADOTPFNR	ADOT Northern Region Planning
AEA	Alaska Energy Authority
AEIDC	Arctic Environmental Information and Data Center
AFB	air force base
AFFI	Alaska Freshwater Fish Inventory
Age-0 juvenile	The description of an organism that, in its natal year, has developed the anatomical and physical traits characteristically similar to the mature life stage, but without the capability to reproduce.
AHMG	Alaska Habitat Management Guides
AHRS	Alaska Heritage Resources Survey
Ahtna	Ahtna, Inc.
AKNHP	Alaska Natural Heritage Program
Algae	Single-celled organisms (as individual or cells grouped together in colonies) that contain chlorophyll-a and are capable of the photosynthesis.
Alluvial	Relating to, composed of, or found in alluvium.
AMP	Airport Master Plan
Anadromous	Fishes that migrate as juveniles from freshwater to saltwater and then return as adults to spawn in freshwater.
Anchor ice	Submerged ice attached or anchored to the bottom, irrespective of the nature of its formation. Often accumulates as frazil slush in open reaches.
ANCSA	Alaska Native Claims Settlement Act
ANILCA	Alaska National Interest Lands Conservation Act of 1980
ANOVA	Analysis of variance, a collection of statistical models, and their associated

Abbreviation	Definition
	procedures, in which the observed variance in a particular variable is partitioned into components attributable to different sources of variation.
APA	Alaska Power Authority
APA Project	APA Susitna Hydroelectric Project
APE	area of potential effect
APLICs	Alaska Public Lands Information Centers
Aquifer	A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to springs and wells.
ARRC	Alaska Railroad Corporation
AS	Alaska Statutes
ASCP	Alaska Shorebird Conservation Plan
ASFDB	Alaska Subsistence Fisheries Database
ASG	Alaska Shorebird Group
Assay	Investigative (analytic) procedure in laboratory medicine, pharmacology, environmental biology, and molecular biology for qualitatively assessing or quantitatively measuring the presence or amount or the functional activity of a target entity (the analyte).
ASTM	American Society for Testing and Materials
ATV	all-terrain vehicle
AVC	Alaska Vegetation Classification
AWC	The Anadromous Waters Catalog, a catalog and atlas maintained by the Alaska Department of Fish and Game (ADF&G) of waters important for the spawning, rearing or migration of anadromous fishes.
Backwater	Off-channel habitat characterization feature found along channel margins and generally within the influence of the active main channel with no independent source of inflow. Water is not clear.
Bank	The sloping land bordering a stream channel that forms the usual boundaries of a channel. The bank has a steeper slope than the bottom of the channel and is usually steeper than the land surrounding the channel.
Bankfull stage (flow)	The discharge at which water completely fills a channel; the flow rate at which the water surface is level with the floodplain.
Bankfull width	The width of a river or stream channel between the highest banks on either side of a stream.
Baseflow	The portion of stream flow that comes from the sum of deep subsurface flow and delayed shallow subsurface flow. It should not be confused with groundwater flow.
Baseline	Baseline (or Environmental Baseline): the environmental conditions that are the starting point for analyzing the impacts of a proposed licensing action (such as approval of a license application) and any alternative.
BCC	birds of conservation concern
BDPs	Best development practices
Beacon (tag)	A beacon is an intentionally conspicuous device, in this case a telemetry tag, designed to attract attention to a specific location.
Beaver complex	Off-channel habitat characterization feature consisting of a ponded water body created by beaver dams.
Benthos (benthic)	Defining a habitat or organism found on the streambed or pertaining to the streambed (or bottom) of a water body.

Abbreviation	Definition
BIA	DOI, Bureau of Indian Affairs
Biotelemetry	The remote detection and measurement of a human or animal function, activity, or condition (as heart rate or body temperature)
BLM	DOI, Bureau of Land Management
BLM-S	BLM sensitive species
BLM-W	BLM watch list species
BMC	birds of management concern
BMPs	best management practices
BOD	biochemical oxygen demand
BOF	Alaska Board of Fisheries
Bonferroni's method	A statistical method used to counteract the problem of multiple comparisons.
Border ice	Ice sheet in the form of a long border attached to the bank or shore; shore ice.
Boulder	Substrate particles greater than 12 inches in diameter. Larger than cobble.
BP	before present
BPIFWG	Boreal Partners in Flight Working Group
Braided streams	Stream consisting of multiple small, shallow channels that divide and recombine numerous times. Associated with glaciers, the braiding is caused by excess sediment load.
Brash ice	Accumulations of floating ice made up of fragments not more than about 2 meters (6 feet) across; the wreckage of other forms of ice.
Break-up	Disintegration of ice cover.
Break-up jam	Ice jam that occurs as a result of the accumulation of broken ice pieces.
Break-up period	Period of disintegration of an ice cover.
Calibration	In the context of hydrologic modeling, calibration is the process of adjusting input variables to minimize the error between predicted and observed water surface elevations or other hydrologic parameters.
Capillary fringe	The subsurface layer in which groundwater seeps up from a water table by capillary action to fill soil pores.
Carbon isotope ratio	The identification of isotopic signature, the distribution of certain stable isotopes and chemical elements within chemical compounds.
Cascade	The steepest of riffle habitats. Unlike rapids, which have an even gradient, cascades consist of a series of small steps of alternating small waterfalls and shallow pools.
CATC	CIRI Alaska Tourism
Catch per unit effort	The quantity of fish caught (in number or in weight) with one standard unit of fishing effort.
Catchability coefficient (fishwheel)	The relationship between the catch rate (CPUE) and the true population size, aka effectiveness.
CCCMA	Canadian Centre for Climate Modeling and Analysis.
CDP	census-designated place
CEII	Critical Energy Infrastructure Information
CFR	Code of Federal Regulations
cfs	cubic feet per second

Abbreviation	Definition
Channel	A natural or artificial watercourse that continuously or intermittently contains water, with definite bed and banks that confine all but overbank stream flows.
CIBW	Cook Inlet Beluga Whales
CIRI	Cook Inlet Region, Inc.
Cirques	A bowl-shaped depression on the side of a mountain at the head of a glacier.
cm	centimeter
CNIPM	Alaska Committee for Noxious and Invasive Plants Management
Cobble	Substrate particles between 3 and 12 inches in diameter. Larger than gravel and smaller than boulder.
Commercial fishery	A term related to the whole process of catching and marketing fish and shellfish for sale. It refers to and includes fisheries resources, fishermen, and related businesses.
Conductivity	In terms of water conductivity, the ability of water to conduct electricity, normally through the presence of dissolved solids that carry electrical charges.
Confluence	The junction of two or more rivers or streams.
Consecutive dry days	Number of days in a row without precipitation.
Consecutive wet days	Number of days in a row with precipitation.
COY	cubs of the year
CPOM	course particulate organic matter, particle size larger than 1 mm in size
Cross-section	A plane across a river or stream channel perpendicular to the direction of water flow.
CRREL	U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.
CSIS	ADF&G Community Subsistence Information System
Datum	A geometric plane of known or arbitrary elevation used as a point of reference to determine the elevation, or change of elevation, of another plane (see gage datum).
DBSD	Denali Borough School District
DCCED	Alaska Department of Commerce, Community, and Economic Development
Decision tree barrier analysis	A step-wise process for evaluating potential barriers in the field. Quantitative metrics are used at each step in the decision tree to identify the impassability of the potential barrier.
Degree-day	Also termed freezing degree-day, a measure of the departure of the mean daily temperature below a given standard, usually 0°C (32°F).
Delta	A low, nearly flat accumulation of sediment deposited at the mouth of a river or stream, commonly triangular or fan-shaped
DEM	Digital elevation model.
Denaturation	Denaturation is a process in which proteins or nucleic acids lose the tertiary structure and secondary structure which is present in their native state, by application of some external stress or compound such as a strong acid or base, a concentrated inorganic salt, an organic solvent, or heat.
Depth	Water depth at the measuring point (station).
Devils Canyon	Located at approximately Susitna River Mile (RM) 150-161, Devils Canyon contains four sets of turbulent rapids rated collectively as Class VI. This feature is a partial fish barrier because of high water velocity.
DHSS	Alaska Department of Health and Social Services
DIDSON	Dual Frequency Identification Sonar. Sonar imaging instrumentation developed by

Abbreviation	Definition
	Sound Metrics Corp. with applications for fish enumeration, behavior and habitat mapping.
Direct solar radiation	Sunlight not blocked by clouds.
Discharge	The rate of stream flow or the volume of water flowing at a location within a specified time interval.
Discontinuous permafrost	Permafrost that is laterally discontinuous, or isolated by thawed soils or bedrock.
Distribution (species)	The manner in which a biological taxon is spatially arranged.
Diurnal	Any pattern that reoccurs daily.
DNA	A nucleic acid containing the genetic instructions used in the development and functioning of all known living organisms.
DO	dissolved oxygen. The amount of gaseous oxygen (O2) dissolved in the water column.
DOI	U.S. Department of the Interior
Downwelling	The downward movement of water from rivers, streams, sloughs and other surface water features into soils and bedrock.
Doyon	Doyon, Ltd.
DPOR	ADNR Division of Parks and Outdoor Recreation
Drainage area	The total land area draining to any point in a stream. Also called catchment area, watershed, and basin.
DSM	Demand Side Management
Duration of ice cover	The time from freeze-up to break-up of an ice cover.
EARMP	East Alaska Resource Management Plan
ECHAM5	A global climate model developed by the Max Planck Institute for Meteorology.
Edge habitat	The boundary between natural habitats, in this case between land and a stream. Level five tier of the habitat classification system.
EE	energy efficiency
Effectiveness (fishwheel)	aka catachability coefficient, the relationship between the catch rate (CPUE) and the true population size
EFH	essential fish habitat
EIM	Environmental Information Management
EIS	environmental impact statement
El.	elevation
Electrofishing	A biological collection method that uses electric current to facilitate capturing fishes.
Emergence	The process of becoming visible after being concealed, the escape of an organism from an egg.
EMS	emergency medical services
Entrainment	The unintended diversion of fish into an unsafe passage route.
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EROS	Earth Resources Observation System.
ESA	Endangered Species Act
Escapement (spawning)	The number or proportion of fish surviving (escaping from) a given fishery at the end of the fishing season and reaching the spawning grounds.

Abbreviation	Definition
et al.	"*et alia*"; and the rest
Evapotranspiration	The sum of evaporation and plant transpiration to the atmosphere.
FAA	Federal Aviation Administration
FBOM	fine benthic organic matter
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FHA	USDOT Federal Highway Administration
Firn	Granular, partially consolidated snow that has passed through one summer melt season but is not yet glacial ice.
Fish barrier	Barriers to fish migration
Fishers exact test	A statistical significance test used in the analysis of contingency tables. Although in practice it is employed when sample sizes are small, it is valid for all sample sizes.
Fishery	Generally, a fishery is an activity leading to harvesting of fish. It may involve capture of wild fish or raising of fish through aquaculture.
Fishing	Any activity, other than scientific research conducted by a scientific research vessel, that involves the catching, taking, or harvesting of fish; or any attempt to do so; or any activity that can reasonably be expected to result in the catching, taking, or harvesting of fish, and any operations in support of it.
Fishing gear	The equipment used for fishing (e.g. gillnet, hand line, harpoon, haul seine, long line, bottom and midwater trawls, purse seine, rod-and-reel, pots and traps). Each of these gears can have multiple configurations.
Fishwheel	A device for catching fish which operates much as a water-powered mill wheel. A wheel complete with baskets and paddles is attached to a floating dock. The wheel rotates due to the current of the stream it is placed into. The baskets on the wheel capture fish traveling upstream. The fish caught in the baskets fall into a holding tank.
FLIR	Forward looking infrared, an imaging technology that senses infrared radiation. Can be used for watershed temperature monitoring.
Flood	Any flow that exceeds the bankfull capacity of a stream or channel and flows out on the floodplain.
Floodplain	1. The area along waterways that is subject to periodic inundation by out-of-bank flows. 2. The area adjoining a water body that becomes inundated during periods of over-bank flooding and that is given rigorous legal definition in regulatory programs. 3. Land beyond a stream channel that forms the perimeter for the maximum probability flood. 4. A relatively flat strip of land bordering a stream that is formed by sediment deposition. 5. A deposit of alluvium that covers a valley flat from lateral erosion of meandering streams and rivers.
Floodplain vegetation – groundwater / surface water regime functional groups	Assemblages of plants that have established and developed under similar groundwater and surface water hydrologic regimes.
Fluvial	Of or pertaining to the processes associated with rivers and streams and the deposits and landforms created by them.
FMP	Fishery Management Plan
Focus Area	Areas selected for intensive investigation by multiple disciplines as part of the AEA study program.
Fork length	A measurement used frequently for fish length when the tail has a fork shape. Projected straight distance between the tip of the snout and the fork of the tail.
FPOM	fine benthic organic matter
fps	feet per second

Abbreviation	Definition
FR	Federal Register
Frazil	Fine spicules, plates, or discoids of ice suspended in water. In rivers and lakes it is formed in supercooled, turbulent waters.
Frazil pan	A circular agglomerate of loosely packed frazil that floats.
Freeze-up jam	Ice jam formed as frazil ice accumulates and thickens during the freeze-up period.
Freeze-up period	Period of initial formation of an ice cover.
Fry	A recently hatched fish. Sometimes defined as a young juvenile salmonid with absorbed egg sac, less than 60 mm in length.
FS	featured species
ft	feet
ft MSL	feet mean sea level
FY	fiscal year
Fyke net	Hoop nets are tubular shaped nets with a series of hoops or rings spaced along the length of the net to keep it open.
g	gram
Gaging station	A specific site on a stream where systematic observations of stream flow or other hydrologic data are obtained.
Genepop	A population genetics software package originally developed by Michel Raymond and Francois Rousset, at the Laboratiore de Genetique et Environment, Montpellier, France.
Genetic markers	A gene or DNA sequence with a known location on a chromosome that can be used to identify individuals or species.
Genetic tree	A diagram showing the lineage or genealogy of an individual and all the direct ancestors, usually to analyze or follow the inheritance of trait.
Genotype	The genetic makeup of a cell, an organism, or an individual (i.e. the specific allele makeup of the individual) usually with reference to a specific character under consideration.[
Geohydrologic unit	An aquifer, a confining unit, or a combination of aquifers and confining units comprising a framework for a reasonably distinct geohydrologic system.
Geohydrology	The study of water in the Earth's surface, commonly called groundwater.
Geomorphic mapping	A map design technique that defines, delimits and locates landforms.
Geomorphic reach	Level two tier of the habitat classification system. Separates major hydraulic segments into unique reaches based on the channel's geomorphic characteristic.
Geomorphology	The scientific study of landforms and the processes that shape them.
Gillnet	With this type of gear, the fish are gilled, entangled or enmeshed in the netting. These nets may be used to fish on the surface, in midwater or on the bottom.
GIS	Geographic Information System. An integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes.
Glacial mass wasting	When large amounts of glacial ice rapidly disintegrate and melt.
Glacial surge	Relatively rapid movement of a glacier down-gradient. Frequently accompanied by increased flow of meltwater and additional sediment production. These events typically have a sudden onset, extremely high (tens of meters/day) maximum flow rate, and a sudden termination, often with a discharge of stored water.
Glacier geometry changes	Changes in the size or shape of a glacier over time.
Glacier mass balance	The difference between accumulation and ablation of a glacier.

Abbreviation	Definition
Glacier outburst	A sudden release of water from a glacier.
Glacier retreat	The upslope migration of the terminus of a glacier.
Glide	An area with generally uniform depth and flow with no surface turbulence. Low gradient; 0-1 % slope.
GMP	General Management Plan
GMU	Game Management Unit
GPS	global positioning system. A system of radio-emitting and -receiving satellites used for determining positions on the earth.
Gradient	The rate of change of any characteristic, expressed per unit of length (see Slope). May also apply to longitudinal succession of biological communities.
Gravel	Substrate particles between 0.1 and 3.0 inches in size, larger than sand and smaller than cobble.
Grounded ice	Ice that has run aground or is in contact with the ground underneath it.
Groundwater (GW)	In the broadest sense, all subsurface water; more commonly that part of the subsurface water in the saturated zone.
Growth rate	Annual or seasonal. The increase in weight of a fish per year (or season), divided by the initial weight.
Growth Rate Potential	The amount of growth predicted for fish with known prey availability and environmental conditions.
GU	globally unrankable
GVEA	Golden Valley Electric Association
GW/SW interactions	The physical interactions between groundwater and surface water.
GWh	gigawatt-hours
Habitat	The environment in which the fish live, including everything that surrounds and affects its life, e.g. water quality, bottom, vegetation, associated species (including food supplies). The locality, site and particular type of local environment occupied by an organism.
Habitat Suitability Criteria	A graph/mathematical equation describing the suitability for use of areas within a stream channel related to water depth, velocity and substrate by various species/life stages of fish.
Habitat Suitability Index	A suitability index providing a probability that the habitat is suitable for the species, and hence a probability that the species will occur where that habitat occurs.
Habitat Suitability Modeling	A tool for predicting the quality or suitability of habitat for a given species based on known affinities with habitat characteristics, such as depth and substrate type.
Hanging dam	A mass of ice composed mainly of frazil or broken ice deposited under an ice cover in a region of low flow velocity.
Harvest	The total number or weight of fish caught and kept from an area over a period of time.
HEA	Homer Electric Association
Heat transfer model	A model for migration of heat from a warm body to cold.
Hierarchical log-likelihood ratio analysis	A technique used in statistics to examine the relationship between more than two categorical variables.
Histogram	A graphical representation showing a visual impression of the distribution of data. It is an estimate of the probability distribution of a continuous variable.
Homogeneity	Homogeneity is the state of being homogeneous. Pertaining to the sciences, it is a substance where all the constituents are of the same nature; consisting of similar parts, or of elements of the like nature.
Hook and line	A type of fishing gear consisting of a hook tied to a line.

Abbreviation	Definition
Hoop net	Hoop nets are tubular shaped nets with a series of hoops or rings spaced along the length of the net to keep it open.
HRM	Historic River Mile
Hummocked ice	Ice piled haphazardly, one piece over another, to form an uneven surface.
Hydraulic head	A measure of energy or pressure, expressed in terms of the vertical height of a column of water that has the same pressure difference.
Hydraulic model	A computer model of a segment of river used to evaluate stream flow characteristics over a range of flows.
Hydrograph	A graph showing stage, flow, velocity, or other property of water with respect to time.
Hyporheic	The hyporheic zone is the subsurface volume of sediment and porous space beneath and lateral to a river or streambed, where there is mixing of shallow groundwater and surface water.
Hyporheic flow	Shallow subsurface (groundwater) flow through porous sediments adjacent to river channels.
Ice bridge	A continuous ice cover of limited size extending from shore to shore like a bridge.
Ice concentration	The ratio (in eighths or tenths) of the water surface actually covered by ice to the total area of surface, both ice-covered and ice-free, at a specific location or over a defined area.
Ice cover	A significant expanse of ice of any form on the surface of a body of water.
Ice floe	Free-floating piece of ice greater than about 1 meter (3 feet) in extent.
Ice jam	A stationary accumulation of fragmented ice or frazil that restricts or blocks a stream channel.
Ice run	Flow of ice in a river. An ice run may be light or heavy, and may consist of frazil or broken sheet ice.
Ice-free	No floating ice present.
IFRR	Instream Flow Relationships Report
ILP	Integrated Licensing Process
in	Inch
Inclined plane trap	This trap consists of a revolving screen suspended between two pontoons. Downstream migrant fish reaching the back of the trap are dropped into a live box where they can later be enumerated.
Index count	An index is a statistic that is assumed to be correlated to the true parameter of interest (population) in some way
Instream flow	The rate of flow in a river or stream channel at any time of year.
IFIM	Instream Flow Incremental Methodology integrates concepts of water-supply planning, analytical hydraulic engineering models, and empirically derived habitat-versus-flow functions to address water-use and instream-flow issues and questions concerning life-stage-specific effects on selected species and the general well-being of aquatic biological populations.
Interannual stream flow variations	Changes in stream flow on a year-to-year basis.
Interflow	The lateral movement of water in the upper part of the unsaturated zone, or vadose zone, which directly enters a stream channel or other body of water.
Intergravel	Intergravel refers to the subsurface environment within the riverbed.
Invertebrate	All animals without a vertebral column; for example, aquatic insects.
IPCC	Intergovernmental Panel on Climate Change

Abbreviation	Definition
ISER	University of Alaska Anchorage Institute for Social and Economic Research
ISR	Initial Study Report
Juvenile	A young fish or animal that has not reached sexual maturity.
kcmil	circular mils
kg	kilogram
km	kilometer
km^2	kilometer(s) squared
kV	kilovolt
L	liter(s)
LAI	Leaf area index. LAI is the one-sided green leaf area per unit ground area in broadleaf canopies, or as the projected needle leaf area per unit ground area in needle canopies.
lb	pound
Leading edge of ice cover	The upstream extent of a continuous ice cover that is progressing upstream via juxtaposition (accumulation) of frazil ice pans.
licensing participants; Participants	Agencies, ANSCA corporations, Alaska Native entities and other licensing participants
LiDAR	Light Detection and Ranging. An optical remote sensing technology that can measure the distance to a target; can be used to create a topographic map.
Life stage	An arbitrary age classification of an organism into categories relate to body morphology and reproductive potential, such as spawning, egg incubation, larva or fry, juvenile, and adult.
Loci	The position of a gene (or other significant sequence) on a chromosome.
LOEL	Lowest Observable Effect Level
LOKI	A software package developed by Simon C. Heath, which analyses a quantitative trait observed on large pedigrees using Markov chain Monte Carlo multipoint linkage and segregation analysis.
Lotic	Refers to flowing water.
Lower segment Susitna	The Susitna River from Cook Inlet (RM 0) to the confluence of the Chulitna River at RM 98.
LP DAAC	Land Processes Distributed Active Archive Center.
LRTP	Long Range Transportation Plan
LWCF	Land and Water Conservation Fund
LWD	large woody debris
m	meter(s)
M	million
m^2	square meter(s)
Macroinvertebrate	An invertebrate animal without a backbone that can be seen without magnification.
Main channel	For habitat classification system: a single dominant main channel. Also, the primary downstream segment of a river, as contrasted to its tributaries.
Main channel habitat	Level four tier of the habitat classification system. Separates main channel habitat types including: tributary mouth, main channel, split main channel, multiple split main channel and side channel into mesohabitat types. Mesohabitat tyes include pool, glide, run, riffle, and rapid.

Abbreviation	Definition
Mainstem	Mainstem refers to the primary river corridor, as contrasted to its tributaries. Mainstem habitats include the main channel, split main channels, side channels, tributary mouths, and off-channel habitats.
Mainstem habitat	Level three tier of the habitat classification systems. Separates mainstem habitat into main channel, off-channel, and tributary habitat types. Main channel habitat types include: tributary mouth, main channel, split main channel, multiple split main channel and side channel. Off-channel habitat types include: side slough, upland slough, backwater, and beaver complex. Tributary habitat is not further categorized.
Major hydraulic segment	Level one tier of the habitat classification system. Separates the River into three segments: Lower River (RM 0-98), Middle River (RM 98-184), and Upper River (RM 184-233).
Manning's equation	V = 1.486 R2/3S1/2/n in English units (V = R2/3S1/2/n in SI units) where V = mean flow velocity, R = hydraulic radius, and S = hydraulic slope; n is a coefficient of roughness.
MAPS	Monitoring Avian Productivity and Survivorship
Mat-Su	Matanuska Susitna
MBTA	Migratory Bird Treaty Act
MEA	Matanuska Electric Association
Mesh size	The size of holes in a fishing net.
Mesohabitat	A discrete area of stream exhibiting relatively similar characteristics of depth, velocity, slope, substrate, and cover, and variances thereof (e.g., pools with maximum depth <5 ft, high gradient rimes, side channel backwaters).
MET	Meteorological stations.
mg	milligram
mg/L	milligrams per liter
mi	mile(s)
mi^2; sq.mi.	square mile(s)
Middle segment Susitna	The Susitna River from the confluence of the Chulitna River at RM 98 to the proposed Watana Dam Site at RM 184.
Migrant (life history type)	Some species exhibit a migratory life history type and undergo a migration to from rivers/lakes/ocean.
Migration	Systematic (as opposed to random) movement of individuals of a stock from one place to another, often related to season.
Minnow trap	Normally composed of small steel mesh with 2-piece torpedo shape design, this trap is disconnected in the middle for easy baiting and fish removal.
MIROC	Model for Interdisciplinary Research on Climate.
Mixed stock (fishery)	A fishery whose stock consists of fish that are of a variety of ages, sizes, species, geographic or genetic origins or any combination of these variables.
Mixed stock analyses	Traditional mixed stock analyses use morphological, chemical, or genetic markers measured in several source populations and in a single mixed population to estimate the proportional contribution of each source to the mixed population.
ml	milliliter(s)
ML&P	Anchorage Municipal Light and Power
mm	millimeter(s)
MODFLOW	The name of a common USGS finite difference 3-D groundwater flow model.
MON	Museum of the North

Abbreviation	Definition
Monte Carlo	Monte Carlo simulation is a statistical approach whereby the inputs that are used for a calculation are resampled many times assuming that the inputs follow known statistical distributions.
MP	mile post
mph	miles per hour
MRLC	Multi-Resolution Land Characteristics.
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSB	Matanuska-Susitna Borough
MSL	mean sea level
Multidimensional scaling	A set of related statistical techniques often used in information visualization for exploring similarities or dissimilarities in data.
Multiple split main channel	Main channel habitat characterization feature where more than three distributed dominant channels are present.
MVA	megavolt-Ampere
MW	megawatts (one million watts)
MWh	megawatt hour
n.d.	no date
N/A	not applicable *or* not available
NAAQS	National Ambient Air Quality Standards
NARR	North America Regional Reanalysis.
NAWCP	North American Waterfowl Conservation Plan
NAWMP	North American Waterfowl Management Plan
NCI	Northern Cook Inlet
NCIMA	Northern Cook Inlet Management Area (sport fish harvest)
NCM	Newton centimeter
NEPA	National Environmental Policy Act
Nested design	Nested design (sometimes referred to as a hierarchical design) is used for experiments in which there is an interest in a set of treatments and the experimental units are sub-sampled.
NGO	non-governmental organization
NHPA	National Historic Preservation Act
Nitrogen isotope	Stable isotopes are method for understanding aquatic ecosystems because they can help scientists in understanding source links and process information in marine food webs. Certain isotopes can signify distinct primary producers forming the bases of food webs and trophic level positioning. Nitrogen isotopes indicate the trophic level position of various marine organisms.
NLCD	National Land Cover Dataset
NLUR	Northern Land Use Research
NMFS	NOAA National Marine Fisheries Service
No.	number
NO2; NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration

Abbreviation	Definition
Nodes (genetic tree)	Nodes represent taxonomic units, such as an organism, a species, a population, a common ancestor, or even an entire genus or other higher taxonomic group.
NOEL	No Observed Effects Level
NOI	Notice of Intent
Non-native	Not indigenous to or naturally occurring in a given area.
NPS	DOI, National Park Service
NRCS	USDA Natural Resources Conservation Service
NRHP	National Register of Historic Places
NTU	nephelometric turbidity unit
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
O&M	operations and maintenance
O_3	ozone
ºC	degrees Celsius
ºF	degrees Fahrenheit
Off-channel	Those bodies of water adjacent to the main channel that have surface water connections to the main river at some discharge levels.
Off-channel habitat	Habitat within those bodies of water adjacent to the main channel that have surface water connections to the main river at some discharge levels.
OHV	off-highway vehicle
Open lead	Elongated opening in the ice cover caused by water current (velocity lead) or warm water (thermal lead).
OPMP	Office of Project Management and Permitting
ORV	off-road vehicle
Otolith	The ear bone of a fish. Otoliths have rings on them like the rings on a tree stump, and are used to find the age of the fish and its growth rate.
Outmigrant trap	Several types of trapping equipment that can be used to estimate the abundance of downstream migrating anadromous salmonid smolts.
Overbank flow	Flow that exceeds the level of a river's banks and extends into the floodplain. Also overflow.
Overwintering	Freshwater habitat used by salmonids during the winter for incubation of eggs and alevin in the gravel and for rearing of juveniles overwintering in the stream system before migrating to saltwater the following spring.
PAD	Pre-Application Document
Partial barrier	A feature that is impassable to some fish species, during part or all life stages at all flows.
Pb	lead
PCE	primary constituent elements
PDD	Preliminary Decision Document
Period of record	The length of time for which data for an environmental variable has been collected on a regular and continuous basis.
Permafrost	Earth materials that remains continuously at or below 0oC for at least two consecutive years.
Permanent barrier	A feature that is impassable to all fish at all flows. Results in the exclusion of all

Abbreviation	Definition
	species from portions of a watershed.
Permeability	The capacity of a rock for transmitting a fluid; a measure of the relative ease with which a porous medium can transmit a liquid.
Personal use fishery	In Alaska, "Personal use" is a legally defined regulatory category of fishery. It is defined as "the taking, fishing for, or possession of finfish, shellfish, or other fishery resources, by Alaska residents for personal use and not for sale or barter, with gill or dip net, seine, fishwheel, long line, or other means defined by the Board of Fisheries".
pH	A measure of the acidity or basicity of a solution.
PHABSIM	Physical Habitat Simulation, aspecific model designed to calculate an index to the amount of microhabitat available for different life stages at different flow levels. PHABSIM has two major analytical components: stream hydraulics and life stage-specific habitat requirements.
PhD	Doctor of Philosophy
Piezometer	A type of groundwater well installed to specifically measure water levels or pressure levels.
PIT	Passive Integrated Transponder tags used to individually identify animals and monitor their movements.
PL	Public Law
PLC	programmable logic controller
PLP	Preliminary Licensing Proposal
PM	particulate matter
PM&E	protection, mitigation and enhancement
PM_{10}; PM10	particulate matter up to 10 microns in diameter
$PM_{2.5}$; PM2.5	particulate matter up to 2.5 microns in diameter
PMF	probable maximum flood
Pool	Slow water habitat with minimal turbulence and deeper due to a strong hydraulic control.
Porosity	The ratio of the volume of voids in a rock or soil to the total volume.
Potentiometric surface	An imaginary surface representing the static head of ground water in tighty cased wells that tap a water-bearing rock unit (aquifer); or, in the case of unconfined aquifers, the water table.
POW	palustrine open water (ponds under 20 ac)
ppb	parts per billion
PRECPTOT	Total precipitation for a year.
PRISM	Parameter-elevation Regressions on Independent Slopes Model. PRISM uses point measurements of precipitation, temperature, and other climatic factors to produce continuous, digital grid estimates of monthly, yearly, and event-based climatic parameters.
Process domains	Define specific geographic areas in which various geomorphic processes govern habitat attributes and dynamics (Montgomery 1999).
Project	Susitna-Watana Hydroelectric Project
PSD	Prevention of Significant Deterioration
PSP	Proposed Study Plan
Pump test	A method of determining aquifer properties by pumping water from a well and

Abbreviation	Definition
	measuring the water level drawdown or recovery in the well, and nearby piezometers or wells.
Q	Hydrological abbreviation for discharge, usually presented as cfs (cubic feet per second) or cms (cubic meters per second). Flow (discharge at a cross-section).
R (program)	R is an open source programming language and software environment for statistical computing and graphics. The R language is widely used among statisticians for developing statistical software and data analysis.
Radiotelemetry	Involves the capture and placement of radio-tags in adult fish that allow for the remote tracking of movements of individual fish.
Ramping rates	The rate at which (typically inches per hour) a flow is artificially altered to accommodate diversion requirements.
Rapid	Swift, turbulent flow including small chutes and some hydraulic jumps swirling around boulders. Exposed substrate composed of individual boulders, boulder clusters, and partial bars. Lower gradient and less dense concentration of boulders and white water than Cascade. Moderate gradient; usually 2.0-4.0% slope.
RASP	Regional Aviation System Plan
RCC	roller compacted concrete
Rd	recreation-dispersed
Rearing	Rearing is the term used by fish biologists that considers the period of time in which juvenile fish feed and grow.
Recreational Fishery	Harvesting fish for personal use, sport, and challenge (e.g. as opposed to profit or research). Recreational fishing does not include sale, barter, or trade of all or part of the catch.
Redd	The spawning ground or nest of various fishes
Refugia	An area protected from disturbance and exposure to adverse environmental conditions where fish or other animals can find shelter from sudden flow surges, adverse water quality, or other short-duration disturbances.
Regime	The general pattern (magnitude and frequency) of flow or temperature events through time at a particular location (such as snowmelt regime, rainfall regime).
Relative abundance	Relative abundance is an estimate of actual or absolute abundance; usually stated as some kind of index.
Reservoir	A body of water, either natural or artificial, that is used to manipulate flow or store water for future use.
Resident	Resident fish as opposed to anadromous remain in the freshwater environment year-round
Riffle	A fast water habitat with turbulent, shallow flow over submerged or partially submerged gravel and cobble substrates. Generally broad, uniform cross-section. Low gradient; usually 0.5-2.0% slope.
Riparian	Pertaining to anything connected with or adjacent to the bank of a stream or other body of water.
Riparian process domain	Define specific geographic areas in which various geomorphic processes govern floodplain habitat attributes and dynamics.
Riparian vegetation	Vegetation that is dependent upon an excess of moisture during a portion of the growing season on a site that is perceptively more moist than the surrounding area.
Riparian zone	A stream and all the vegetation on its banks that is influenced by the presence of the stream, including surface flow, hyporheic flow and microclimate.
RIRP	Railbelt Integrated Resources Plan
River	A large stream that serves as the natural drainage channel for a relatively large catchment or drainage basin.

Abbreviation	Definition
River corridor	A perennial, intermittent, or ephemeral stream and adjacent vegetative fringe. The corridor is the area occupied during high water and the land immediately adjacent, including riparian vegetation that shades the stream, provides input of organic debris, and protects banks from excessive erosion.
River mile	The distance of a point on a river measured in miles from the river's mouth along the low-water channel.
RM	River Mile(s) (add clarification for origin of RM Project vs historic)
ROS	recreational opportunity spectrum
Rosgen channel-type	The Rosgen stream classification system which categorizes streams based on channel morphology so that consistent, reproducible, and quantitative descriptions can be made.
RS	revised statute
RSP	Revised Study Plan
RTE	rare, threatened and endangered
RTK	Real time kinematic, in reference to a GPS survey method.
Run (habitat)	A habitat area with minimal surface turbulence over or around protruding boulders with generally uniform depth that is generally greater than the maximum substrate size. Velocities are on border of fast and slow water. Gradients are approximately 0.5 % to less than 2%. Generally deeper than riffles with few major flow obstructions and low habitat complexity.
Run (migration)	Seasonal migration undertaken by fish, usually as part of their life history; for example, spawning run of salmon, upstream migration of shad. Fishers may refer to increased catches as a “run” of fish, a usage often independent of their migratory behavior.
s	second
Sand	Substrate particles less than 0.1 inches in diameter, smaller than gravel.
SANPCC	Southcentral Alaska Northern Pike Control Committee
SaSI	Salmonid Stock Inventory
SB	Senate bill
SCORP	Statewide Comprehensive Outdoor Recreation Plan
Screw trap	A floating trap that relies on an Archimedes screw built into a screen covered cone that is suspended between two pontoons is used.
SCRO	ADNR South Central Regional Office
SD1	Scoping Document 1
SD2	Scoping Document 2
SDVCSC	South Denali Visitor Center Steering Committee
Seasonal barrier	A feature that is impassable to all fish at certain flow conditions (based on run timing and flow conditions). Can result in a delay in movement beyond the barrier for some period of time.
Sediment	Solid material, both mineral and organic, that is in suspension in the current or deposited on the streambed.
Sediment load	The portion of the sediment that is carried by a fluid flow which settle slowly enough such that it almost never touches the bed.
Sediment transport	The movement of solid particles (sediment), typically due to a combination of the force of gravity acting on the sediment, and/or the movement of the fluid in which the sediment is entrained.

Abbreviation	Definition
Seine (beach)	A fishing net that hangs vertically in the water with its bottom edge held down by weights and its top edge buoyed by floats. Seine nets can be deployed from the shore as a beach seine, or from a boat.
SES	City of Seward Electric System
sf; ft^2	Square foot (feet)
SHPO	State Historic Preservation Officer
Side channel	Lateral channel with an axis of flow roughly parallel to the mainstem, which is fed by water from the mainstem; a braid of a river with flow appreciably lower than the main channel. Side channel habitat may exist either in well-defined secondary (overflow) channels, or in poorly-defined watercourses flowing through partially submerged gravel bars and islands along the margins of the mainstem.
Side slough	Off-channel habitat characterization of an Overflow channel contained in the floodplain, but disconnected from the main channel. Has clear water,
Side-scan sonar	Side scan sonar uses transducers that emit fan-shaped acoustic pulses down toward the riverbed or seafloor.
Simple daily intensity index	Known also as SDII, it is the annual total precipitation divided by the number of wet days in the year.
Slope	The inclination or gradient from the horizontal of a line or surface.
Slough	A widely used term for wetland environment in a channel or series of shallow lakes where water is stagnant or may flow slowly on a seasonal basis. Also known as a stream distributary or anabranch.
Slush ice	An agglomerate of loosely packed frazil floating on the water surface or adhered to the bed or underside of the ice cover.
SMAP	Susitna Matanuska Area Plan
Smolt	An adolescent salmon which has metamorphosed and which is found on its way downstream toward the sea.
Smoltification	The physiological changes anadromous salmonids and trout undergo in freshwater while migrating toward saltwater that allow them to live in the ocean.
SMP	Shoreline Management Plan
SNAP	Scenarios Network for Alaska and Arctic Planning.
SNP markers	Single-nucleotide polymorphism (SNP) is a change to a single nucleotide in a DNA sequence. The relative mutation rate for an SNP is extremely low. This makes them ideal for marking the history of genetic trees.
SO2; SO_2	Sulfur dioxide
Soil heat transfer	Heat flow between the soil surface and the deeper layers. Heat transfer varies with soil type, moisture, horizon, etc. The flow of heat is directed from warmer layers to cooler layers. Heat transfer in soil is substantially influenced by the snow cover, vegetation, and terrain.
Soil water storage variations	Seasonal changes in where and how water is stored in a hydraulic system.
Solar geometry	Angle of the sun's rays to the surface.
Spaghetti tag	A long, thin external tag type used to mark individual fish. Sometimes referred to as anchor or dart tags, they are usually made of vinyl tubing that can have study information printed upon.
Spawning	The depositing and fertilizing of eggs by fish and other aquatic life.
Split main channel	Main channel habitat characterization where three of fewer distributed dominant channels.
Sport fishery	Also known a recreational fishery, a sport fishery consists of fish taken for pleasure or competition. It can be contrasted with commercial fishing, which is fishing for

Abbreviation	Definition
	profit, or subsistence fishing, which is fishing for survival.
Spring	Area where there is a concentrated discharge of groundwater that flows at the ground surface.
SpUD	Special use district
SQL	Standard query language
SRMAs	Special Recreation Management Areas
Stable isotope analysis	Stable isotopes have become a popular method for understanding aquatic ecosystems because they can help scientists in understanding source links and process information in marine food webs. Certain isotopes can signify distinct primary producers forming the bases of food webs and trophic level positioning.
Stage	The distance of the water surface in a river above a known datum.
Stage-discharge relationship	The relation between the water-surface elevation, termed stage (gage height), and the volume of water flowing in a channel per unit time.
Staging	Increase in water levels upstream of the leading edge of ice cover caused by the partial blockage of the channel by ice.
STATSGO	U.S. General Soil Map Data, a digital general soil association map developed by the National Cooperative Soil Survey and distributed by the Natural Resources Conservation Service of the U.S. Department of Agriculture.
STB	Surface Transportation Board
Stranding	Fish stranding is any event in which fish are restricted to poor habitat as a consequence of physical separation from a main body of water.
Stratified sampling	A method of sampling from a population. In statistical surveys, when subpopulations within an overall population vary, it is advantageous to sample each subpopulation (stratum) independently. Stratification is the process of dividing members of the population into homogeneous subgroups before sampling.
Streambed	The bottom of the stream channel; may be wet or dry.
Subsistence fishery	A fishery that is typically small-scale and low-technology aimed at supporting oneself at a minimum level.
Supercooled water	Water with a temperature slightly below the freezing point (0°C or 32°F).
SVO	Successor Village Organizations
SW	Surface water. Water that has not infiltrated below ground surface, including rivers, streams, sloughs, lakes, ponds, wetlands.
SWHS	Statewide Harvest Survey
TCP	traditional cultural property
TCW	Talkeetna Mountains and Chulitna-Watana Hills
TDG	total dissolved gas
TDS	total dissolved solids
TEK	Traditional Environmental Knowledge
Temporary barrier	A feature that that is impassable to all fish for a period of time and is not flow dependent. Temporary instream barriers are widely used for construction and maintenance purposes, as well as access and erosion control.
Terminus	The down-gradient end of a glacier.
Thalweg	A continuous line that defines the deepest channel of a watercourse.
Thermal break-up	Melting in place. Also called in situ break-up.
Thermal cycling	Consists of cycles of repeated heating and cooling of the reaction for DNA melting

Abbreviation	Definition
	and enzymatic replication of the DNA.
Thermal ice	Solid ice formed in place in low-velocity areas.
Three Rivers Confluence	The confluence of the Susitna, Chulitna, and Talkeetna rivers at Susitna River Mile (RM) 98.5 represents the downstream end of the Middle River and the upstream end of the Upper River.
TM	Thematic Mapper. One of the Earth observing sensors introduced in the Landsat program.
TOC	total organic carbon
Tracer study	In terms of groundwater applications, the use chemical or physical (usually temperature) properties to determine groundwater pathways and mass exchange with surface water.
Trap and haul	A fish passage facility designed to trap fish for upstream or downstream transport to continue their migration.
Tributary	A stream feeding, joining, or flowing into a larger stream (at any point along its course or into a lake). Synonyms: feeder stream, side stream.
Tributary mouth	Main channel habitat characterization of clear water areas that exist where tributaries flow into Susitna River main channel or side channel habitats.
Trimline	Soil stripped of vegetation by a glacier.
Trotline	A heavy fishing line with baited hooks attached at intervals by means of branch lines called snoods. A snood is a short length of line which is attached to the main line using a clip or swivel, with the hook at the other end.
TSP	total suspended particulate
Turbidity	The condition resulting from the presence of suspended particles in the water column which attenuate or reduce light penetration.
TWG	Technical Workgroup
U.S., US	United States
U.S.C.; USC	U.S. Code
UAAES	University of Alaska Agriculture Experiment Station
UAFAFES	University of Alaska Fairbanks Agricultural and Forestry Experiment Station
UCG	underground coal gasification
UCIMA	Upper Cook Inlet Management Area (commercial fish harvest)
Unconfined aquifer	Aquifer whose upper surface is a water table free to fluctuate.
Undercut bank	A bank that rises vertically or overhangs the stream.
Underwater video	Underwater video imaging which can record images in real-time over short time intervals and can provide information on fish species presence/absence in the immediate vicinity. Although water clarity and lighting can limit the effectiveness of video sampling, a distinct advantage of video over DIDSON is the ability to clearly identify fish species.
Unsaturated zone	A subsurface zone above the water table where the pore spaces may contain a combination of air and water.
Upland slough	Off-channel habitat characterization feature that is similar to a side slough, but contains a vegetated bar at the head that is rarely overtopped by mainstem flow. Has clear water.
Upper segment Susitna	The Susitna River upstream of the proposed Watana Dam Site at RM 184.
Upstream fish passage	A fishway system designed to pass fish upstream of a passage impediment, either by volitional passage or non-volitional passage.

Abbreviation	Definition
Upwelling	The movement of groundwater into rivers, stream, sloughs and other surface water features. This is also called groundwater discharge and may be associated with a gaining reach of a river or stream.
USACE	U.S. Army Corps of Engineers
USCB	U.S. Department of Commerce, Census Bureau
USDA	U.S. Department of Agriculture
USDOT	U.S. Department of Transportation
USFS	USDA, Forest Service
USFWS	DOI, Fish and Wildlife Service
USGS	DOI, Geological Survey
USR	Updated Study Report
USSCP	U.S. Shorebird Conservation Plan
VFD	Volunteer Fire Department
VHF	very high frequency
VOC	volatile organic compound
Volitional passage	Fish passage made continuously available without trap and transport.
VRM	Visual Resource Management system
WaSiM	Water Balance Simulation Model.
Watana Dam	The dam proposed by the Susitna-Watana Hydroelectric project. The approximately 750-foot-high Watana Dam (as measured from sound bedrock) would be located at river mile (RM) 184 on the Susitna River. The dam would block the upstream passage of Chinook salmon, possibly other salmon species, and resident fish that migrate through and otherwise use the proposed Watana Dam site and upstream habitat in the Susitna River and tributaries.
Water slope	Change in water surface elevation per unit distance.
Water stage	The water surface elevation above the bottom of the river channel or above some arbitrary datum.
Water table	The top water surface of an unconfined aquifer at atmospheric pressure.
Wetted channel width (wetted Perimeter)	The length of the wetted contact between a stream of flowing water and the stream bottom in a plane at right angles to the direction of flow.
WGEN	Weather generator model that can be used to generate daily values for precipitation, maximum temperature, minimum temperature, and solar radiation. The model accounts for the persistence of each variable, the dependence among the variables, and the seasonal characteristics of each variable.
WSR	Wild and Scenic River
yd	Yard

Revised Study Plan (RSP)

1. INTRODUCTION TO RSP

This document provides the Alaska Energy Authority's (AEA) Revised Study Plan (RSP) for original licensing of the proposed Susitna-Watana Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC or Commission) Project No. 14241. This RSP is required under FERC's Integrated Licensing Process (ILP) regulations, 18 CFR § 5.13, and includes a suite of 58 individual study plans to support the licensing of the Project. This RSP builds upon the study plans in the Proposed Study Plan (PSP), and has been prepared through extensive consultation with Federal and State resource agencies, Alaska Native entities, Non-governmental Organizations (NGOs), members of the public, and other licensing participants (collectively, licensing participants).

As described in detail below, although AEA is pursuing a license under FERC's default ILP regulations, AEA has gone beyond the ILP regulatory requirements in the study development process to take a more collaborative approach. AEA recognizes the importance of working closely with licensing participants in the development of licensing studies that will support AEA's License Application, inform protection, mitigation and enhancement (PM&E) measures, serve as a foundation to environmental review under the National Environmental Policy Act (NEPA), and support all needed state and federal permits including FERC's licensing determination under the Federal Power Act (FPA). AEA appreciates the extraordinary effort of all licensing participants over the last several months to engage actively in this intensive process.

As a result of these efforts, this RSP incorporates significant changes from the PSP released in July 2012. Based on recent comments filed with FERC by licensing participants, AEA believes that this RSP resolves the majority of study-related issues raised in the ILP. While some issues do remain for Commission resolution, AEA believes that this enhanced consultative effort—which included a complete additional iteration of the study plans as an interim draft RSP distributed for comment—was well worth the significant investment of time, resources and effort by all to participate in this process.

1.1. Background of RSP Development

1.1.1. NOI, PAD, and Communication Protocol

On December 29, 2011 AEA filed with FERC its NOI and PAD to start formal licensing for the proposed Project. As required by FERC's regulations, 18 CFR § 5.6, the PAD provided licensing participants with existing relevant and reasonably available information related to the Project, to enable licensing participants to identify information needs, develop study requests and study plans, and prepare documents analyzing issues related to any application filed by AEA.

Section 5 of the PAD identified issues and preliminary study concepts that AEA developed during early consultation with licensing participants. Although FERC's ILP regulations do not require broad-based consultation prior to preparation and distribution of the PAD, AEA felt it was important to set the tone for an open and enhanced public process. Consequently, starting in early 2011, AEA implemented an outreach program and initiated baseline environmental information gathering activities. During this period, AEA conducted meetings and posted extensive licensing information on its Project website, http://susitna-watanahydro.org. These early meetings, summarized in Appendix 6-1 of the PAD, were instrumental in helping AEA identify and scope issues, and develop initial study plans included in the PAD.

In addition, as part of its goals of facilitating communication and cooperation among AEA and other licensing participants, AEA voluntarily developed a Communication Protocol that it included in the PAD. The Communication Protocol was intended to be "a structured framework for communications among all Participants and [to] provide AEA's plans regarding access to information regarding the consultation activities related to the licensing and planning of the Project." PAD § 2.3. At the same time, the Communication Protocol intentionally "provide[s] a *flexible framework* for dissemination of information and for document consultation among all participants involved in the Project licensing." *Id.* (emphasis added).

For example, the Communication Protocol contemplates that "a variety of meetings" will be held during the licensing effort, including "meetings required by the ILP as well as additional general information/project update meetings and technical workgroup meetings." PAD § 2.3.3. Recognizing this, the Protocol does not mandate *all* meetings to be scheduled 30 days in advance, or *all* agendas and meeting materials to be posted on the website two weeks prior to the meeting.[1] Not only would such an approach be impossible under the Commission's ILP regulations,[2] it would stifle the very open, continual dialogue that the Communications Protocol intends to promote.

Accordingly, the Communication Protocol provides that AEA "will *strive to* notify all Participants of meetings scheduled by AEA at least 30 days prior to the meeting date *to the extent practicable.*" *Id.* § 2.3.3 (emphasis added). The Protocol recognizes that circumstances may not allow for advance notice, providing that "AEA may hold a meeting with less than 30 days notice." *Id.* The Protocol provides similar flexibility with regard to the production of meeting agendas, meeting summaries, technical documents, and posting documents on its website.[3] *Id.* §§ 2.3.3, 2.3.4.1, 2.3.4.2.

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[1] *See* Communication Protocol § 2.3.3 (providing that "AEA *will strive* to make available documents and other information necessary to prepare for a consultation meeting at least two weeks prior to the scheduled meeting") (emphasis added). As discussed in Section 1.2 below, for example, for quarterly progress reporting during the 2013-2014 study phase of the licensing effort, AEA does not anticipate that agendas and written materials will always be ready for public distribution at least two weeks prior to a scheduled quarterly TWG meeting, as the purpose of these meetings will be to provide a more contemporaneous and complete reporting of ongoing work. For this reason, written materials associated with these quarterly TWG meetings may not be available until closer to the schedule meeting or, in some instances, at the meeting itself.

[2] In some instances, for example, the Commission's ILP regulations establish a period of less than 30 days prior to a comment deadline, or a 15-day period for a meeting prior to or following a mandated filing deadline. *See*, *e.g.*, 18 CFR §§ 5.13, 5.14(d), 5.15(c)(2), 5.15(f). In those instances, it would not be possible to follow a rigid 30-day prior notice period to schedule an informal or Technical Wrivorkgroup meeting.

[3] With regard to documents posted to AEA's website, AEA understands that there has been some misunderstanding about the amount of information AEA intends to maintain on its Project website. While Section 2.3.1 of the Communication Protocol provides generally that "[t]he consultation record will be updated regularly and available to the public on the website," AEA never intended for its website to be a complete repository for all licensing materials, essentially duplicating FERC's eLibrary system. Rather, Section 2.3.2 of the Communication Protocol addresses the specific issue of website materials, which provides that AEA will maintain on the website "key documents developed during the course of the licensing consultation, such as the PAD and NOI, meeting notes,

AEA endorses the ideals expressed in the Communication Protocol and will continually assess and improve its efforts,[4] as necessary, to promote timely dissemination of information and effective communication—as licensing parties continue to press forward together in this licensing process. By the same token, AEA does not intend to allow adherence to the Communication Protocol unintentionally to stifle the frequent dialogue, informal communications, and exchange of ideas that AEA believes are essential to resolving disputes and achieving consensus on the many complex issues related to this licensing effort.[5]

1.1.2. FERC NEPA Scoping

On February 24, 2012, FERC issued a public notice acknowledging the filing of AEA's NOI and PAD, officially commencing the licensing proceeding, and soliciting public comment on the PAD and study requests from licensing participants. In addition, FERC issued Scoping Document 1 to outline the subject areas to be addressed in its environmental analysis of the Project pursuant to NEPA. FERC held six Scoping Meetings for the Project. The meetings were held the week of March 26, 2012 in Anchorage, Wasilla, Glennallen, Sunshine, Cantwell, and Fairbanks and focused on obtaining comments and input on resource issues related to Project operations from resource agencies, Alaska Natives, local governments, NGOs, and members of the general public. The purpose of the meetings was for FERC to scope the issues, review and discuss existing Project information, identify information and study needs; and discuss the process plan and schedule for licensing activities required under the ILP regulations.

Following these meetings, federal and state resource agencies and other licensing participants filed 169 scoping comment letters with FERC. Following its review of the meeting transcripts and written comments, FERC issued Scoping Document 2 on July 16, 2012.

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meeting summaries, study plans and study reports, preliminary licensing proposal/draft license application and final license application." Based on this language and FERC's ILP regulations, AEA intends for its website to contain: (1) all documents that AEA is required to make publicly available under FERC's ILP regulations, 18 CFR 5.2, unless impractical or impossible due to copyright restrictions, public disclosure prohibitions, file size considerations, or other limitations; (2) all key issuances by FERC in the licensing effort, such NEPA documents, notices and orders; and (3) agendas and meeting summaries from more formal Technical Workgroup Meetings. For other filings and issuances, FERC's user-friendly eLibrary system is a more effective tool for accessing the numerous documents associated with the licensing process. For efficiency, AEA's website contains a link to FERC's eLibrary system.

[4] For example, AEA acknowledges that during the intensive fall 2012 period—when it was holding multiple agency and stakeholder meetings, often on a weekly basis, in an effort to reach consensus on nearly 60 proposed studies, as noted in Table 1-1 below—it did not always have the opportunity to circulate agendas in advance of meetings, provide 30 days' notice prior to a meeting, or readily post meeting summaries on the website. *See, e.g.,* Letter from James W. Balsiger, National Marine Fisheries Service, to Kimberly D. Bose, Federal Energy Regulatory Commission, at 2-3, Project No. 14241-001 (filed Nov. 1, 2012).

[5] For these reasons, AEA does not agree with the National Marine Fisheries Service (NMFS) and other licensing participants that Commission intervention is warranted to enforce the voluntary guidelines in the Communication Protocol. *See, e.g.,* Letter from James W. Balsiger, National Marine Fisheries Service, to Kimberly D. Bose, Federal Energy Regulatory Commission, at 2-4, Project No. 14241-001 (filed Nov. 1, 2012). In this time-limited period of the ILP study plan development, rigidly following the Protocol as advocated by NMFS would have significantly impeded, or even precluded altogether, AEA's ability to work closely with NMFS and other licensing participants in an effort to reach resolution on issues related to this RSP. This exemplifies why AEA intentionally provided flexibility when drafting the Communication Protocol.

1.1.3. Development of PSP

Following its filing of the PAD, AEA continued its approach of participant outreach to facilitate meaningful involvement by resource agencies, NGOs, Alaska Native entities, and other licensing participants in the licensing process. First, AEA organized resource-based Technical Workgroups (TWG) with licensing participants and held a series of monthly meetings to present and discuss AEA's proposed study plans and study planning process. A listing of the meetings and topics covered during these early TWG meetings is provided in Table 1-1 of the PSP, and documentation of these early TWG meetings appears in Attachment 1-1 of the PSP. In addition to 14 separate TWG meetings held by AEA between the PAD and PSP during this period, AEA and its consultant team held many individual and small group meetings and follow-up discussions with individual licensing participants to discuss study issues, existing information, and information needs.

Second, in an effort to assist licensing participants in preparing what AEA expected to be a large number of study requests, AEA took the initiative to prepare and distribute to licensing participants a total of 46 preliminary model draft study requests, based on the early TWG meetings and other consultation with licensing participants. On May 18, 2012, AEA filed these study requests with FERC. Although FERC's ILP regulations do not require prospective applicants to prepare model study requests, or otherwise to assist licensing participants in developing their requested studies, AEA voluntarily undertook this additional, significant effort for purposes of gathering and synthesizing information developed during the early TWG meetings and other consultation efforts, easing the burdens placed on licensing participants, and assisting licensing participants' preparation of their formal study requests.

Third, through an innovative agreement between AEA, Alaska Department of Natural Resources Office of Project Management and Permitting, and federal agencies involved in the licensing process, AEA agreed to provide funding to help support federal resource agencies' participation in the Project licensing. Pursuant to this agreement, federal agencies will be able to retain their own expert consultants to enhance and augment their technical expertise in this licensing effort.[6]

As a result of these efforts, AEA developed a comprehensive PSP. Together, licensing participants and FERC staff submitted a total of 52 individual formal study requests, many of which were similar in purpose and scope to the study issues and concepts outlined in Chapter 5 of the PAD, as modified and updated in collaboration with licensing participants during TWG and other meetings and set forth in AEA's draft model study requests.

In response to the 52 formal study requests submitted, AEA's PSP proposed to undertake all but one of the requested resource studies, although the PSP did propose some alterations and adjustments to the studies requested by licensing participants. In total, the PSP contained 58 individual study plans, organized by corresponding natural resource topical areas and contained within each respective resource section of the PSP. As required by FERC's ILP regulations, 18 CFR § 5.11(b)(4), AEA's PSP included an explanation of all studies submitted by licensing

[6] In this regard, AEA acknowledges that many individuals submitting comments have requested that all studies be subject to peer review. *See* Appendix 1 (AEA responses to comments GEN-09 and GEN-10). While FERC's ILP regulations do not require formal peer review of licensing studies, all study reports developed in this process will be subjected to scrutiny and expert review—with the involvement of AEA, AEA's technical consultants, FERC, FERC's third-party contractor, federal and state resource agencies, and agencies' technical consultants.

participants but not adopted in the PSP. In light of AEA's extensive outreach effort, moreover, the PSP included specific documentation of consultation relevant to the study plan development. AEA filed the PSP with FERC on July 16, 2012.

1.1.4. Development of RSP and Efforts to Resolve Differences over Study Requests

Following its filing and distribution of the PSP, AEA continued its enhanced collaborative process for developing a study plan for the proposed Project. Although FERC's ILP regulations establish a minimal requirement of a single consultation meeting following submittal of the PSP, 18 CFR § 5.11(e), AEA consulted extensively with licensing participants following distribution of the PSP. Shortly after its release of the PSP, AEA held a series of TWG meetings in Anchorage to review each of the 58 proposed studies in the RSP. These meetings occurred over a five-day period on August 8, 9, 15, 16, and 17, 2012. Following these initial meetings, AEA held monthly TWG meetings with licensing participants to solicit comments on AEA's PSP and resolve concerns and differences of opinion related to study objectives, methodologies, scopes, and levels of effort. In addition, over the past several months since issuing the PSP, AEA has conducted numerous individual and focused outreach meetings and teleconferences with licensing participants—all in an attempt to reach agreement on licensing studies. In total, in the brief three-month period following its release of the PSP, AEA held 23 separate TWG meetings, in addition to other, less formal consultation meetings and contacts with licensing participants. TWG meetings held since the filing of the PSP are summarized in Table 1-1.

With regard to AEA's responsibility under FERC's ILP regulations to describe its efforts to resolve differences related to study request, 18 CFR § 5.13(a), during this period AEA continued hold meetings and individual consultation with licensing participants. During TWG meetings and other consultations with AEA, licensing participants raised issues and concerns, which appear in the meeting summaries in Appendix 4 of this RSP. As set forth in Appendix 3, AEA either adopted changes to its proposed studies to accommodate participants' concerns and comments, or explained its basis for declining to make a recommended change. Throughout this highly collaborative period, licensing participants worked closely in efforts to resolve differences and craft a study plan intended to meet participants' resource and information needs for assessing effects of the construction and operation of the proposed Project.

In light of the progress to date in resolving concerns related to the proposed studies, on September 14, 2012 AEA and other licensing participants requested FERC to grant a 30-day extension to allow additional time for licensing participants to submit comments on the PSP, and to continue to resolve differences related to the proposed studies.[7] The Commission granted this request on September 17.[8]

AEA and the other licensing participants made good use of this additional time granted by the Commission. To memorialize the progress reached since the PSP was issued in July, AEA agreed to prepare—based on comments received during the post-PSP collaborative process—an

[7] Letter from Wayne Dyok, Alaska Energy Authority, to Kimberly D. Bose, Federal Energy Regulatory Commission, Project No. 14241-001 (filed Sept. 14, 2012).

[8] Notice of Extension of Time to File Comments on the Proposed Study and Revised Study Plan, Project No. 14241-000 (issued Sept. 17, 2012).

interim draft RSP, which other licensing participants could use when preparing their written ILP comments submitted to FERC. Although this effort intensified the consultation effort, AEA successfully redrafted the study plans, releasing them for public comment by the end of October 2012. Just prior to completing these revisions, AEA held a series of TWG meetings over a five-day period in mid-October, to once again individually review each study plan, summarize and discuss the updates to AEA's study plans since the PSP filing, and provide written response to all comments received from licensing participants. AEA's written response to comments received through the completion of the interim draft RSP at the end of October appears in Appendix 3.

Although the extension of time and interim draft RSP certainly were well beyond the scope of ILP regulatory requirements, AEA believes that these efforts were well worth the investment of time and resources. This RSP, like its PSP predecessor, continues to propose a total of 58 individual study plans; as a result of the intensive and frequent consultation between AEA and other licensing participants over the last three months, however, most of the proposed plans in the RSP have undergone significant modification. The study plans continue to be organized by corresponding natural resource topical areas and contained within each respective resource section of the RSP. For each proposed study within a resource area, the RSP provides all information specified under FERC's ILP regulations, 18 CFR § 5.11, along with additional information about the proposed study. As required by the ILP regulations, moreover, Appendices 1 and 2 of this RSP contain all written comments submitted by licensing participants following AEA's release of the interim draft RSP, together with AEA's detailed response to each proposed study and study component, 18 CFR § 5.13(a). In Section 3 of the RSP, AEA addresses a study that again was requested by certain licensing participants, and which AEA has not adopted in this RSP.

While several licensing participants did not have time to thoroughly review the interim draft RSP when preparing their written comments to FERC,[9] participants that were able to review the interim draft RSP generally commented that most of their concerns and differences were addressed. AEA's response to all written comments filed with the Commission following the interim draft RSP appear in Appendix 1.

1.1.5. Summary of Study Plan Development Process

Based on the above summary, AEA believes that the extraordinary effort of all licensing participants have gone far to resolve most of the study concerns and differences raised in the licensing proceeding. Of the 52 study requests originally submitted by licensing participants, the 58 individual study plans in this RSP substantially adopt the objectives and methodologies of all but one of those requests. Most of the studies proposed by AEA in this RSP essentially consolidate the various study requests by specific resource areas. In this fashion, nearly all of licensing participants' study requests have been incorporated into this RSP. If approved by

[9] In this regard, AEA notes FERC staff's request for the RSP to "clearly track all differences between [AEA's] study proposal and the requested studies." Letter from Jennifer Hill, Federal Energy Regulatory Commission, to Wayne Dyok, Alaska Energy Authority, at A-2, Project No. 14241-000 (issued Nov. 14, 2012). As the U.S. Fish and Wildlife Service (USFWS) and NMFS have requested a similar "cross-walk" document from AEA, and focused their submitted comments on AEA's original PSP, AEA has prepared a separate "cross-walk" document for the original study requests of NMFS and USFWS, which AEA is filing with FERC and distributing to licensing participants concurrently with this RSP.

FERC as proposed, these studies will provide information needed to investigate potential effects to environmental resources resulting from Project construction and operation.

1.2. Process and Schedule Overview

In accordance with FERC's September 17 notice extending the comment period for the RSP, licensing participants have until January 18, 2013 to file any comments on this RSP. Following this deadline, FERC is scheduled to issue its study plan determination by February 1, 2013, also in accordance with the September 17 notice.

Within 20 days after FERC's study plan determination, any federal agency with authority to provide mandatory conditions under Sections 4(e) or 18 of the FPA, 16 USC §§ 797(e), 811, or any state agency or tribe with authority to issue water quality certification for the licensing of the Project under Section 401 of the Clean Water Act (CWA), 33 USC § 1341, may initiate the formal dispute resolution procedures under the ILP with respect to studies pertaining directly to the exercise of their authorities under FPA Sections 4(e) and 18, or under CWA Section 401. 18 CFR § 5.14. Following the completion of any study plan dispute process, FERC will issue its final determination, including any amendments to its study plan determination, no later than May 2, 2013. 18 CFR § 5.14(*l*).

As provided in each of the study plans in this RSP, and as required under FERC's ILP regulations, 18 CFR § 5.11(b)(3), AEA will provide periodic progress reports to licensing participants. These reports will be provided through periodic TWG meetings scheduled quarterly through 2013 and 2014. The purpose of these meetings will be to update licensing participants with information on study progress and initial results, as available. While AEA will strive to schedule these quarterly meetings at least 30 days in advance,[10] the agendas and any other written materials for these meetings may not be available until closer to the meeting date, or at the meeting itself, to allow AEA to present a more complete and contemporaneous progress report of ongoing work.[11] In accordance with the Communication Protocol, "[t]o the extent possible, a meeting summary will be posted to the Project Website within 15 days."[12] In addition, any comments on the meeting summary "should be submitted within 15 days of posting."[13]

By February 3, 2014, AEA will issue its Initial Study Report (ISR), followed by a meeting to discuss study results and any proposed new studies or study modifications, and a public comment period. 18 CFR § 5.15(c). All first year studies other than the Study of Fish Distribution and Abundance in the Upper Susitna River are expected to be completed by the end of 2014, and AEA will present final results in its Updated Study Report (USR), which will be issued by February 2, 2015, followed by another public meeting and comment period. 18 CFR

[10] Communications Protocol § 2.3.3.

[11] *Cf. id.* (providing that AEA "*will strive* to post a written meeting agenda on the Project website at least two weeks prior to the scheduled meeting" and that AEA "will strive to make available documents and other information necessary to prepare for a consultation meeting at least two weeks prior to the scheduled meeting") (emphasis added).

[12] *Id.* § 2.3.4.1.

[13] *Id.*

§ 5.15(f). The information in the ISR and USR, together with the results of the fish distribution study, which is expected to be completed by the end of April 2015, will be updated as necessary and analyzed as part of AEA's License Application. The updated process, plan, and schedule for the Project is provided in Table 1.1-1, which includes additional detail regarding specific study dispute resolution steps and milestones. AEA has included timeframes for Formal Dispute Resolution, highlighted in yellow [18 CFR 5.14], which only apply if AEA and the licensing participants cannot resolve any study disputes informally.

1.3. Project Facilities and Operations

This section provides a brief overview of the Project location, facilities and proposed operational characteristics. At this time there several updates from the descriptions in the PAD, including the proposed dam height and normal maximum reservoir level, the study area boundaries for the transmission and road corridors, along with updated information on project operations described below. The proposed Project is located in the Southcentral region of Alaska, approximately 120 miles (mi) north-northeast of Anchorage and 110 mi south-southwest of Fairbanks. As proposed, the Project would include construction of a dam, reservoir and power plant on the Susitna River starting at river mile (RM) 184, approximately 32 mi upstream of Devils Canyon. Transmission lines connecting into the existing Railbelt transmission system and an access road would also be constructed. Because engineering and environmental studies are helping define the locations and configurations of the Project components, the current study area for the Project is larger than that which will be proposed within the Project Boundary and includes alternative transmission and road corridors that are expected to eventually be narrowed down to one or two proposed corridors (Figure 1.2-1).

Dam and Reservoir

As currently envisioned, the Project would include a large dam with a 23,546-acre reservoir at El 2050 ft mean sea level (msl). The height and type of dam construction are still being evaluated as part of ongoing engineering feasibility studies, but analysis to date indicates that a roller-compacted concrete structure is viable and economic. The dam has a nominal crest elevation (El.) 2,075 ft (msl) corresponding with a maximum height of about 750 ft above the prepared rock foundation and a crest length of approximately 3,100 ft. The maximum height of the structure will depend both on the results of the ongoing geotechnical site investigations (which will indicate the extent of excavation required below the river bed) and the results of the PMP/PMF studies (which together with the spillway design analysis will determine the freeboard above normal TWL). The Watana Reservoir normal top water level (TWL) has been reassessed and is proposed as El. 2,050 ft msl, which will impound a reservoir approximately 42.5 mi long (measured along the centerline of the reservoir at El. 2050) with an average width of approximately 1 to 2 mi. The total water surface area at normal maximum operating level is approximately 23,546 acres. The minimum reservoir level will be about 1,850 ft msl during normal operation, resulting in a maximum drawdown of 200 ft. Based on recently updated GIS data, the reservoir will have a total capacity of 5.2 million ac-ft, of which 3.4 million ac-ft will be active storage.

The dam incorporates three facilities for discharge:

1. Penstocks which direct water through the power facilities;
2. Emergency Release facilities installed within the plugged diversion tunnels; and,
3. Outlet facilities discharging below the spillway.

The outlet facilities which will facilitate the discharge of up to 24,000 cfs (together with the powerhouse flow representing up to a routed 50-year flood, or a flushing flow) will be located so that they may be used even when the reservoir level is at its minimum level.

Construction materials for the dam and appurtenant structures will utilize, as far as possible, rock from the structure excavations to minimize the quarry development. Stable excavations and rock cuts will be designed with suitable rock reinforcement and berms.

The bulk of the rock excavated to provide aggregate for concrete etc. is projected to be derived from a quarry to be located on the left abutment upstream of the dam. The planning of the quarry will attempt to ensure that the floor of the quarry is below the lowest projected water level in the reservoir, in order to minimize visual impact and leave the quarry always flooded during operation. In a similar manner, the area upstream of the dam is being investigated to try to define a spoil area upstream of the dam that will be permanently submerged.

Clearing of shrubs and trees within the projected reservoir is not contemplated throughout the entire reservoir area. It is proposed that clearing of all substantive vegetation only be initiated for a distance of some two to three miles upstream of the dam, although consideration will be given during studies to clearing the area between the active storage top and bottom water level of trees throughout the length of the reservoir.

The quarry will incorporate sloping roads to facilitate access from bench to bench, and during operation it is expected that any floating debris will be captured by boat and brought to the ramps in the flooded quarry for removal and disposal. The intakes themselves will incorporate trashracks and rakes for removal of any debris not collected by boat operations.

Thick alluvial deposits will be removed from the river bed, and there will be excavation of weathered or loose rock in order to found the dam on sound bedrock.

Hydroelectric Facilities

The powerhouse will be located immediately downstream of the dam, and will house three generating units, each with a nominal capability of 200 MW unit output under average net head for a total plant capacity of 600 MW under average head. However, based on discussions with Railbelt utilities regarding electrical system reliability, AEA may propose up to four units with a nominal capacity of 150 MW and a total capacity of 600 MW. The capacity of the Project eventually proposed for licensing could extend up to 800 MW. The exact sizing and number of units may change as a result of further transmission system studies.

The average annual energy of the Project will be about 2,800,000 megawatt hours. If only three units are proposed, the powerhouse will be designed and constructed with an extra empty generating unit bay for the potential installation of a fourth unit at a future time. There would be two outlet works facility structures and four power intake structures (one corresponding to the extra unused powerhouse bay if three units are proposed).

Ancillary Facilities

Watana Dam site development will require various facilities to support the construction activities throughout the entire construction period. Following construction, the operation of the Project will require a small permanent staff and facilities to support the permanent operation and maintenance (O&M) program.

The most significant item among the temporary site facilities will be a construction camp. The construction camp will be a largely self-sufficient community normally housing approximately 800 persons, but with a peak capacity of up to 1,000 people. After construction, AEA plans to remove most of the camp facility, leaving only those aspects that are to be used to support the smaller permanent residential and operation and maintenance facilities.

Other site facilities include contractor work areas, site power, services, and communications. Site power and fiber optic cabling for construction will be brought either on the transmission line route, or along the side of the access road. Items such as power and communications will be required for construction operations, independent of camp operations.

Permanent facilities will include community facilities for O&M staff members and any families. Other permanent facilities will include maintenance buildings for use during operation of the power plant.

The airstrip and helicopter/airplane hard standing will be left in place after construction.

Transportation Access

There would be both temporary and permanent site access facilities to provide a transportation system to support construction activities, and to facilitate orderly development and maintenance of the Project. The current planning assumes restricted public access during construction for safety considerations. Another goal is to co-locate access roads and transmission facilities, to the extent possible, in the same corridor to minimize environmental impacts.

Three possible alternatives for access roads and transmission lines have been identified for the Project (Figure 1.2-1). Two of the alternatives would accommodate east-west running transmission lines in combination with a new site access road connecting to the Alaska Intertie and the Alaska Railroad. One of these corridors, designated as the Chulitna Corridor, would contain a road approximately 42.7 miles-long running north of the Susitna River, and extending to the Chulitna siding area. The other alternative, designated as the Gold Creek Corridor, would contain a road approximately 49.2 miles-long running south of the Susitna River, and extend to the Gold Creek area. Neither of these two access roads would connect to public roads, ending at the railway tracks.

A third corridor, designated as the Denali Corridor, would run due north, connecting the Project site to the Denali Highway by road over a distance of about 41.4 miles. If a transmission line is constructed within this corridor, it would be extended westward along the existing Denali Highway and connect to the Alaska Intertie near Cantwell.

If the Denali Corridor is selected the affected sections of the Denali Highway will be upgraded in order to facilitate safe construction of the Project. The Denali Highway upgrades would not be a part of the Project.

Regardless of which road is chosen, the majority of the new road will follow terrain and soil types that allow construction using side borrow techniques, resulting in a minimum of disturbance to areas away from the alignment. A berm type cross-section will be formed, with the crown of the road being approximately 2 to 3 ft above the elevation of adjacent ground. To reduce the visual impact, the side slopes will be flattened and covered with excavated peat and other naturally occurring materials. A 200-foot right-of-way is anticipated to be sufficient for this type of construction.

Permanent access to the Watana Dam site will connect with the existing Alaska Railroad either at Chulitna, Cantwell or Gold Creek, where—at the chosen location—a railhead and storage facility occupying up to 40 ac will be constructed alongside the existing passing bays. New sidings of a length up to 5,000 ft will be constructed so that off-loading and transfer of goods and materials can take place without interrupting the daily operations of the Alaska Railroad Corporation (ARRC). This facility will act as the transfer point from rail to road transport and as a backup or interim storage area for materials and equipment, and as an inspection and maintenance facility for trucks and their loads. Within the 40 acre site would be a small residential camp for early use before the main camp at site is complete. It is intended that elements of this camp will be removed to the main site camp, leaving sufficient facilities for drivers trucking equipment to the construction site, for laborers and staff operating the transfer, for emergency use, and for support staff such as cooks and maintenance workers.

If the Denali Corridor is chosen for road access, the pavement on the first section of the Denali Highway in the community of Cantwell will be extended for a distance of approximately four miles to help minimize problems with vehicle dust and kicked-up stones. In addition, the following measures will be taken:

- Speed restrictions will be imposed along appropriate segments;
- Improvements will be made to the intersections including pavement markings and traffic signals.

Electric Transmission Facilities

The transmission lines will begin at a new substation at Watana Dam and consist of three 230-kV lines, in either single or double-circuit configuration. The same three corridors under consideration for the access road are also those under consideration to route the Project primary transmission lines to the Alaska Intertie. One or two transmission corridors may be chosen. The transmission system will include a switching station at the points of tie-in (at Chulitna, Gold Creek and/or Cantwell). Extending out from the Watana substation, the transmission corridors are essentially co-located with the access road corridors except for three specific areas:

1) For the northern westward route (Chulitna Corridor), the first five miles (westward from the power facilities) of the double circuit 230-kV transmission lines will not follow the coincident road corridor. The two lines will cross the river from the substation (together with any line destined for the northern route) in a northerly direction for two mi, after which the two lines will turn northwesterly to cross Tsusena Creek and three mi later will intersect the Chulitna road corridor. At the extreme westerly end of the corridor, it will widen to facilitate the divergence of the road and the transmission line which will continue to a switching station on the Alaska Intertie.
2) For the southern westward route (Gold Creek Corridor) the transmission lines would generally follow the planned road corridor. Some 5 miles northeast of Gold Creek will be

a switching station on the existing Alaska Intertie, beyond which, to the west, the road will be the sole occupant of the corridor.

3) For the northern route, the only divergence between the road and transmission line corridor will occur at Deadman Lake, at which location the road will be aligned west of Deadman Hill, while the transmission will follow a lower elevation corridor on the east of the hill. Both corridors will rejoin some 9 mi later on the north side of the Deadman Hill.

At the Denali Highway, the northern transmission corridor will turn west and continue along the Denali Highway to the Cantwell switching station.

The right-of-way for the transmission lines within the corridors will consist of a linear strip of land. The width will depend on the number of lines. The transmission rights-of-way will be 200, 300, or 400 feet, depending on whether one, two, or three lines run in parallel and may run coincident with a road right-of-way in many locations.

The switching stations and substation will occupy a total of approximately 16 acres.

Rights-of-way for permanent access to switching stations and substation will be required linking back to the permanent site access road. These rights-of-way will be 100 ft wide.

Access to the transmission line corridors will be:

a) Via unpaved vehicle access track from the permanent access roads at intermittent points along the corridor. The exact location of these tracks will be established in the final design phase.
b) By helicopter, where there is no access road projected.

Within the transmission corridor itself an unpaved vehicle access track up to 25 ft wide will run along the entire length of the corridor, except at areas such as major river crossings and deep ravines where an access track would not be utilized for the movement of equipment and materials.

Project Operations

Project operating flexibility is important to Railbelt utilities. AEA is performing “production modeling” simulation, encompassing the entire Alaska Railbelt connected system in order to maximize the benefit of the Watana generating station, and may propose to operate the Project in a load-following mode such that firm energy is maximized during the critical winter months of November through April each year to meet Railbelt utility load requirements. To accomplish efficient dispatch, the reservoir would be drafted annually by an average of about 150 ft, but a maximum drawdown of 200 feet (to 1850 ft) will be possible and could infrequently occur. Instream flow releases would be made through the powerhouse or through low level outlet works during the rare occasions when the power plant is off line during emergency outages. Flow discharges through the powerhouse under this operating plan would range from the minimum required instream flow release (yet to be determined) to a high of about 15,000 cfs (based on the 600 MW nominal installed capacity) during times of maximum power generation. Based on preliminary studies, daily power generation during a peak winter month (January) would average about 9,200 MWh and powerhouse discharges would average approximately 9,600 cfs during that time.

For efficient operation of the whole system, powerhouse discharges are expected to vary over a 24-hour period during the peak winter months. It is difficult to characterize typical powerhouse operations before production modeling simulation of the Railbelt is complete. To provide a preliminary indication of powerhouse discharge variability under the relatively conservative assumption of the Watana powerhouse providing the entire load variability of the Railbelt during a typical January, daily powerhouse discharges could range from about an average of 5,600 cfs to about 13,000 cfs. Powerhouse discharges could be as high as 15,000 cfs (at maximum plant output based on a 600 MW project) for short periods of time during the day to meet load spikes or emergency conditions. The daily flow variation may be constrained because of environmental needs. For a Base Case preliminary test case operating plan, initial model runs have been made using the Case E-VI minimum instream flow criteria developed during the 1980s project studies. Those criteria specified a minimum wintertime flow of 2,000 cfs at Gold Creek, and a minimum summertime flow release of varying amounts at or above about 9,000 cfs. At this time, for planning purposes, AEA is considering a minimum winter flow of not less than 3,000 cfs at Gold Creek. During the winter the average daily flow would be gradually increased to reflect colder conditions in January and February. The average daily flows would be gradually reduced during March and April.

During 2013, a detailed analysis of downstream water level variations will become available. These results will be based on cross-sectional, water level, river flow, and other data gathered during field studies performed in 2012. The results of the production operation modeling—i.e., the projected operation of the Project derived therefrom—will be used, together with HEC-RAS modeling to project the variations in water levels at locations downstream of the Project.

In the interim, before final 2013 studies of water level variations are available, it is useful to have an early preliminary indication of downstream water level variations. Cross-sectional data collected in the 1980s are available at about 100 cross-sections between the Watana Dam site (RM 184) and the vicinity of Sunshine (RM 84). Combined with other data and information available from 1980s reports, including rating curves developed at the cross-sections with the HEC-2 Water Surface Profiles program and roughness coefficients, it is possible to develop a downstream flow routing model using the USACE program HEC-ResSim. While results from this model eliminate the void of having no indication at all of downstream water level fluctuations, it must be clearly noted that final results in 2013 will differ from the results presented on the following figures for at least the following reasons: (1) input data will be changed from 1980s data to 2012 data; (2) the analysis model will change from HEC-ResSim to HEC-RAS, which is much more detailed and uses better hydraulic routing methods, and (3) the hourly flow releases at Watana Dam will be updated based on production modeling results.

One calendar year of preliminary hourly flow routing results from HEC-ResSim are presented in Figures 1.2-2, 1.2-3, and 1.2-4, respectively, for cross-sections in the tailwater area just below the Watana Dam site, near Gold Creek, and near Sunshine. The unregulated stage (red) line represents natural conditions without Watana Dam. The regulated stage (gold) line represents simulated conditions with the proposed Watana Dam. The results presented on these figures incorporate the following conditions and assumptions:

- Ice free conditions must be included in the analysis throughout the year as flow simulation under an ice cover is beyond the capabilities of HEC-ResSim.
- The Watana powerhouse provides the entire load variability of the Railbelt. Although this is not a realistic operation for an entire year, it was included for the entire year for

illustration purposes. AEA anticipates that existing hydropower in the Railbelt system (e.g., Bradley Lake) would typically provide the load variability and that the Project would be used to provide remaining load variability subject to environmental constraints. This would significantly reduce the need for powerhouse flow fluctuations.

- Minimum release requirements are Case E-VI from the 1980s, modified to include minimum flows of 3,000 cfs at Gold Creek.
- All cross-sectional data and rating curves are from the 1980s.
- Load data originates from the 2010 Railbelt Integrated Resources Plan.

The following figures indicate two primary changes in water level when comparing the unregulated and regulated conditions. First, there is a seasonal shift of flow from the natural high flow months into the cold season months of November through April. This results from the primary function of the reservoir, which is to store water during the months of higher flow and lower electricity demand (May through October) and release more flow for generation during the period of lower flow and higher electricity demand (November through April).

The second primary change in water level variations would be the addition of water level fluctuations on a diurnal basis as Watana generation responds to the hourly change in electricity demand in the Railbelt. Results on the three stage figures generally indicate a reduction in water level fluctuations as the flow moves downstream. It must be noted that water level fluctuations will vary from one location to another along the river, depending on the shape of the cross-section. Determining the unregulated flow record for long periods with an ice cover is an inherently difficult task that can be expected to have lower accuracy compared to ice free conditions. The unregulated recorded flows are frequently constant for an entire winter month, with a step change on the first day of the following month.

Another notable aspect of the regulated flow operation with Watana Dam is exhibited on the figures during late August of the example year when reservoir outflows rapidly increase so that reservoir outflows are essentially the same as reservoir inflows. This is an indication that the reservoir has filled and passing the inflows to maintain the maximum normal pool level. This is also a preliminary operating mode that could be moderated by future detailed generation scheduling and inflow forecasting.

Construction Schedule

The current Project schedule allows 13 years for Project development including: FERC licensing, license implementation, design and contracting, construction, demobilization, and site restoration. Several assumptions have been made regarding the times required for the various activities.

The following are the time periods for major components of Project Development:

- Total schedule – 13 years, 2012-2024
- Pre-Application studies and related activities 3.5 years
- FERC and Cooperating agencies post-filing activities – approximately 1.5 years.
- Project Construction – 7.5 years
- Reservoir filling – one to two years
- Site Restoration – throughout construction.

Design work would be initiated prior to issuance of the license, so that construction critical to the schedule (such as access roads and construction support facilities) will be ready to commence shortly after issuance of the license and subsequent approvals.

Study Area

As show in Figure 1.2-1, the whole study area under evaluation for the siting of Project facilities consists of 97,244 acres. The proposed reservoir normal maximum water surface elevation includes all lands and waters up to elevation 2,050 feet that encompass approximately 23,546 acres. The area around the proposed dam site being evaluated for siting of construction and operation camps, airstrip and quarries encompasses 9,578 acres. The transmission and road corridor study areas encompass the following acreages (approximate):

Gold Creek Road and Transmission Corridor – 18,497 acres

Chulitna Road and Transmission Corridor – 19,687 acres

Denali Road and Transmission Corridor – 25,936 acres

1.4. 2012 Early Study Efforts

AEA is currently completing initial studies carried out during 2012. These early studies have in many cases helped inform the study planning process and provided updated information that supplements existing information. Much of the information that was gathered in 2012 has informed the study planning process particularly with respect to planning the logistical aspects of 2013 and 2014 studies. In some cases, updating information consists of taking information developed in the 1980s and converting it into modern digital datasets for use in comparative analysis with the new information being obtained in the FERC formal studies. The following list identifies the specific 2012 studies; please refer to Attachment 1-1 for a summary of each study effort.

Water Resources

- Review of Existing Water Temperature Model Results and Data Collection
- Aquatic Habitat and Geomorphic Mapping of the Middle River Using Aerial Photography
- Reconnaissance-Level Geomorphic and Aquatic Habitat Assessment of Project Effects on Lower River Channel
- Documentation of Susitna River Ice Break-up and Formation

Instream Flow

- Instream Flow Planning Study
- River Flow Routing Model Data Collection

Fish and Aquatic Resources

- Synthesis of Existing Fish Population Data
- Adult Salmon Distribution Habitat Utilization Study
- Upper Susitna River Fish Distribution and Habitat Study
- Cook Inlet Beluga Whale Anadromous Prey Analysis

Botanical Resources

- Vegetation and Wildlife Habitat Mapping Study
- Wetland Mapping Study
- Riparian Study

Wildlife Resources

- Eagle and Raptor Nest Study
- Past and Current Big Game Harvest Study
- Wildlife Habitat Use and Movement Study

Recreation and Aesthetic Resources

- Aesthetic and Recreation Resources Study

Cultural Resources

- Cultural Resources Study

1.5 Tables

Table 1-1. Technical Workgroup and Agency Consultation Meetings since development of the PSP.

Date	Licensing participant	Subject
08/08/2012	AEA, ADF&G, ADNR-OPMP, AHTNA, BLM, Chickaloon Village, DHSS, EPA, FERC, MSB, Natural Heritage Institute/Hydropower Reform Coalition, NPS, OHA/SHPO, and other interested parties	• Regional Economic Evaluation • Social Conditions and Public Goods and Services Study • Transportation • Air Quality • Health Impact Assessment • Project Safety (PMP and Seismic Hazards) • Recreation, River Flow, and Aesthetics • Cultural and Paleontological Resources • Subsistence Study
08/09/2012	AEA, ADF&G Wildlife Conservation, ARRI, BLM, Office of Project Management and Permitting, Natural Heritage Institute, USFWS, FERC, and other interested parties	• 16 Wildlife Study Plans • 5 Botanical Study Plans
08/15/2012	AEA, USFWS, ADNR, ADNR-OPMP, NMFS, EPA, ADF&G, FERC, Natural Heritage Institute/Hydropower Reform Coalition, ARRI, Alaska Ratepayers, and other interested parties	• Characterization of Aquatic Habitats • Fisheries Studies (in River, in Future Reservoir, Salmon Escapement, Passage Barriers, Genetic Baseline, Harvest, Passage at Dam, River Productivity) • Cook Inlet Beluga Whale • Aquatic Resources in Other Project Areas
08/16/2012	AEA, USFWS, ADNR, ADNR-OPMP, NMFS, ADF&G, USGS, Tribal Council, FERC, Natural Heritage Institute/Hydropower Reform Coalition, ARRI, Alaska Ratepayers, and other interested parties	• Instream Flow • Riparian Instream Flow • Groundwater-Related Aquatic Habitat • Glacial Runoff • Geology/Soils
08/17/2012	AEA, USFWS, ADNR, ADNR-OPMP, NMFS, ADF&G, USGS, Tribal Council, FERC, Natural Heritage Institute/Hydropower Reform Coalition, ARRI, Alaska Ratepayers, and other interested parties	• Geomorphology and Fluvial Geomorphology Modeling • Ice Processes • Baseline Water Quality • Mercury and Bioaccumulation
09/06/2012	ADF&G, USFWS, FERC, AEA, and other interested parties	• Landbird and Shorebird Studies
09/07/2012	AEA, BLM, OHA, MatSu Borough, NOAA, Chickaloon, AHTNA, CIRI, FERC, and other interested parties	• Cultural Resources
09/13/2012	AEA, ADF&G Wildlife Conservation, FERC, and other interested parties	• Terrestrial Mammal Studies (Bear, Dall's Sheep, Furbearers, Wolverines, Bats) • Wildlife Habitat Evaluation • Wood Frogs • Landbirds and Shorebirds

Date	Licensing participant	Subject
09/13/2012	AEA, USFWS, FERC, Louis Berger Group, ARRI	• Fish Distribution and Abundance Studies (Sampling strategies and techniques)
09/13/2012	AEA, USFWS, ADF&G	• Fish Distribution and Abundance Studies (Sampling strategies and techniques)
09/14/2012	AEA, USFWS, ARRI, ADF&G, Village of Eklutna,, FERC, Coalition for Susitna Alternatives, and other interested parties	• Instream Flow Study Site Selection • Geomorphology and Ice Processes
09/18/2012	AEA, ADEC, EPA, USACE, USEPA, USFWS, and other interested parties	• Wetland Delineation, Mapping, and Functions
09/19/2012	AEA, NMFS, ADF&G	• Cook Inlet Beluga Whale Study
09/20/2012	AEA, ADF&G, ADNR, Alaska HIA, BLM, FERC, Natural Heritage Institute/Hydropower Reform Coalition, NOAA, NPS, and other interested parties	• Recreation Survey • Socioeconomic Study • River Flow Study • Aesthetics Study
09/24/2012	AEA, BLM, CIRI, Coalition for Susitna Dam Alternatives, AOHA, MatSu Borough, and other interested parties	• Cultural Resources Study Plan (APE map and other maps)
9/25/2012	AEA, ADF&G	• Salmon Escapement Study Fish Genetic Baseline Study
9/27/2012	AEA, USFWS, NMFS, ADF&G, ARRI	• Fish Distribution and Abundance Studies (Sampling strategies and techniques)
9/27/2012	AEA, USFWS, NMFS, FERC, Louis Berger Group, ADF&G, UAF, ARRI	• River Productivity Study
10/01/2012	AEA, USFWS, NMFS, Natural Heritage Institute/Hydropower Reform Coalition, ADNR, Coalition for Susitna Dam Alternatives, FERC, BLM, and other interested parties	• Instream Flow Riparian Study Plan (Focus Areas, Study Site Design, Groundwater-Surface Water Interaction, Ice)
10/02/2012	AEA, BLM, NMFS, USFWS, ADF&G, FERC, Natural Heritage Institute/Hydropower Reform Coalition, ARRI, Alaska Ratepayers, and other interested parties	• Instream Flow Study (Focus Areas, Fish and Aquatics, Models, Method Selection, Pilot Winter Studies)
10/03/2012	AEA, ADNR (State Parks), ADF&G, BLM, FERC, NPS, and other interested parties	• Aesthetic Resources (Key Observation Points, Analysis Process) • River Flow Study • Survey Instruments
10/04/2012	AEA, NOAA, USFWS, ARRI, ADF&G, NMFS, FERC, Natural Heritage Institute/Hydropower Reform Coalition, and other interested parties	• Instream Flow Field Reconnaissance Debrief

Date	Licensing participant	Subject
10/04/2012	AEA, USFWS, ADF&G, FERC, and other interested parties	• Waterbirds Studies (Study Plan, Migration and Breeding, Productivity, Harlequin Duck) • Bird Migration Surveys
10/16/2012	AEA, ADF&G, USFWS, FERC, ADNR OPMP, Natural Heritage Institute, Coalition for Susitna Dam Alternatives, and other interested parties	• PSP and ILP Study Plan Process • Terrestrial Wildlife Studies (Birds, Wood Frog, Moose, Caribou, Dall's Sheep, Large Carnivores, Wolverine, Terrestrial and Aquatic Furbearers, Habitat Evaluation, Harvest, Little Brown Bat, Small Mammals) • Botanical Mapping Studies (Vegetation and Wildlife Habitat, Riparian Vegetation, Wetland)
10/17/2012	AEA, ADF&G, ADNR, ADNR-DMLW, AHTNA, CIRI, Coalition for Susitna Dam Alternatives, FERC, Natural Heritage Institute/Hydropower Reform Coalition, NPS, SHPO, and other interested parties	• Transportation, Air Quality, and Health Impact Assessment • Regional Economics and Socioeconomics • Subsistence • Recreation, River Flow, and Aesthetic • Cultural Resource
10/23/2012	AEA, ADNR, USGS, USFWS, DEC, Natural Heritage Institute/Hydropower Reform Coalition, USDA, FERC, ADF&G, NMFS, Coalition for Susitna Dam Alternatives, and other interested parties	• PSP and ILP Study Plan Process • Geomorphology Study • Fluvial Geomorphology Modeling • Baseline Water Quality • Mercury • Project Hydrology
10/24/2012	AEA, USGS, USFWS, ADNR, AGO, Hydropower Reform Coalition, USDA, ARRI, DGGS, ADF&G, DEC, Coalition for Susitna Alternatives, FERC, NMFS, and other interested parties	• PSP and ILP Study Plan Process • Fish and Aquatic Instream Flow • Riparian Instream Flow • Groundwater-Related Aquatic Habitat • Glacial and Runoff Changes • Project Hydrology
10/25/2012	AEA, ADF&G, ARRI, AGO, ADF&G, USFWS, USDA, BLM, ADNR, NMFS, FERC, and other interested parties	• PSP and ILP Study Plan Process • Habitat Characterization Study • Fish Distribution and Abundance • River Productivity • Cook Inlet Beluga Whale • Hydrology
11/02/2012	AEA, NMFS and ADF&G	• Cook Inlet Beluga Whale • Eulachon

Table 1.1-1. Project Process Plan and Schedule (dispute process highlighted in yellow).

Responsible Party	Pre-Filing Milestone	Date	FERC Regulation
AEA	Issue Public Notice for NOI/PAD	12/29/11	5.3(d)(2)
AEA	File NOI/PAD with FERC	12/29/11	5.5, 5.6
FERC	Alaska Native Entity Meetings	1/30/12	5.7
FERC	Issue Notice of Commencement of Proceeding and Scoping Document 1	2/27/12	5.8
FERC	Scoping Meetings	3/26-29/12	5.8(b)(viii)
All licensing participants	PAD/SD1 Comments and Study Requests Due	5/31/12	5.9
FERC	Issue Scoping Document 2	7/16/12	5.1
AEA	File Proposed Study Plan (PSP)	7/16/12	5.11(a)
All licensing participants	Proposed Study Plan Meetings	8/15-16/12	5.11(e)
All licensing participants	Proposed Study Plan Meetings	10/16-25/12	N/A
All licensing participants	Proposed Study Plan Comments Due	11/14/12	5.12; FERC Notice
AEA	File Revised Study Plan	12/14/12	5.13(a); FERC Notice
All licensing participants	Revised Study Plan Comments Due	1/18/13	5.13(b); FERC Notice
FERC	Director's Study Plan Determination	2/1/13	5.13(c); FERC Notice
Mandatory Conditioning Agencies only	Any Study Disputes Due	2/21/13	5.14(a)
Dispute Panel	Third Dispute Panel Member Selected	3/8/13	5.14(d)
Dispute Panel	Dispute Resolution Panel Convenes	3/13/13	5.14(d)(3)
AEA	Applicant Comments on Study Disputes Due	3/18/13	5.14(j)
Dispute Panel	Dispute Resolution Panel Technical Conference	3/2513	5.14(j)
Dispute Panel	Dispute Resolution Panel Findings Issued	4/12/13	5.14(k)
FERC	Director's Study Dispute Determination	5/2/13	5.14(l)
AEA	First Study Season	2013	5.15(a)
AEA	Initial Study Report	2/3/14	5.15(c)(1)

Responsible Party	Pre-Filing Milestone	Date	FERC Regulation
All licensing participants	Initial Study Report Meeting	2/18/14	5.15(c)(2)
AEA	Initial Study Report Meeting Summary	3/5/14	5.15(c)(3)
All licensing participants	Any Disputes/Requests to Amend Study Plan Due	4/4/14	5.15(c)(4)
All licensing participants	Responses to Disputes/Amendment Requests Due	5/4/14	5.15(c)(5)
FERC	Director's Determination on Disputes/Amendments	6/4/14	5.15(c)(6)
AEA	Second Study Season	2014	5.15(a)
AEA	Updated Study Report due	2/2/15	5.15(f)
All licensing participants	Updated Study Report Meeting	2/17/15	5.15(f)
AEA	Updated Study Report Meeting Summary	3/4/15	5.15(f)
All licensing participants	Any Disputes/Requests to Amend Study Plan Due	4/3/15	5.15(f)
All licensing participants	Responses to Disputes/Amendment Requests Due	5/4/15	5.15(f)
FERC	Director's Determination on Disputes/Amendments	6/3/15	5.15(f)
AEA	File Preliminary Licensing Proposal or Draft License Application	4/14/15	5.16(a)
All licensing participants	Preliminary Licensing Proposal/Draft License Application Comments Due	7/13/15	5.16(e)
AEA	File Final License Application	9/11/15	5.17
AEA	Issue Public Notice of License Application Filing	9/11/15	5.17(d)(2)

1.6. Figures

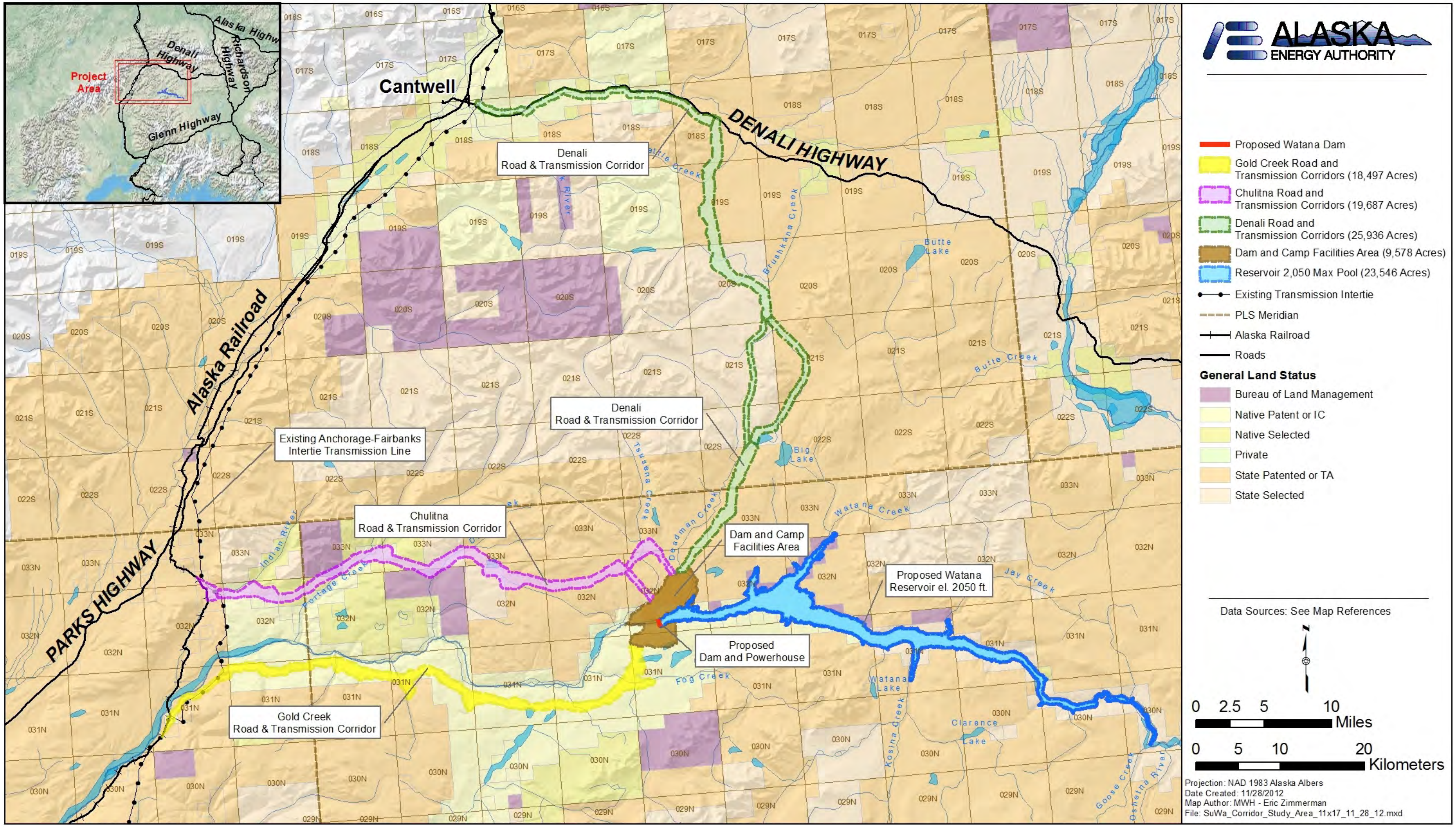

Figure 1.2-1. Susitna-Watana Project Area.

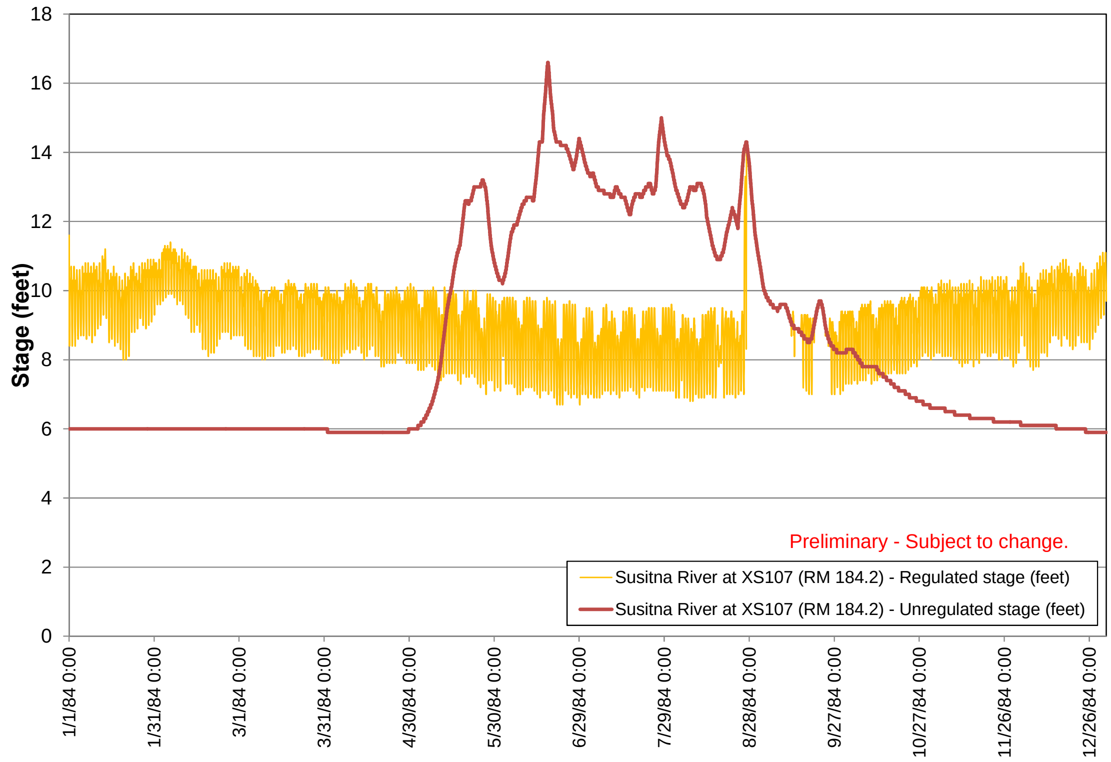

Figure 1.2-2. Susitna River Stage near Watana Tailwater.

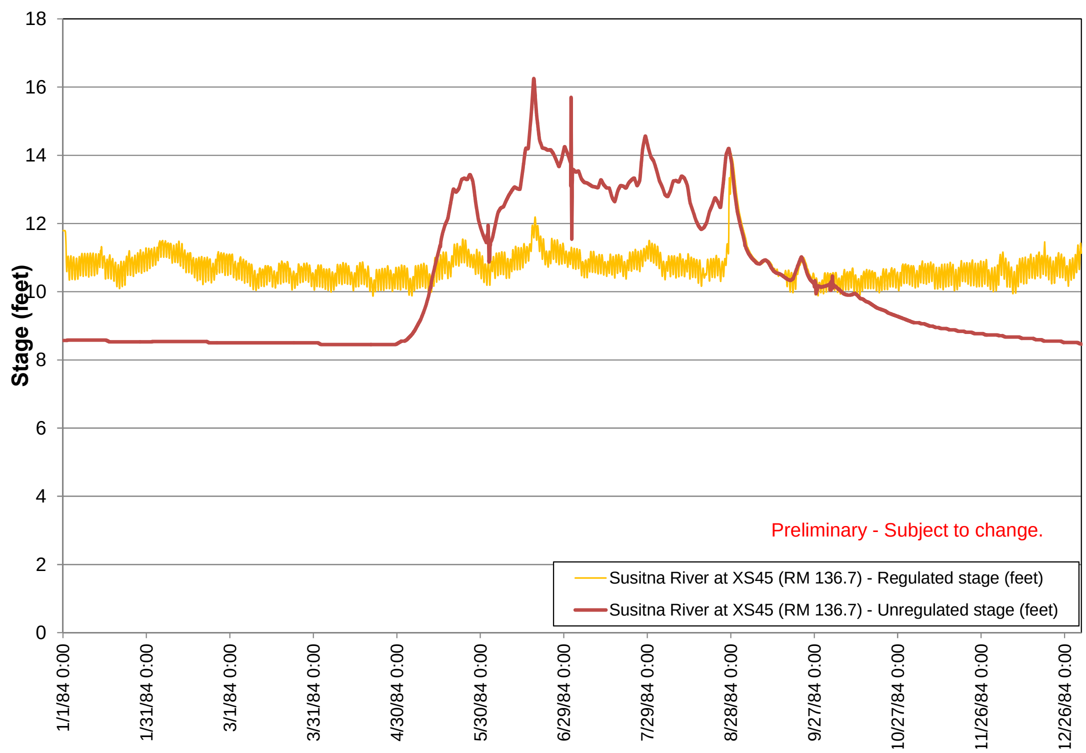

Figure 1.2-3. Susitna River Stage near Gold Creek.

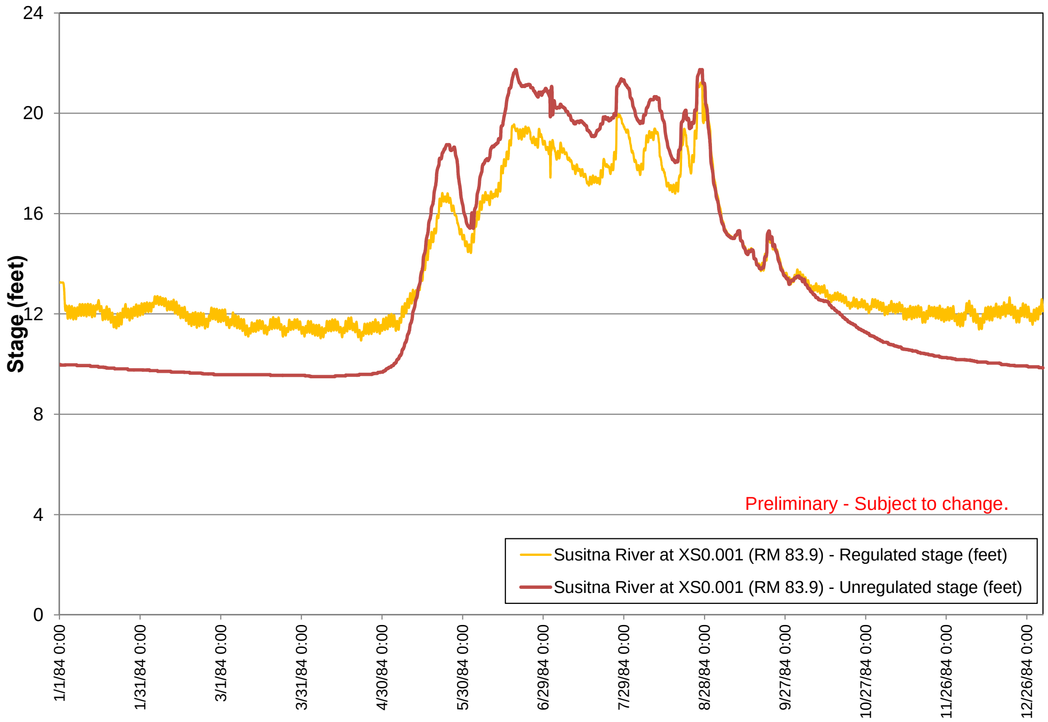

Figure 1.2-4. Susitna River Stage near Sunshine.

1.7. Attachments

ATTACHMENT 1-1. 2012 EARLY STUDY EFFORTS

ATTACHMENT 1-1
2012 EARLY STUDY EFFORTS

2012 Early Study Efforts

Water Resources

Review of Existing Water Temperature Model Results and Data Collection

The objective of the 2012 Review of Existing Water Temperature Model Results and Data Collection Study was to provide a baseline for water temperature modeling of the Susitna River and proposed reservoir to be conducted in 2013-2014. Specific objectives included: (1) evaluate 1980s water temperature modeling (i.e., SNTEMP and DYRESM) results; (2) determine applicability of past modeling results; and (3) initiate collection of stream temperature and meteorological data required for 2013-2014 modeling. The study area included the Susitna River from river mile (RM) 10.1 to RM 233.4.

SNTEMP and DYRESM assumptions and predictive capabilities were evaluated to determine applicability to current conditions. Model configurations, input parameters, and calibration/validation were assessed, and flows and a range of release schedules were compared with recent records to assess applicability to the currently proposed Project. If existing temperature models are applicable, results will be synthesized to evaluate potential effects of the proposed Project on water temperature and guide the design of 2013-2014 study plans.

The 2012 monitoring locations were selected from water temperature data and monitoring locations from the 1980s. Locations were selected based on: (1) adequate representation throughout the Susitna River and tributaries; (2) preliminary consultation with AEA and licensing participants; and (3) understanding of other proposed studies and study sites (e.g., instream flow, ice processes). Water temperature data loggers were installed at 39 sites, and meteorological (MET) data were collected at eight locations between RM 25.6 and RM 224.

Aquatic Habitat and Geomorphic Mapping of the Middle River Using Aerial Photography

Aquatic habitat and geomorphic features were quantified using aerial photography from the 1980s and evaluated for applicability to current conditions. Quantification of geomorphic features and aquatic habitat types provided a basis for selecting study sites, understanding flow-habitat relationships, and assessing geomorphic conditions. Objectives of the 2012 Aquatic Habitat and Geomorphic Mapping of the Middle River Using Aerial Photography Study included: (1) identify the surface area of riverine habitat types over a range of stream flows; (2) compare current and 1980s geomorphic feature/units and associated aquatic habitat type data to characterize the relative stability of the channel under unregulated flow conditions; and (3) delineate large-scale geomorphic river segments to stratify the river into study segments for use in 2013-2014 study design and implementation. The study area included the Middle Susitna River from RM 98 to RM 184.

Aerial photography from 2012 was combined with historic information and digitized to create a spatial representation (i.e., GIS database) of geomorphic features/units and macro- and meso-scale riverine habitat types. The information was compared with aquatic habitat and geomorphology under 1980s and current conditions. The Middle River was then delineated into large-scale geomorphic river segments with relatively homogeneous characteristics including channel width, entrenchment ratio, sinuosity, slope, geology/bed material, single/multiple channel, braiding index, and inflow from major tributaries.

Reconnaissance-Level Geomorphic and Aquatic Habitat Assessment of Project Effects on Lower River Channel

The 2012 Reconnaissance-Level Geomorphic and Aquatic Habitat Assessment of Project Effects on Lower River Channel Study assessed the Project's potential to affect aquatic habitat and channel morphology in the Lower Susitna River. The study quantified the magnitude of change associated with stream flow, riverine habitat features, and sediment transport under existing pre-Project and anticipated post-Project conditions. Analyses performed included a stream flow assessment, riverine habitat-flow relationship assessment, sediment transport assessment, geomorphic assessment of channel change, and delineation of large-scale geomorphic river segments with relatively homogeneous characteristics (e.g., channel width, lateral confinement by terraces, entrenchment ratio, sinuosity, slope, bed material, single/multiple channel, and hydrology). Specific objectives included: (1) evaluating the relative magnitude of changes to the flow regime; (2) assessing potential changes to channel morphology and aquatic habitat; (3) evaluating the relative magnitude of changes to the sediment regime, potential impacts on sediment/substrate gradations, and the vertical and lateral stability of the channel; (4) delineating large-scale geomorphic river segments with relatively homogeneous characteristics; (5) conducting a geomorphic assessment of historic channel change and whether changes have affected the frequency and distribution of mesohabitat units; and (6) providing information to assist AEA and licensing participants in developing 2013-2014 study plans. The study area included the Lower Susitna River from RM 0 to RM 98.

Documentation of Susitna River Ice Break-up and Formation

The overall objective of the 2012 Documentation of Susitna River Ice Break-up and Formation Study was to document baseline ice conditions and assess potential effects on ice processes downstream of the proposed Project. Specific objectives included: (1) document the timing and progression of break-up and ice cover formation on the Susitna River between RM 0 and RM 234; (2) document open leads between RM 0 and RM 234 throughout the winter; (3) document the interaction between river ice processes and channel morphology, vegetation, and aquatic habitats; and (4) provide baseline data to help identify the river reaches most likely to experience changes in river ice formation as a result of Project construction and operation.

Susitna River ice studies conducted in the 1980s were reviewed and synthesized, as appropriate, for use in developing 2013-2014 study plans. Information was compiled into a geospatial format for comparison with current observations. Recent studies of the effects of hydroelectric projects on river ice in arctic and sub-arctic climates were also be reviewed.

Open leads in the Middle River, mapped in 2012, were compared with locations of open leads documented in 1984-1985. Time-lapse cameras were installed in spring 2012 at 11 locations between RM 9 and RM 184 for observing ice break-up and ice-cover formation. Ice break-up progression was documented in spring 2012 between RM 0 and RM 234 via aerial observations. Documentation of freeze-up progression was conducted in fall/winter 2012 and included observations of the presence of frazil ice, ice bridges, ice cover, and snow cover. Meteorological and stream temperature data compilation occurred in fall/winter 2012, and river stage data from the National Weather Service observer at Sunshine Station and Gold Creek gage were obtained daily. Telemetered stage and camera installations from the 2012 flow routing and transect study were observed daily for signs of ice formation.

Physical ice processes models were considered to predict the effects of the proposed Project on river ice processes. The model and/or modeling approach will be selected, as part of the formal studies, in consultation with the Army Corps of Engineers Cold Regions Research Engineering Laboratory (CRREL), AEA, other technical experts, and licensing participants during the 2012 study year so that the model can be approved for use in 2013-2014.

Ice-scarred floodplain trees were mapped in support of delineating Riparian Ice Process Domains for selecting 2013 Riparian Instream Flow Focus Area Study sites. On-the-ground tree ice-scar reconnaissance was performed from approximately RM 168.5 to RM 172.5. Helicopter photo-reconnaissance was conducted along the middle Susitna River (RM 99 to RM 184). On-the-ground 1980's tree ice-scar reconnaissance was performed from approximately RM 124 to RM 126. When river ice conditions allow in the winter of 2012, additional tree scar surveys will be conducted by snow machine.

On-the-ground conditions were observed for developing field protocols and costs for installing Groundwater and Surface Water wells and stage recorders at potential Instream Flow Riparian and Fish Focus Area study sites. On-the-ground groundwater/surface water reconnaissance was performed from approximately RM 168.5 to RM 172.5. On-the-ground 1980's groundwater well search-and-find survey and groundwater / surface water reconnaissance was performed from approximately RM 124 to RM 126.

Instream Flow

Instream Flow Planning Study

The 2012 Instream Flow Planning Study outlined the objectives and methods for characterizing existing information to use as a foundation for future flow-habitat studies.

A comprehensive instream flow study plan was developed in 2012 as part of the Project licensing process. The 2013-2014 instream flow study will assess aquatic habitat response to Project-induced changes in river flow, water temperature, turbidity, and other river channel/water quality parameters. The objective of the 2012 Instream Flow Planning Study was to obtain information to be used as the foundation for, and assist in development of, the 2013-2014 Instream Flow Study. Specific 2012 study objectives included: (1) synthesize 1980s instream flow study information and evaluate applicability to the currently proposed Project; (2) identify appropriate fish species/life stages, study reaches, study sites, and instream flow modeling methods for the 2013-2014 Instream Flow Study; (3) conduct a site reconnaissance survey with agencies and stakeholders, and identify preliminary study sites, potential transect locations, and analytical methods; (4) collect habitat suitability criteria (HSC) data at selected locations on the Susitna River; (5) coordinate instream flow study data needs across resource disciplines and studies; and (6) assist in the development of the 2013-2014 Instream Flow Study Plan. The study area includes all aquatic habitats and riparian areas related to river flow in the Susitna River downstream of the proposed Watana Dam (RM 184 to RM 0).

The 2012 study methods addressed the following tasks: (1) review 1980s instream flow study documents; (2) preliminary identification of fish target species, life stages, and/or guilds; (3)

preliminary determination of species periodicity; (4) compilation and review of habitat utilization data by life stage/guild; (5) identification of physical habitat processes; (6) river stratification and study site selection; (7) review existing HSC data/initiate collection of new data; (8) review and selection of habitat modeling methods/components; (9) assist in assessment of temperature modeling; and (10) develop the 2013-2014 study plan.

The following field efforts were completed in 2012:

- Field teams conducted a reconnaissance-level, on-ground survey of lateral habitat features and mainstem channel to evaluate potential instream flow study sites (sites in the lower Middle Reach were toured in July 2012). A site visit with the agencies and AEA was held in late September to discuss study site selection and modeling procedures.
- Field teams conducted aquatic habitat and HSC data collection during July, August, and September in the lower, middle, and upper Susitna River and its tributaries. Sampling methods consisted of seine capture and visual observation during snorkel and pedestrian surveys. Coordination/training with field staff was performed on Montana Creek, a tributary to the lower Susitna River, and near Curry in the Middle Susitna River Reach.
- Field personnel conducted reconnaissance visits to selected sloughs and side channels to enable some ground truthing of the aerial videography.

River Flow Routing Model Data Collection

A hydraulic flow routing model of the Susitna River downstream of Watana Dam will be required to support a variety of other models used to assess the Project's impact on river hydraulics, temperature, ice processes, sediment transport, aquatic resources, and terrestrial resources. The U.S. Army Corps of Engineers' HEC-RAS model is being considered for this purpose. The 2012 River Flow Routing Model Data Collection Study initiated data collection required for developing a routing model.

The purpose of the 2012 field effort was to provide input, calibration, and verification data for a river flow routing model that extends from the proposed dam site (RM 184) to RM 75. Specific objectives included: (1) surveying cross-sections to define channel topography and hydraulic controls between RM 75 and RM 184, excluding Devils Canyon; (2) measuring stage and discharge at each cross-section during high, low, and intermediate flows; (3) measuring water surface slope during discharge measurements and documenting substrate type, groundcover, habitat type, and woody debris in the floodplain to develop roughness estimates; and (4) installing and operating water-level recording stations in collaboration with other studies.

The primary study area included the Susitna River mainstem channel between RM 75 and RM 184. Additional measurements were made at inactive U.S. Geological Survey (USGS) stations at RM 26 (Susitna Station) and RM 223 (Susitna River near Cantwell), as well as in the Susitna delta.

Cross-sections were surveyed in 2012, with over 100 cross-sections surveyed overall, and more will be undertaken in 2013. Water level, surface slope, and discharge measurements were made concurrently with bathymetric surveys at each location. A survey team recorded main channel and overbank locations, substrate and vegetation descriptions, water temperature, estimated D84 substrate size, and field roughness following USGS guidance. Water-level monitoring was conducted at several stations.

Fish and Aquatic Resources

Synthesis of Existing Fish Population Data

Objectives of the 2012 Synthesis of Existing Fish Population Data Study included: (1) consolidate and synthesize contemporary and historical fisheries resource data from the study area into a comprehensive reference document; and (2) develop a geospatial database of existing fisheries resources for use in analyses and studies to be conducted in 2013-2014. The data synthesis was intended to improve understanding of baseline conditions, refine the list of potential fisheries data gaps, and assist in developing well-focused aquatic resource studies for 2013-2014.

The following information was compiled: (1) river mile locations for geographic landmarks used in historical studies; (2) resident and anadromous fish species composition within the upper Susitna River (upstream of RM 184), middle Susitna River (RM 184 to RM 99), and lower Susitna River (RM 99 to RM 0); (3) distribution of resident and anadromous fish species among riverine habitat types; (4) relative abundance of fish species in river segments and riverine habitat types; (5) run timing, spawning, and incubation periods for resident and anadromous species; (6) representative indicators of fish growth, condition factor, age structure, and genetic information; (7) physical habitat attributes beneficial to or preferred by fish species and life stages; (8) physical habitat attributes that appear to limit fish populations; and (9) fish communities, benthic macroinvertebrate communities, and habitat conditions at stream crossings associated with proposed transmission line and access corridors.

Adult Salmon Distribution Habitat Utilization Study

The 2012 Adult Salmon Distribution and Habitat Utilization Study was the initial component of a multi-year data collection and interpretation effort. The goals of the 2012 study were to: (1) characterize the distribution, migration behavior, and proportional abundance of adult salmon and determine their use of mainstem, side channel, and slough habitats in the lower, middle, and upper Susitna River; (2) determine whether historical study results and conclusions are consistent with the current distribution and relative abundance of spawning adult salmon in the mainstem Susitna River; (3) provide spawning habitat data to support the selection of sites for the instream flow study, develop site-specific habitat suitability criteria, and develop habitat sampling protocol for 2013-2014; and (4) develop information to refine the scope, methods, and study sites for assessing habitat use by adult salmon during the 2013-2014 studies.

Study objectives included: (1) capturing, radio-tagging, and tracking adults of the five species of Pacific salmon in the middle Susitna River in proportion to their abundance; (2) determining the migration behavior and spawning locations of radio-tagged fish in the lower, middle, and upper Susitna River; (3) assessing the feasibility of using sonar to determine spawning locations in turbid water; (4) characterizing salmon migration behavior and run timing above Devils Canyon; (5) comparing historical and current data on relative abundance, locations of spawning and holding salmon, and use of mainstem, side-channel, slough, and tributary habitat types by adult salmon; (6) locating individual holding and spawning salmon in clear and turbid water and collecting habitat data from holding and spawning salmon in the middle and lower river mainstem consistent with developing HSC for instream flow modeling; and (7) evaluating the effectiveness of methods used in 2012 to address study goals and objectives, and assessing their suitability for future studies.

The study area included the Susitna River from Cook Inlet (RM 0) upstream to the Oshetna River (RM 234.4), with an emphasis on river reaches between its confluence with the Chulitna River (RM 98) and Devils Canyon (RM 154). This study was coordinated with basin-wide radio telemetry studies being conducted by the Alaska Department of Fish & Game (ADF&G). This study differs from the ADF&G studies in that spatial data will be collected from radio-tagged fish on a finer scale, with the objective being to obtain locations of spawning and holding salmon at the macro- and microhabitat levels.

Upper Susitna River Fish Distribution and Habitat Study

The 2012 Upper Susitna River Fish Distribution and Habitat Study constitutes the first year of a multi-year effort aimed at characterizing the existing distribution of Chinook salmon and other fish species in the Susitna River and its tributaries above Devils Canyon. Specific objectives included: (1) determining the distribution of adult and juvenile Chinook salmon and relative abundance of juvenile Chinook salmon in the Susitna River and its tributaries above Devils Canyon; (2) characterizing aquatic habitat in the Susitna River and its tributaries/lakes from Devils Canyon upstream to, and including, the Oshetna River and determining the suitability of that habitat for Chinook salmon; (3) determining fish species composition and relative abundance in the proposed reservoir inundation zone; (4) characterizing the type and amount of aquatic habitat within the proposed reservoir inundation zone; (5) identifying the locations of potential fish barriers in tributaries between Devils Canyon and the Oshetna River; (6) collecting genetic samples of Chinook salmon; and (7) providing information for the development of plans for studies to be conducted in 2013-2014. The study area included the mainstem Susitna River, tributaries, and several lake systems associated with the Susitna River between Devils Canyon (RM 154) and the Oshetna River RM (234.4) (including the Oshetna River).

Habitat mapping was conducted in tributaries, the mainstem Susitna River, and in lakes. Adult Chinook salmon spawning surveys were conducted in tributaries and the mainstem; timing of the surveys was based on existing run-timing information and clear water habitat conditions. Juvenile Chinook salmon and other fish species were sampled in tributaries, the mainstem Susitna River, and in lakes; sampling was scheduled based on typical outmigration timing. When appropriate, a simple geomorphic and biologic model was developed to identify the distribution of juvenile Chinook habitat in the mainstem river and tributary streams.

A two-day habitat training session was conducted for the field crews for the 2012 Fish Distribution, Radio Telemetry, and Fishwheel surveys. The habitat training was conducted in the upper Susitna River and its tributaries. The field data audits were conducted at Stephan Lake Lodge, at fish sampling sites on the unnamed tributary that enters the mainstem Susitna River at historic river mile 192, Curry Camp, and at Fishwheel 2 in the mainstem Susitna River. Training sites were selected to represent a variety of channel types.

Cook Inlet Beluga Whale Anadromous Prey Analysis

Project-induced changes to river stage and discharge may impact Cook Inlet beluga whale (CIBW) access to the lower Susitna River and/or to available prey. An understanding of CIBW distribution (both spatially and temporally) and their prey species is necessary to evaluate potential Project impacts on CIBWs and their critical habitat.

The 2012 Cook Inlet Beluga Whale Anadromous Prey Analysis consisted of literature and data reviews of the use of the Susitna River by CIBW and by key prey species (eulachon and adult

Chinook, sockeye, chum, and coho salmon). Study objectives included: (1) summarizing the life history, run timing, abundance, distribution, and habitat of CIBW anadromous prey species in the Susitna River and in other Cook Inlet tributaries used by CIBWs; (2) summarizing temporal and spatial distribution of CIBWs in Cook Inlet, the Susitna River delta, and the Susitna River relative to the availability of eulachon and adult Chinook, sockeye, chum, and coho salmon; and (3) consulting with the National Marine Fisheries Service (NMFS) for Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA) permitting and requirements for the Project study program.

Existing information on pink salmon (juveniles and adults) and all life stages of Chinook, sockeye, chum, and coho salmon above RM 50 was compiled as part of the Synthesis of Existing Fish Population Data Study, and additional data will be collected during fisheries studies conducted in 2013-2014. The study program focused on compiling and synthesizing life history and habitat use information of: eulachon, adult Chinook, sockeye, chum, and coho salmon, and CIBWs. The study area included the Susitna River within the range of anadromous fish distribution, with an emphasis on the lower river (RM 0-50), and the area of the Susitna River delta that could be affected by Project operations. Fish escapement and run timing data were also compiled for other Cook Inlet tributaries where significant salmon and/or eulachon predation by CIBWs occurs. Results of the study will be used to begin identifying potential Project-induced impacts to beluga whales and their critical habitat and identify data needs to be addressed as part of the 2013-2014 beluga whale study.

AEA, in consultation with NMFS, will address MMPA and ESA permit requirements for the Project studies program and begin preparation of appropriate permit applications. A "No Impact" protocol will be developed for implementation in association with all studies that have the potential to affect CIBWs.

Botanical Resources

Vegetation and Wildlife Habitat Mapping Study

The 2012 Vegetation and Wildlife Habitat Mapping Study characterized and quantified direct loss of vegetation communities and wildlife habitat within the Project footprint, evaluated baseline wildlife habitat in the Project vicinity, and evaluated potential direct and indirect effects of Project maintenance and operations on vegetation communities and wildlife habitat. This initiated a multi-year study for locations where aerial imagery was currently available. Upon a complete assessment of the Project area, mitigation alternatives will be developed to address adverse Project-induced impacts.

The overall, multi-year objectives of the Vegetation and Wildlife Habitat Mapping Study are to: 1) characterize the vegetation communities and wildlife habitat in the Project area; 2) quantify the potential impacts due to Project construction; 3) evaluate potential changes to the vegetation communities and wildlife habitat from Project maintenance and operations and related activities; and 4) develop the 2013–2014 Vegetation and Wildlife Habitat Mapping Study Plan. The assessment of the Project area vegetation and wildlife habitat will be completed as aerial imagery becomes available and the Project area is refined (e.g., preferred alternative access and transmission corridors).

The study objective for 2012 was to develop a vegetation map using existing habitat delineations, current aerial imagery, and field verification. Vegetation and wildlife habitat surveys were conducted June through August, following the protocols described in the 2012 Study Plan. A total of 357 field plots were sampled. The vegetation and wildlife habitat field surveys focused on the proposed reservoir, the Gold Creek transmission and road corridors, and near the Denali transmission line and road corridor, where imagery of sufficient quality to identify habitat photosignatures was available. Enough field data should be available to support the preliminary mapping of vegetation and wildlife habitats in fall and winter 2012.

Wetland Mapping Study

Project construction, facilities, and operation and maintenance may affect wetlands upstream and downstream from the dam site, and along access and transmission line routes. A thorough understanding of how Project activities will affect wetland resources in the study area is critical for developing best management practices, rehabilitation options for promoting recovery of wetlands exposed to short term impacts, and compensatory mitigation for permanent wetland losses. Wildlife use is related to the impact of Project activities on wetlands; therefore, results from this study are necessary to evaluate baseline and future wildlife use of the Project area. The results of the Wetlands Mapping Study will also be used to supplement the Vegetation and Wildlife Habitat, Riparian, Rare Plant, and Invasive Plant studies.

The overall, multi-year objectives of the Wetlands Mapping Study are to: 1) characterize wetlands in the Project area; 2) quantify the potential impact to wetlands and wetland function from Project construction; 3) evaluate potential changes to wetlands and wetland functions from Project maintenance and operations and related activities; and 4) develop the 2013–2014 Wetlands Mapping Study Plan.

The 2012 study included the following study components: 1) determine appropriate scales and areal extents for wetland delineations in consultation with USACE and compile available wetland mapping at various scales for development of wetland delineations based on current aerial photography; 2) incorporate data from the Vegetation and Wildlife Habitat Mapping Study and available data on natural fire patterns along the reservoir reach of the Susitna River; 3) identify wetland delineation field sites and data from the 1980s studies for potential resampling; 4) identify sample locations and conduct initial field surveys.

A complete assessment of the Project area wetlands and wetland functions will be completed as aerial imagery becomes available and the Project area is refined (e.g. preferred alternative access and transmission corridors).

The study objective for 2012 was to develop a wetland map using existing habitat delineations, current aerial imagery, and field verification. Wetlands surveys were conducted June through August, following the protocols described in the 2012 Study Plan. A total of 357 field plots were sampled. The wetlands field surveys focused on the proposed reservoir and Gold Creek transmission and road corridors, where imagery of sufficient quality to identify habitat photosignatures was available. Enough field data should be available to support the preliminary mapping of wetlands in fall and winter 2012.

Riparian Study

Construction and operation of the Susitna-Watana Hydroelectric Project will alter the natural flow regime of the Susitna River. A thorough understanding of how Project activities will affect riparian communities and hydrologic processes in the study area is critical for developing best management practices, developing predictive models of potential changes in riparian ecosystems downstream of the proposed dam, and assessing potential impacts to wildlife.

This multi-year study will characterize and quantify riparian habitats and successional stages downstream from the dam site and evaluated potential direct and indirect effects of Project operations on riparian habitats. The study was initiated in 2012 at locations where aerial imagery was currently available. Upon a complete assessment of the Project area, mitigation alternatives will be developed from the data to address adverse Project-induced impacts.

This study addresses the following issues: 1) losses of vegetation and wetland communities and productivity from reservoir inundation and the development of other Project facilities (direct effects); 2) changes to vegetation and wetland communities along access roads, transmission corridors, and reservoir edges due to alteration of solar radiation, temperature moderation, erosion and dust deposition, reservoir fluctuation, pathogen dispersal and abundance; and 3) potential changes in wetlands, wetland functions, riparian vegetation, and riparian succession patterns related to altered hydrologic regimes below the dam.

Riparian botanical surveys were conducted June through July, following the protocols described in the 2012 Study Plan. A total of 88 field plots were sampled. The riparian botanical survey area focused on the active floodplain of the Susitna River between the proposed dam site to the north and the town of Willow to the south. Due to time constraints, some transects will need to be revisited during the 2013 surveys to collect additional plot data.

<u>Wildlife Resources</u>

Eagle and Raptor Nest Study

The Project may result in eagle nest site loss or alteration and disturbance due to increased human activity. Information on eagle and other raptor nest site locations is necessary to develop avoidance and mitigation measures in compliance with the Bald and Golden Eagle Protection Act, the Migratory Bird Treaty Act, and associated Executive Orders.

The 2012 study identified and compiled existing nest site and habitat use information, developed survey areas, and completed multiple inventory and monitoring surveys for Bald and Golden eagles. Potential Project-related impacts to eagles and raptors, as well as critical data gaps, were identified. The 2013–2014 study plans will be developed in consultation with AEA, U.S. Fish and Wildlife Service (USFWS), and other licensing participants.

The inventory and monitoring methodologies established aerial and ground-based protocols for eagle nest surveys, using appropriately trained observers and suitable survey platforms (helicopter, fixed-wing aircraft). Inventory and monitoring data reporting will comply with the protocols and standards described in the Memorandum of Understanding between the FERC and the USFWS regarding implementation of Executive Order 13186. Although the primary study focus was to evaluate the potential for the Project to affect eagles and eagle nests, all nests of raptors and Common Ravens were recorded during surveys. Recommendations for survey extent and methods were developed in coordination with the USFWS before beginning surveys.

The data gathered in 2012 will form the basis of future studies to evaluate the potential impacts of the Project on Bald Eagles, Golden Eagles, and other raptors. Delineation and survey results of all suitable habitats within the Project area will identify occupied habitats and may be used in the future to evaluate occupied versus available habitats. Eagle nest sites and ground-based observations may be compared to determine pair territory size. Data on territory size can be used to determine whether raptors displaced from nest sites due to Project-related habitat loss, alteration, or disturbance maintain alternative nest sites within their territory that would be unaffected by the Project, or whether nesting pairs may be displaced into already occupied territories. Historical and current data may also be compared to evaluate trends in raptor populations and habitat use.

Occupancy surveys for nesting raptors were performed in May from a helicopter. Dozens of raptor nests were observed. Occupied nest sites were located and mapped. The raptor study area comprises the entire area within a 2-mile buffer surrounding the Project area (reservoir study area, facilities/infrastructure area, and access route and transmission-line corridors). The next fieldwork planned for raptors is nest productivity surveys, scheduled for July 8–13 and 23–27, 2013.

Past and Current Big Game Harvest Study

The Project would create an access road to the dam site, as well as a large water body that could be used for floatplane access to the region. These Project features, along with transmission line corridor(s), have the potential to facilitate human access to the Project area and change the pattern of human harvest of big game, furbearers, small game mammals, and upland game birds.

The objective of this study is to identify, acquire, and analyze available big game and furbearer harvest and population data from the Alaska Department of Fish and Game (ADF&G) for identification of past and current trends in hunter access modes, hunting locations, and harvest locations. Existing data from harvest reports will be compiled and reviewed for its adequacy to address Project-specific changes in human access. The analysis will also determine whether the watershed tributary-scale Uniform Coding Unit (UCU) data are adequate for detecting and predicting potential Project-related changes in total harvest and harvest locations due to potential changes in human access.

This study addresses the following issues: 1) potential impact of changes in predator and prey abundance and distribution related to increased human activities and habitat changes resulting from Project development; and 2) potential impacts to wildlife from changes in hunting, vehicular use, noise, and other disturbances due to increased human presence resulting from Project development.

The wildlife data-gap analysis conducted for the Project identified the need for an updated drainage-specific compilation of subsistence, sport hunter, and trapper harvest data for all game animals and furbearers. Hunter access to this region has changed since the 1980s, but potential changes in patterns of harvest at this scale have not been evaluated or compared to movements of moose or caribou. Compilation of historic data could also be useful for identifying any potential trends in human access and harvest locations over the past decades and will provide input to ADF&G's management goals for big game and furbearers in the Project area.

Initial efforts in 2012 focused on compilation and analysis of hunter harvest and effort within harvest report units contained within the ADF&G harvest record database. Movement and aggregation patterns of game resources were evaluated from available ADF&G telemetry databases (moose and caribou) or other available data maintained by ADF&G. Spatial resolution, adequacy, and completeness of the harvest data record for detecting potential changes in use of wildlife resources in the Project area were evaluated. Collection of additional harvest data may be recommended if existing data are determined to be at an insufficient resolution to detect potential changes in harvest due to changes in human access. Additional information gathering may involve interviews with trappers, upon approval and in coordination with subsistence interviews that will be conducted in the affected communities in 2013–2014.

Wildlife Habitat Use and Movement Study

Construction and operation of the Project will result in wildlife habitat loss and alteration, blockage of movements of mammals, disturbance, and changes in human activity due to construction and operation of the Project from the proposed dam site, and along access and transmission line routes. The Project may result in loss of, or displacement from, seasonally used sensitive habitats in the middle and upper Susitna River basin, such as caribou calving areas, bear foraging habitats, and Dall sheep lambing areas and mineral licks. In order to evaluate potential Project-related effects and inform subsequent studies, the 2012 study effort aimed to characterize critical data gaps based on existing Project area wildlife abundance, distribution, movements and sensitive habitat data. This study was the initiation of a multi-year effort that will continue in 2013–2014.

This study was broken into tasks by resource (species), each with specific objectives, study areas, methods, and analytical outputs. Information on the current use of the following areas was compiled: critical moose and caribou calving areas, rutting areas, wintering areas, and migration or movement corridors; bear foraging and den habitats; Dall sheep lambing areas and mineral licks; and wolf den and rendezvous sites. Data were compiled from various sources and evaluated to determine the need for additional aerial surveys, ground-based monitoring, and/or the potential establishment of remote surveillance. This information will be used to develop 2013–2014 study plans.

Recreation and Aesthetic Resources

Aesthetic and Recreation Resources Study

Construction and operation of the Project may impact recreation resources by increasing activity, altering portions of the Susitna River and adjacent land, and/or restricting or increasing access. These impacts could result in changes in the nature of the recreation experience, changes in hunting or fishing opportunities, and/or changes in other recreation opportunities. Temporary recreation impacts could be generated by construction personnel, traffic, materials, staging areas, the worker camp, and noise. The Project is likely to also have positive recreation impacts. The proposed access roads and transmission line corridors, reservoir, and recreational facilities would provide new recreational opportunities to the public.

Construction and operation of the Project also may alter the character of aesthetic resources as a result of increased human activity, noise and development. Temporary visual and noise impacts would be generated by construction personnel, traffic, materials, staging areas, and worker camps. The dam and reservoir would become a new visual feature in the middle Susitna River basin. These structures could be viewed by various categories of persons, including Project personnel and support staff, recreationists, subsistence users, and individuals flying overhead.

The Project could have positive visual impacts as a result of the access roads, reservoir, and recreational facilities providing new recreational and viewing opportunities to the public.

The study objectives for the 2012 Recreation and Aesthetics Study focused on information gathering activities to identify relevant recreation and aesthetic resource information that will inform the formal study planning process and environmental and social effects analysis for Project construction and operation. Information will also be used to guide Project design and mitigation of construction, operation and maintenance activities to minimize impacts, and identify opportunities for design and siting refinements that maximize opportunity and access to recreation opportunities and/or important views. Coordination across social resources (i.e., cultural, subsistence, and socioeconomic) from the outset of information gathering is considered an essential component of the Aesthetics Study. Interdisciplinary coordination focused on identifying locations of sensitive aesthetic and/or recreational resources such as cultural properties, cultural vistas, and areas used by local outfitters (i.e., rafting, fishing, and hunting).

The 2012 work effort concentrated on data collection, and an evaluation of the comprehensiveness and applicability of existing data. An evaluation of further measures that may be required to collect appropriate data will also be provided for use in 2013-2014.

Cultural Resources

Cultural Resources Study

Construction and operation of the Project may result in damage or loss of cultural resources from construction or increased human activity in the upper Susitna River basin. Documentation of currently known cultural resources sites will help to inform the 2013-2014 studies. This information, as well as a plan for unanticipated cultural resource discoveries, will be useful to prevent inadvertent disturbance from other field studies for the Project.

The cultural resources study objectives were designed primarily to provide the information necessary to enable the applicant and lead federal agency to meet the requirements of National Historic Preservation Act (NHPA) and its accompanying regulations (36 CFR 800). The major objectives for 2012 work included: 1) create GIS database to help enable development of predictive models and management of cultural resources information for 2013-2014 studies; 2) develop a predictive model, identifying areas of high, medium, and low potential for the occurrence of cultural resources; 3) continue to identify and document cultural resources within the Project study area, building upon work done between 1978-1985; and 4) prepare plans and procedures addressing unanticipated discoveries of cultural resources, human remains, and paleontological resources.

Construction and operation of the Project may impact sites of cultural significance along transportation and powerline alignments, as well as in the area to be inundated by the reservoir. It is important that these resources be inventoried and evaluated, so that the Project can identify protection, mitigation and enhancement measures as appropriate. It is expected that potential impacts to many cultural resources in the Project area can be mitigated either via removal (data recovery/ archaeological excavation), or minor changes to Project alignments (avoidance).

In July, 2012, the cultural resources subcontractor generated the first iteration of a cultural resource site locational model for the Susitna area, used the modeled surface to help develop survey strategies for the SUWA corridors/potential APE, closely examined spatial data from previous (legacy) cultural resource fieldwork, and designated and mapped potential test areas for use by the field crew in August 2012. In addition, spreadsheets and shapefiles of cultural resources requiring site visits within the APE, as well as of potential test areas, were created using GPS devices. Work continued on reviewing and copying relevant files and maps from the 1979-1985 studies housed at the University of Alaska Museum of the North in Fairbanks.

The cultural resources survey of geotechnical borehole locations was completed in early July and the main 2012 field program was performed between late July and mid-August.

2. PROPOSED 2013 AND 2014 ILP STUDIES

AEA is proposing to perform 58 individual studies in eleven resource sections listed below. Each study description follows a standard study plan template to provide a consistent presentation across disciplines. The study descriptions include: fundamental discussions of existing information and why the study is necessary to augment existing information; a description of the objectives and scope of the study; and how the information could be used to inform the development of license conditions for the Project.

Implementation of the studies will commence soon after FERC's study plan determination. Each study description has information regarding the scheduling of the work efforts but in general each study will include:

- Preparatory Phase, January – March 2013 and 2014;
- Field Phase or Deployment Phase, spanning April – October (typically September) 2013 and 2014;
- Analysis Phase, June – November 2013 and 2014; and
- Reporting Phase, December 2013-January 2014 and December 2014-January 2015.

Upon issuance of FERC's study plan determination, AEA will finalize a comprehensive schedule for all studies. AEA has prepared a preliminary comprehensive schedule based on the 58 study plans described in this RSP (see Attachment 2-1). Due to the interrelationships among the proposed studies (discussed below) and unforeseen circumstances that may arise during implementation of the studies (e.g., weather delays), AEA notes that all dates in the attached schedule (except mandated regulatory deadlines) are estimated at this time and will be continually updated throughout the study plan implementation phase, to account for actual events as they occur.

Attachment 2-1 also includes a table entitled "Table of Study Predecessor and Successor Activities." Because the studies in this RSP are interdisciplinary in nature, most have direct input or output needs from other resource studies. While each study plan provides a description and illustration of these interrelationships for specific information needs and requirements that will be obtained via other study efforts, the table in Attachment 2-1 is a comprehensive master listing of the flow of information among all studies in the RSP, prepared at the task level (ranging from internal exchanges of information to publicly available deliverables). While AEA believes that this table is essential in demonstrating how the interrelationships among all the studies will unfold over the two-year study program, AEA emphasizes that, like the master schedule, this table is preliminary at this time, and all dates (except mandated regulatory deadlines) are estimates. Because the table is a working document, it is subject to change and will be continually updated throughout AEA's implementation of the study plan approved by FERC.

In addition, the general relationships, key information flow patterns, and interdependencies among studies are shown in Figure 2-1 (Riverine-based Studies) and 2-2 (Upland-based Studies).

Some general concepts that apply to each study plan implementation effort include:

- The schedule for each proposed study is reasonably flexible to accommodate unforeseen problems that may affect schedule.

- Field crews may make reasonable modifications to a study in the field to accommodate actual field conditions and unforeseen problems. AEA's contractor field crews will follow accepted protocols to the extent possible. When modifications are made, AEA will work to advise licensing participants of the change, particularly for any substantial modifications.
- When a number of alternative modifications are available to the field crew and with all other things being equal, the contractor field crew will chose the low-cost alternative.
- Implementation of many studies will require access to private property. AEA is in the process of obtaining permission from land owners for access. Specifically excluded from study areas are locations where access is unsafe (very steep terrain or high water flows) or private property for which AEA has not received specific approval from the landowner to enter the property to perform the study.

The following studies are described in this RSP, as listed below.

<u>Geology and Soils (Section 4)</u>

1. Geology and Soils Characterization Study (Section 4.5)

<u>Water Quality (Section 5)</u>

1. Baseline Water Quality Study (Section 5.5)
2. Water Quality Modeling Study (Section 5.6)
3. Mercury Assessment and Potential for Bioaccumulation Study (Section 5.7)

<u>Geomorphology (Section 6)</u>

1. Geomorphology Study (Section 6.5)
2. Fluvial Geomorphology Modeling below Watana Dam Study (Section 6.6)

<u>Hydrology-Related Resources (Section 7)</u>

3. Groundwater Study (Section 7.5)
4. Ice Processes in the Susitna River Study (Section 7.6)
5. Glacier and Runoff Changes Study (Section 7.7)

<u>Instream Flow (Section 8)</u>

1. Fish and Aquatics Instream Flow Study (Section 8.5)
2. Riparian Instream Flow Study (Section 8.6)

<u>Fish and Aquatic Resources (Section 9)</u>

1. Study of Fish Distribution and Abundance in the Upper Susitna River (Section 9.5)
2. Study of Fish Distribution and Abundance in the Middle and Lower Susitna River (Section 9.6)
3. Salmon Escapement Study (Section 9.7)
4. River Productivity Study (Section 9.8)
5. Characterization and Mapping of Aquatic Habitats (Section 9.9)
6. The Future Watana Reservoir Fish Community and Risk of Entrainment Study (Section 9.10)

7. Study of Fish Passage Feasibility at Watana Dam (Section 9.11)
8. Study of Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries (Section 9.12)
9. Aquatic Resources Study within the Access Alignment, Transmission Alignment, and Construction Area (Section 9.13)
10. Genetic Baseline Study for Selected Fish Species (Section 9.14)
11. Analysis of Fish Harvest in and Downstream of the Susitna-Watana Hydroelectric Project Area (Section 9.15)
12. Eulachon Run Timing, Distribution, and Spawning in the Susitna River (Section 9.16)
13. Cook Inlet Beluga Whale Study (Section 9.17)

Wildlife Resources (Section 10)

1. Moose Distribution, Abundance, Movements, Productivity, and Survival (Section 10.5)
2. Caribou Distribution, Abundance, Movements, Productivity, and Survival (Section 10.6)
3. Dall's Sheep Distribution and Abundance (Section 10.7)
4. Distribution, Abundance, and Habitat Use by Large Carnivores (Section 10.8)
5. Wolverine Distribution, Abundance, and Habitat Occupancy (Section 10.9)
6. Terrestrial Furbearer Abundance and Habitat Use (Section 10.10)
7. Aquatic Furbearer Abundance and Habitat Use (Section 10.11)
8. Small Mammal Species Composition and Habitat Use (Section 10.12)
9. Bat Distribution and Habitat Use (Section 10.13)
10. Surveys of Eagles and Other Raptors (Section 10.14)
11. Waterbird Migration, Breeding, and Habitat Use Study (Section 10.15)
12. Landbird and Shorebird Migration, Breeding, and Habitat Use Study (Section 10.16)
13. Population Ecology of Willow Ptarmigan in Game Management Unit 13 (Section 10.17)
14. Wood Frog Occupancy and Habitat Use (Section 10.18)
15. Evaluation of Wildlife Habitat Use (Section 10.19)
16. Wildlife Harvest Analysis (Section 10.20)

Botanical Resources (Section 11)

1. Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin (Section 11.5)
2. Riparian Vegetation Study Downstream of the Proposed Sustina-Watana Dam (Section 11.6)
3. Wetland Mapping Study (Section 11.7)
4. Rare Plant Study (Section 11.8)
5. Invasive Plant Study (Section 11.9)

Recreation and Aesthetic Resources (Section 12)

1. Recreation Resources Study (Section 12.5)
2. Aesthetic Resources Study (Section 12.6)
3. River Recreation Flow and Access Study (Section 12.7)

Cultural and Paleontological Resources (Section 13)

1. Cultural Resources Study (Section 13.5)

2. Paleontological Resources Study (Section 13.6)

Subsistence Resources (Section 14)

1. Subsistence Resources Study (Section 14.5)

Socioeconomic and Transportation Resources (Section 15)

1. Regional Economic Evaluation Study (Section 15.5)
2. Social Conditions and Public Goods and Services Study (Section 15.6)
3. Transportation Resources Study (Section 15.7)
4. Health Impact Assessment Study (Section 15.8)
5. Air Quality Study (Section 15.9)

Project Safety (Section 16)

1. Probable Maximum Flood Study (Section 16.5)
2. Site-Specific Seismic Hazard Study (Section 16.6)

As noted in Section 1, licensing participants submitted a total of 52 formal study requests, of which AEA is proposing to undertake all but one of these requested resource studies, with some alterations and adjustments as noted in study plan sections or comment response tables. For the 51 study requests that align with studies AEA is proposing, this RSP does not in every instance adopt each element or aspect of the proposed study request. Rather, AEA has incorporated the majority of the elements, with alterations or adjustments, or by providing similar approaches to the requested studies. As described in detail in Section 1.1 above, following AEA's release of the PSP, AEA consulted regularly and extensively with licensing participants to discuss any remaining differences between AEA's proposed studies and participants' formal study requests, During this intensive consultative effort, any comments raised by licensing participants regarding any differences were noted in TWG meeting notes, in other consultation documents, and in written comments recently filed with the Commission. AEA has provided responses to these concerns and others in the comment response tables in Appendix 1 and 3.

Since the filing of the PSP, AEA did not receive any new formal study requests. Therefore, the previously filed 51 study requests outlined in the PSP are the study requests that been the subject of continuous consultation between AEA and interested parties and are also those study requests many interested parties refer to in their recent FERC-filed comments on the PSP. Table 2-1 presents a listing of the individual study requests, identifies the study requestor(s), and identifies where in AEA's study plan the study topic is addressed.

2.1. Tables

Table 2-1. Summary of formal study requests filed with FERC.

Study Request Title	Requestor	Date filed with FERC	PSP Section Study Request Corresponds to
Probable Maximum Flood	FERC	05-31-2012	Section 16 – Project Safety, 16.5
Geology and Soils Assessment	FERC	05-31-2012	Section 4 – Geology and Soils

Study Request Title	Requestor	Date filed with FERC	PSP Section Study Request Corresponds to
Site-Specific Seismic Hazard Evaluation	FERC	05-31-2012	Section 16 – Project Safety, 16.6
Noise Assessment	FERC	05-31-2012	Section 12 – Recreation and Aesthetic Resources, 12.7
Recreational Boating and River Access Study	FERC	05-31-2012	Section 12 – Recreation and Aesthetic Resources, 12.5 and 12.6
Recreation Resources Study	FERC	05-31-2012	Section 12 – Recreation and Aesthetic Resources, 12.5
Study of Eagles and Other Raptors	USFWS	05-31-2012	Section 10 – Wildlife Resources, 10.14
Study of Waterbird Migration, Breeding, and Habitat	USFWS	05-31-2012	Section 10 – Wildlife Resources, 10.15
Study of Landbirds and Shorebirds	USFWS	05-31-2012	Section 10 – Wildlife Resources, 10.16
Piscivorous Wildlife and Mercury – Risk Assessment Study	USFWS	05-31-2012	Section 5 – Water Quality, 5.7
Vegetation and Wildlife Habitat Mapping Study	USFWS	05-31-2012	Section 11 – Botanical Resources,11.5; Section 10 - Wildlife Resources, 10.19
Riparian Habitat Mapping Study	USFWS	05-31-2012	Section 11 – Botanical Resources, 11.6
Wetland Mapping and Functional Assessment Study	USFWS	05-31-2012	Section 11 – Botanical Resources, 11.7
Instream Flow for Floodplain and Riparian Vegetation Study	USFWS	05-31-2012	Section 8 – Instream Flow, 8.6
River Productivity Study	USFWS	05-31-2012	Section 9 – Fish and Aquatic Resources, 9.8
Fish Passage Study	USFWS	05-31-2012	Section 9 – Fish and Aquatic Resources, 9.11
Early Life History and Juvenile Fish Distribution and Abundance in the Susitna River	USFWS	05-31-2012	Section 9 – Fish and Aquatic Resources, 9.5, 9.6 and 9.7
Adult and Juvenile Non-Salmon Anadromous, Resident and Invasive Fish Studies in the Susitna River basin (RM0-233)	USFWS	05-31-2012	Section 9 – Fish and Aquatic Resources, 9.5 and 9.6
Adult Salmon Distribution, Abundance, Habitat	USFWS	05-31-2012	Section 9 – Fish and Aquatic Resources, 9.5

Study Request Title	Requestor	Date filed with FERC	PSP Section Study Request Corresponds to
Utilization and Escapement in the Susitna River			
Susitna River Instream Flow and Habitat Utilization Study	USFWS	05-31-2012	Section 8 – Instream Flow, 8.5
Groundwater-Related Aquatic and Floodplain Habitat Study	USFWS	05-31-2012	Section 7 – Hydrology-Related Resources, 7.5
Water Quality Study	USFWS	05-31-2012	Section 5 – Water Quality, 5.5
Geomorphology Study	USFWS	05-31-2012	Section 6 – Geomorphology, 6.5
Flow Routing Study	USFWS	05-31-2012	Section 5 – Water Quality, 5.6; Section 6 – Geomorphology, 6.6; Section 7 – Hydrology-Related Resources 7.6; and Section 8 Instream Flow, 8.5 and 8.6
Ice Processes in the Susitna River	USFWS	05-31-2012	Section 7 – Hydrology-Related Resources, 7.6
Project Effects Under Climate Change Condition Study	USFWS	05-31-2012	Section 7 – Hydrology-Related Resources, 7.7
Fish Passage Study	NOAA-NMFS	05-31-2012	Section 9 – Fish and Aquatic Resources, 9.11
Early Life History and Juvenile Fish Distribution and Abundance in the Susitna River Study	NOAA-NMFS	05-31-2012	Section 7 – Hydrology-Related Resources, 7.5 and Section 8 – Instream Flow, 8.5
Adult Salmon Distribution Abundance, Habitat Utilization and Escapement in the Susitna River	NOAA-NMFS	05-31-2012	Section 9 – Fish and Aquatic Resources, 9.5 and 9.6
Susitna River Instream Flow Study Request	NOAA-NMFS	05-31-2012	Section 8 – Instream Flow, 8.5
Susitna River Groundwater Study	NOAA-NMFS	05-31-2012	Section 7 – Hydrology-Related Resources, 7.5
Susitna River Water Quality Study	NOAA-NMFS	05-31-2012	Section 5 – Water Quality, 5.5
Susitna River Geomorphology Study Request	NOAA-NMFS	05-31-2012	Section 6 – Geomorphology, 6.5
Susitna River Flow Routing Study Request	NOAA-NMFS	05-31-2012	Section 5 – Water Quality, 5.6; Section 6 – Geomorphology, 6.6; Section 7 – Hydrology-Related Resources 7.6; and Section 8 Instream Flow, 8.5 and 8.6

Study Request Title	Requestor	Date filed with FERC	PSP Section Study Request Corresponds to
Susitna River Ice Processes Study Request	NOAA-NMFS	05-31-2012	Section 7 – Hydrology-Related Resources, 7.6
Susitna River project Effects Under Changing Climate Conditions Study Request	NOAA-NMFS	05-31-2012	Section 7 – Hydrology-Related Resources, 7.7
Susitna-Watana Marine Mammal Study Request	NOAA-NMFS	05-31-2012	Section 9 – Aquatic Resources, 9.16 and 9.17
Recreation Resources Assessment	USDOI – NPS	05-24-2012	Section 12 – Recreation and Aesthetic Resources, 12.5
Aesthetic Resources, Assessment of Visual and Auditory Impacts	USDOI – NPS	05-24-2012	Section 12 – Recreation and Aesthetic Resources, 12.6
Adult Chinook and Coho Salmon Spawner Distribution and Abundance Studies	ADF&G	05-30-2012	Section 9 – Fish and Aquatic Resources, 9.5, 9.6, and 9.7
Fish Genetics	ADF&G	05-30-2012	Section 9 – Fish and Aquatic Resources, 9.14
Moose Browse survey in the Susitna-Watana Hydroelectric Project Area	ADF&G	05-30-2012	Section 10 – Wildlife Resources, 10.5
Instream Flow Study	ADF&G	05-30-2012	Section 8 – Instream Flow, 8.5
Evaluation of Surface Water and Ground Water Exchange	ADF&G	05-30-2012	Section 7 – Hydrology-Related Resources, 7.5
Request for Information or Study Effects of the Project and Related Activates on Hydrology for Anadromous Fish	Center for Water Advocacy	05-31-2012	Section 8 – Instream Flow, 8.5
Recreational Flow Study	American White Water	05-31-2012	Section 12 – Recreation and Aesthetic Resources, 12.7
Mineral Resources Assessment	Cook Inlet Region INC	05-31-2012	Section 4 – Geology and Soils
Temperature Impact on Aquatic Community	Natural Resources Defense Council	05-30-2012	Section 5 – Water Quality, 5.6; Section 8-Instream Flow, 8.5
Altered Flow, Turbidity and Sediment Transport	Natural Resources Defense Council	05-30-2012	Section 6 – Geomorphology, 6.5
Salmon Viability Criteria	Natural Resources Defense Council	05-30-2012	Section 9 – Fish and Aquatic Resources, 9.7
National-Level Economic	Natural Heritage Institute,	05-31-2012	Section 3 – Studies Not Proposed

Study Request Title	Requestor	Date filed with FERC	PSP Section Study Request Corresponds to
Valuation	*et al.*		
National-Level Economic Valuation	American Whitewater	05-31-2012	Section 3 – Studies Not Proposed
National-Level Economic Valuation	Alaska Hydro Project Alaska Survival Coalition for Susitna Dam Alternatives	11-14-2014	Section 3 – Studies Not Proposed

2.2. Figures

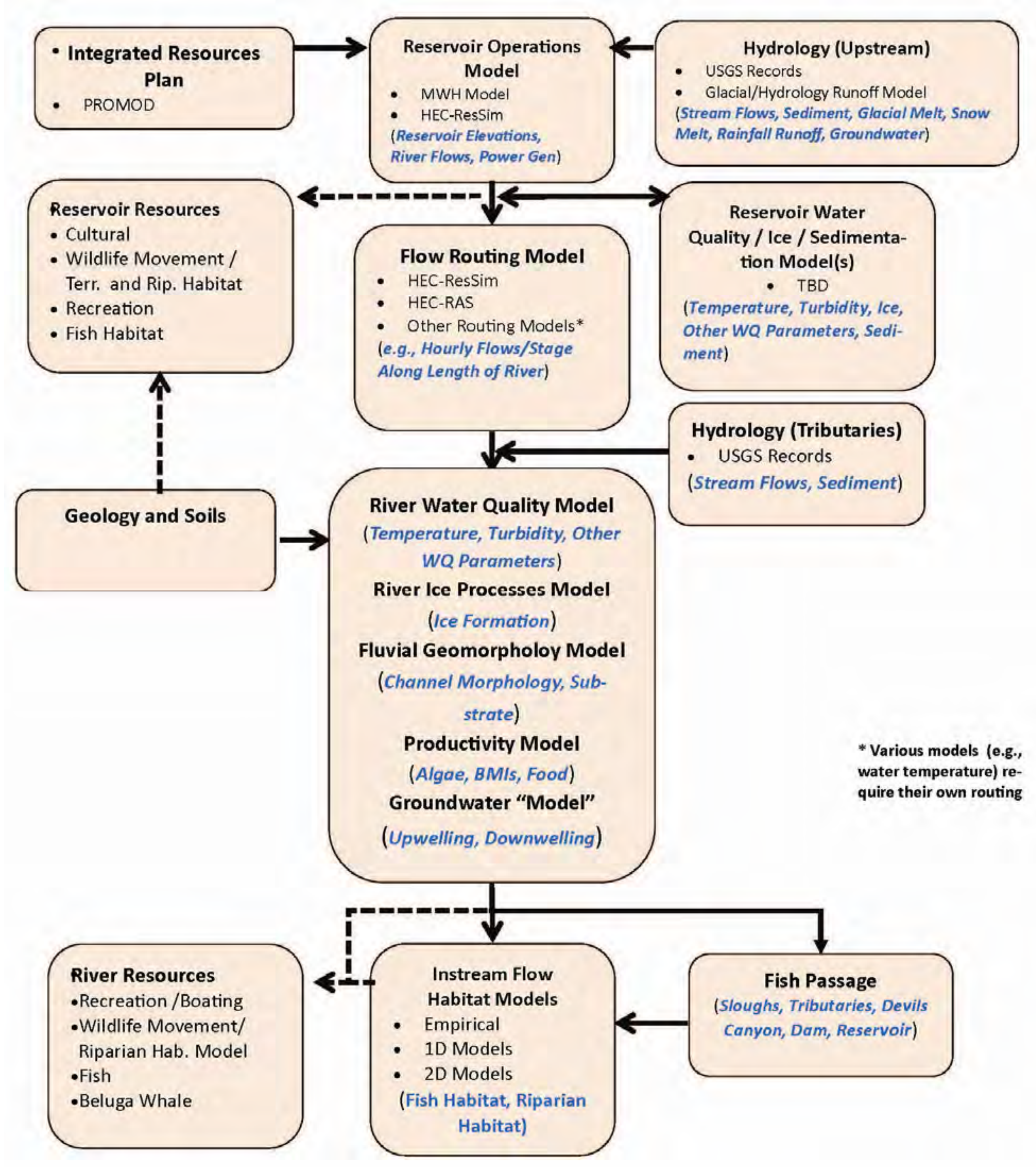

Figure 2-1. Interrelationships amongst Riverine-based Studies.

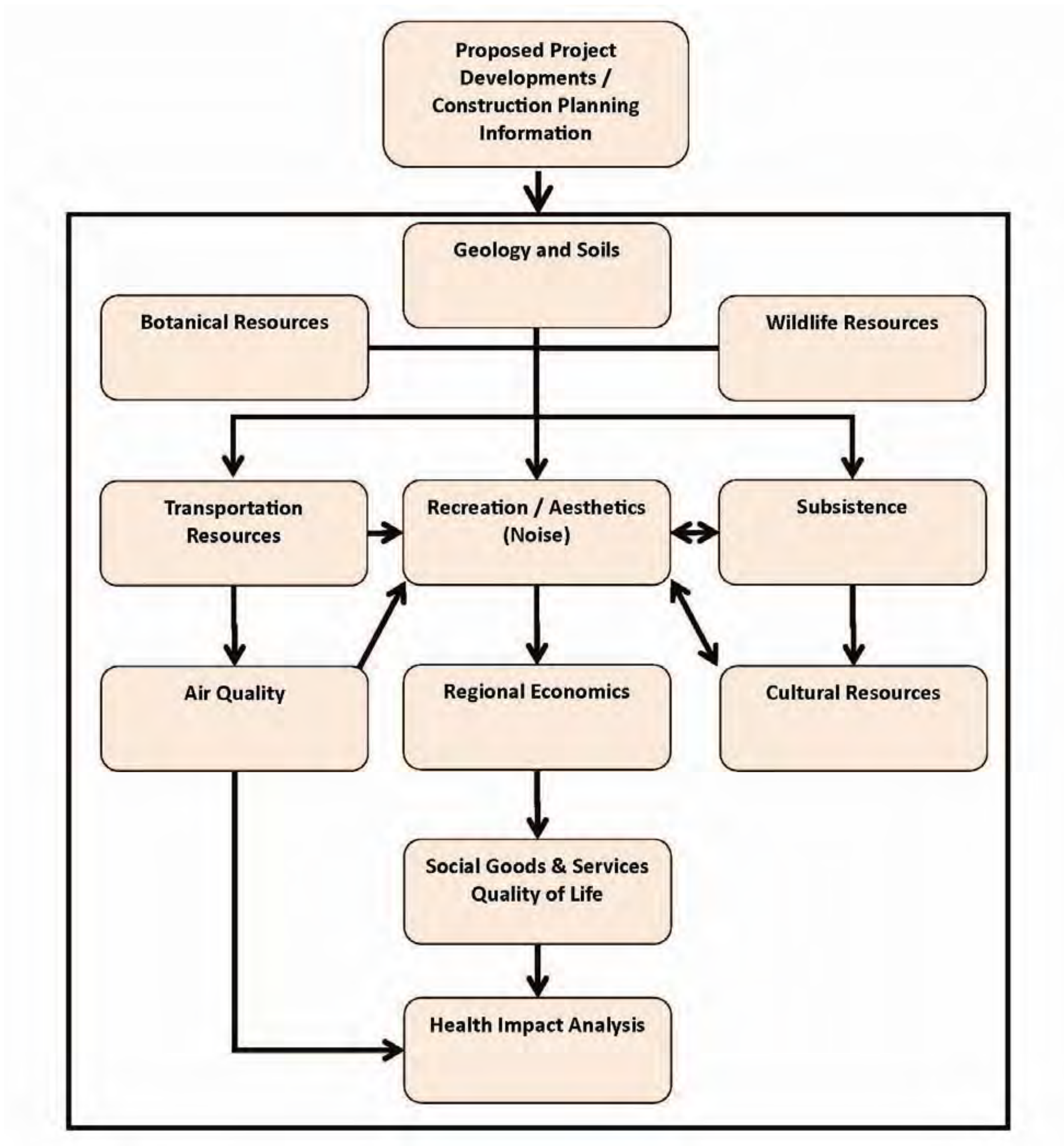

Figure 2-2. Interrelationships amongst Upland-based Studies.

2.3. Attachments

ATTACHMENT 2-1. COMPREHENSIVE SCHEDULE

ATTACHMENT 2-1
COMPREHENSIVE SCHEDULE

Susitna-Watana Hydroelectric Project Schedule

Activity ID	Activity Name	Rem Duration	Start	Finish
Susitna-Watana Hydroelectric Project Schedule		664d	04-Jan-12	24-Feb-15
Pre Filing Activities		664d	04-Jan-12	24-Feb-15
Milestones		664d	04-Jan-12	24-Feb-15
First & Second Season - Studies		664d	04-Jan-12	24-Feb-15
Geology & Soils Characterization Study (4.5)		375d	01-May-13	02-Feb-15
ST4630	Comprehensive Investigations (Dam Site & Reservoir Area)	83d	01-May-13*	30-Aug-13
ST4660	Comprehensive Investigations (Access Road & Transmission Line)	83d	01-May-14*	29-Aug-14
ST4661	Initial Study Report	0d		03-Feb-14*
ST4662	Updated Study Report	0d		02-Feb-15*
Baseline Water Quality Study (5.5)		548d	02-Jul-12	02-Feb-15
ST4680	MET Station Installation & Data Collection	458d	15-Aug-12*	30-Sep-14
ST4690	Thermal Imaging	20d	15-Nov-12*	28-Dec-12
ST4720	Data Analysis & Management	427d	02-Oct-12*	30-Sep-14
ST4730	Fish Tissue Sampling	40d	03-Sep-13*	31-Oct-13
ST4740	Sediment Sampling	40d	03-Sep-13*	31-Oct-13
ST4750	Water Quality Monitoring	205d	16-Apr-13*	28-Mar-14
ST4760	Deployment of Temp Monitoring Apparatus	458d	15-Aug-12*	30-Sep-14
ST4770	QAPP/SAP Preparation & Review	62d	02-Jul-12*	28-Sep-12
ST4771	Initial Study Report	0d		03-Feb-14*
ST4772	Updated Study Report	0d		02-Feb-15*
Water Quality Modeling Study (5.6)		517d	15-Aug-12	02-Feb-15
ST4800	Generate Results for Operational Scenarios	122d	15-May-14*	14-Nov-14
ST4810	Verification Runs	63d	01-Jul-14*	30-Sep-14
ST4820	Re-Calibration Adjustments	121d	01-Apr-14*	30-Sep-14
ST4840	Model Calibration (Water Quality)	110d	01-Jul-13*	31-Dec-13
ST4850	Model Evaluation/Selection	31d	15-Aug-12*	28-Sep-12
ST4860	Coordination w/ Water Quality Data Collection & Analysis	306d	02-Oct-12*	28-Mar-14
ST4861	Initial Study Report	0d		03-Feb-14*
ST4862	Updated Study Report	0d		02-Feb-15*
Mercury Assessment and Potential for Bioaccumulation Study (5.7)		568d	01-Jun-12	02-Feb-15
ST4870	Soil Vegetation Sampling	52d	15-Aug-13*	31-Oct-13
ST4880	Sediment Sampling	52d	15-Aug-13*	31-Oct-13
ST4900	Avian Furbearer Studies	62d	01-Jul-13*	30-Sep-13
ST4910	Fish Tissue Sampling	295d	01-Jun-12*	30-Sep-13
ST4920	Data Analysis & Management	93d	01-Oct-13*	28-Mar-14
ST4940	Follow Up Studies (as needed)	166d	02-Jan-14*	30-Sep-14
ST4960	Water Quality Monitoring (Monthly)	155d	01-Jul-13*	28-Mar-14
ST4961	Initial Study Report	0d		03-Feb-14*
ST4962	Updated Study Report	0d		02-Feb-15*
Geomorphology Study (6.5)		606d	03-Apr-12	02-Feb-15
ST4970	Initial Geomorphic Reach Deliniation/Finalize Deliniation	275d	02-Jul-12*	30-Sep-13
ST4980	Identify and Map Paleo Geomorphic Features & Geology	213d	02-Oct-12*	30-Sep-13
ST4990	Determine Morphometric Parameters	275d	02-Jul-12*	30-Sep-13
ST5010	Identify Key Governing Geomorphic Process	275d	02-Jul-12*	30-Sep-13
ST5020	Acquire Aerial Photo	275d	02-Jul-12*	30-Sep-13
ST5030	Digitize 1980's Habitat and Geomorphic Features	110d	02-Jul-12*	28-Dec-12
ST5040	Digitize 2012 Habitat and Geomorphic Features	261d	02-Oct-12*	31-Dec-13

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Note: Please refer to the individual study plans in Sections 4 through 16 for a discussion and figures explaining the relationship between studies.

SUSITNA-WATANA HYDRO

Susitna-Watana Hydroelectric Project Schedule

Activity ID	Activity Name	Rem Duration	Start	Finish
ST5050	Assess Habitat Area Change 1980-2012	257d	15-Nov-12*	20-Feb-14
ST5060	Assess Channel Change 1980-2012	257d	15-Nov-12*	20-Feb-14
ST5070	Initial & Final Flow Assessment	183d	02-Oct-12*	15-Aug-13
ST5080	Determine Effective Discharge & Characterization of Bed Mobilization	51d	04-Jun-13*	15-Aug-13
ST5090	Initial/Detailed Sediment Balance	213d	02-Oct-12*	30-Sep-13
ST5100	Recon. Level Assessment of Potential Lower River Channel Change	45d	15-Nov-12*	21-Feb-13
ST5120	Large Woody Debris	307d	15-May-13*	30-Sep-14
ST5130	Reservoir Geomorphology	334d	02-Apr-13*	30-Sep-14
ST5140	Geomorphology of Stream X-ings along Access & Trans Corridor	334d	02-Apr-13*	30-Sep-14
ST5150	Integration & Support of Interpreting Fluv. Geomorphology Modeling Results	426d	02-Jan-13*	31-Dec-14
ST5180	Develop Geomorphic System / Finalize Classification System	213d	03-Apr-12*	29-Mar-13
ST5181	Inital Study Report	0d		03-Feb-14*
ST5182	Updated Study Report	0d		02-Feb-15*
Fluvial Geomorphology Modeling Below Watana Dam Study (6.6)		**606d**	**03-Apr-12**	**02-Feb-15**
ST5200	Selection of 1D and 2D Models	213d	03-Apr-12*	29-Mar-13
ST5210	Selection of Focus Area	115d	16-Jul-12*	31-Jan-13
ST5230	Coordination w/ Other Studies on Modeling Needs Including Focus Areas	399d	15-Nov-12*	30-Sep-14
ST5240	2013 Field Data Collection	120d	02-Apr-13*	30-Sep-13
ST5250	Supplemental Field Data Collection 2014	120d	01-Apr-14*	29-Sep-14
ST5260	Coordinate w/ Other Studies on Processes Modeled	192d	01-Nov-12*	30-Sep-13
ST5270	1D Model Development & Calibration	168d	02-Apr-13*	31-Dec-13
ST5280	Perform 1D Modeling of Exis Conditions & Initial Proj Run	70d	01-Oct-13*	18-Feb-14
ST5290	Reevaluate D/S Study Limits Based on 1D Results	45d	02-Jan-14*	28-Mar-14
ST5300	2D Model Development & Calibration	213d	01-Jul-13*	30-Jun-14
ST5310	Perform 2D Modeling Existing Conditions	63d	01-Jul-14*	30-Sep-14
ST5320	Perform 1D Modeling of Alternate Scenarios	192d	18-Feb-14*	31-Dec-14
ST5340	Perform 2D Modeling of Alternate Scenarios	110d	01-Jul-14*	31-Dec-14
ST5350	Post Process & Provide Model Results to Other Studies	168d	01-Apr-14*	31-Dec-14
ST5360	Interpretation of Channel Change & Integration w/ Other Studies	168d	01-Apr-14*	31-Dec-14
ST5370	Initial Study Report	0d		03-Feb-14*
ST5372	Updated Study Report	0d		02-Feb-15*
Groundwater Study (7.5)		**486d**	**02-Oct-12**	**02-Feb-15**
ST5380	Existing Data Synthesis	213d	02-Jan-13*	31-Dec-13
ST5390	Geohydrologic Process-Domains and Terrain	213d	02-Jan-13*	31-Dec-13
ST5400	Watana Dam/Reservoir	323d	04-Jun-13*	14-Nov-14
ST5410	Upwelling/Springs Broadscale Mapping	362d	02-Apr-13*	14-Nov-14
ST5420	Riparian Veg Dependency on Surface/Grdwater Interactions	407d	02-Jan-13*	14-Nov-14
ST5430	Aquatic Habitat/Grdwater/Surface Water Interactions	455d	02-Oct-12*	14-Nov-14
ST5450	Water Quality in Selected Habitats	455d	02-Oct-12*	14-Nov-14
ST5460	Winter Ground/Surface Water Interactions	364d	02-Oct-12*	30-Jun-14
ST5470	Shallow Groundwater Users	426d	02-Jan-13*	31-Dec-14
ST5480	Initial Study Plan	0d		03-Feb-14*
ST5490	Updated Study Report	0d		02-Feb-15*
Ice Processes in the Susitna River Study (7.6)		**652d**	**04-Jan-12**	**02-Feb-15**
ST2510	Existing Condition 1D Model Development	213d	02-Jan-13*	31-Dec-13
ST2520	Intensive Site Models	89d	01-Oct-14*	02-Feb-15
ST2530	Proposed Condition 1D Model Development	261d	01-Oct-13*	31-Dec-14
ST2570	Open Lead Surveys, Ice Thickness & Elevation (2012)	46d	04-Jan-12*	30-Mar-12

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Note: Please refer to the individual study plans in Sections 4 through 16 for a discussion and figures explaining the relationship between studies.

SUSITNA-WATANA HYDRO

Susitna-Watana Hydroelectric Project Schedule

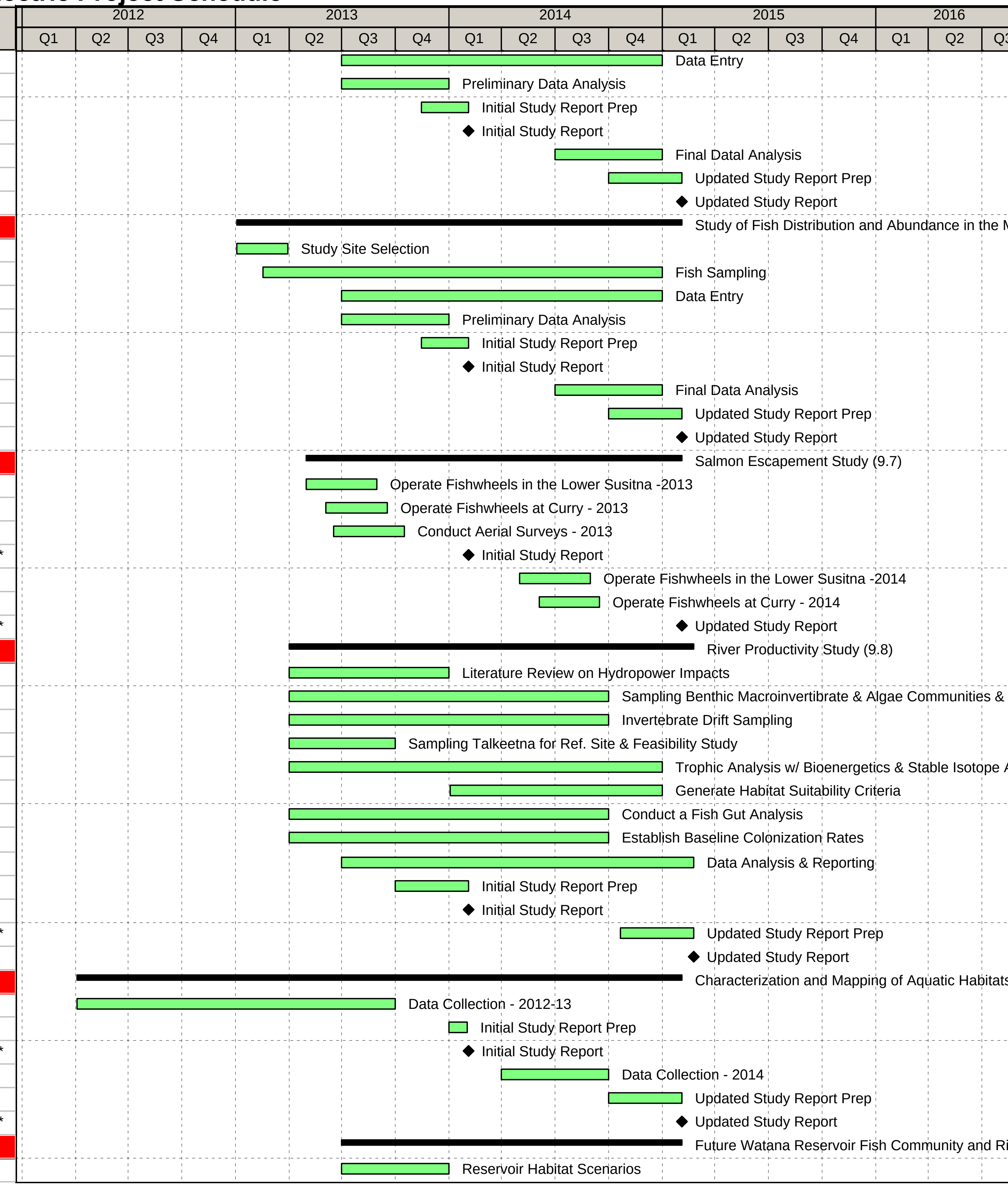
Activity ID	Activity Name	Rem Duration	Start	Finish
ST2580	Break Up Reconnaissance	58d	03-Apr-12	29-Jun-12
ST2590	Freezup Reconnaissance	93d	02-Oct-12*	29-Mar-13
ST2630	Open Lead Surveys, Ice Thickness & Elevation (2013)	45d	02-Jan-13*	29-Mar-13
ST2640	Break Up Reconnaissance	58d	02-Apr-13	28-Jun-13
ST2650	Freezup Reconnaissance	92d	02-Oct-13	28-Mar-14
ST2710	Initial Study Report Prep	56d	18-Nov-13*	03-Feb-14
ST2720	Initial Study Report	0d		03-Feb-14*
ST2730	Open Lead Surveys, Ice Thickness & Elevation (2014)	45d	02-Jan-14*	28-Mar-14
ST2740	Break Up Reconnaissance	58d	01-Apr-14	30-Jun-14
ST2770	Updated Study Report	0d		02-Feb-15
Glacial & RunOff Changes Study (7.7)		438d	02-Jan-13	02-Feb-15
ST3840	Review Existing Literature	45d	02-Jan-13*	29-Mar-13
ST3850	Process Remote Sensing Imagery	165d	02-Jan-13*	30-Sep-13
ST3870	Spring Fieldwork	271d	02-Apr-13*	30-Jun-14
ST3880	Fall Fieldwork	245d	15-Aug-13*	30-Sep-14
ST3900	Analyze Glacier Mass Balance & Meteorological Data	292d	15-Aug-13*	31-Dec-14
ST3910	Glacial Extent Variation	122d	15-May-13*	15-Nov-13
ST3930	Hydrological & Glacier Melt Model Developement	103d	02-Jan-13*	28-Jun-13
ST3940	Hydrological & Glacier Melt Model Calibration/Validation	323d	01-Jul-13*	31-Dec-14
ST3960	Initial Study Report	0d		03-Feb-14*
ST3970	Updated Study Report	0d		02-Feb-15*
Fish & Aquatics Instream Flow Study (8.5)		606d	03-Apr-12	02-Feb-15
ST3000	Study Area Selection	594d	03-Apr-12*	31-Dec-14
ST3110	Review of 1980's Data & Information	594d	03-Apr-12*	31-Dec-14
ST3220	Model Selection by Habitat Type	93d	02-Oct-12*	29-Mar-13
ST4500	Hydraulic Flow Routing	594d	03-Apr-12*	31-Dec-14
ST4510	Hydrology	594d	03-Apr-12*	31-Dec-14
ST4520	Peiodicity	594d	03-Apr-12*	31-Dec-14
ST4530	HSC/HCI Fish: Field Data Collection	594d	03-Apr-12*	31-Dec-14
ST4540	Collect Physical & Hydraulic Data for Habitat Modeling	323d	01-Jul-13*	31-Dec-14
ST4550	Coordinate with Other Disciplines Quality Data Collection & Modeling	536d	02-Jul-12*	31-Dec-14
ST4570	Hydraulic Model Integration & Calibration	168d	01-Apr-14*	31-Dec-14
ST4580	Initial Study Report	0d		03-Feb-14*
ST4590	Updated Study Report	0d		02-Feb-15*
Riparian Instream Flow Study (8.6)		438d	02-Jan-13	02-Feb-15
ST1010	Critical Review of 1980's Susitna River Data	213d	02-Jan-13*	31-Dec-13
ST1020	Finalize Riparian Groundwater/Surface Water Field Design	45d	02-Jan-13*	29-Mar-13
ST1030	Implement Riparian Groundwater/Surfacewater Installation & Sampling	381d	02-Apr-13*	31-Dec-14
ST1040	Riparian Vegetation: Field Data Collection - 2013	149d	02-Apr-13*	15-Nov-13
ST1050	Riparian Vegetation: Field Data Collection - 2014	121d	01-Apr-14*	30-Sep-14
ST1060	Sediment Dating: Sampling & Analysis - 2013	168d	02-Apr-13*	31-Dec-13
ST1070	Sediment Dating: Sampling & Analysis - 2014	168d	01-Apr-14*	31-Dec-14
ST1080	Develop Groundwater/Surfacewater Modeling	426d	02-Jan-13*	31-Dec-14
ST1090	Initial Study Report	0d		03-Feb-14*
ST1100	Updated Study Report	0d		02-Feb-15*
Study of Fish Distribution and Abundance in the Upper Susitna River (9.5)		438d	02-Jan-13	02-Feb-15
ST2220	Fish Sampling	426d	02-Jan-13*	31-Dec-14
ST2950	Study Site Selection	45d	02-Jan-13*	29-Mar-13

Note: Please refer to the individual study plans in Sections 4 through 16 for a discussion and figures explaining the relationship between studies.

SUSITNA-WATANA HYDRO

Susitna-Watana Hydroelectric Project Schedule

Activity ID	Activity Name	Rem Duration	Start	Finish
ST2951	Data Entry	323d	01-Jul-13*	31-Dec-14
ST2952	Preliminary Data Analysis	110d	01-Jul-13*	31-Dec-13
ST3050	Initial Study Report Prep	57d	15-Nov-13*	03-Feb-14
ST3060	Initial Study Report	0d		03-Feb-14
ST3120	Final Datal Analysis	110d	01-Jul-14*	31-Dec-14
ST3140	Updated Study Report Prep	89d	01-Oct-14*	02-Feb-15
ST3150	Updated Study Report	0d		02-Feb-15
Study of Fish Distribution and Abundance in the Middle and Lower Susitna River(9.6)		**438d**	**02-Jan-13**	**02-Feb-15**
ST3310	Study Site Selection	45d	02-Jan-13*	29-Mar-13
ST3320	Fish Sampling	405d	15-Feb-13*	31-Dec-14
ST3350	Data Entry	323d	01-Jul-13*	31-Dec-14
ST3360	Preliminary Data Analysis	110d	01-Jul-13	31-Dec-13
ST3370	Initial Study Report Prep	57d	15-Nov-13*	03-Feb-14
ST3380	Initial Study Report	0d		03-Feb-14
ST3381	Final Data Analysis	110d	01-Jul-14*	31-Dec-14
ST3390	Updated Study Report Prep	89d	01-Oct-14*	02-Feb-15
ST3400	Updated Study Report	0d		02-Feb-15
Salmon Escapement Study (9.7)		**375d**	**01-May-13**	**02-Feb-15**
ST2380	Operate Fishwheels in the Lower Susitna -2013	83d	01-May-13*	30-Aug-13
ST2390	Operate Fishwheels at Curry - 2013	71d	04-Jun-13*	16-Sep-13
ST2400	Conduct Aerial Surveys - 2013	81d	17-Jun-13*	15-Oct-13
ST2410	Initial Study Report	0d		03-Feb-14*
ST2420	Operate Fishwheels in the Lower Susitna -2014	83d	01-May-14*	29-Aug-14
ST2430	Operate Fishwheels at Curry - 2014	72d	03-Jun-14*	15-Sep-14
ST2440	Updated Study Report	0d		02-Feb-15*
River Productivity Study (9.8)		**405d**	**02-Apr-13**	**24-Feb-15**
ST4020	Literature Review on Hydropower Impacts	168d	02-Apr-13*	31-Dec-13
ST4060	Sampling Benthic Macroinvertibrate & Algae Communities & Organic Matter	334d	02-Apr-13	30-Sep-14
ST4100	Invertebrate Drift Sampling	334d	02-Apr-13	30-Sep-14
ST4120	Sampling Talkeetna for Ref. Site & Feasibility Study	120d	02-Apr-13*	30-Sep-13
ST4140	Trophic Analysis w/ Bioenergetics & Stable Isotope Analysis	381d	02-Apr-13	31-Dec-14
ST4150	Generate Habitat Suitability Criteria	213d	02-Jan-14*	31-Dec-14
ST4160	Conduct a Fish Gut Analysis	334d	02-Apr-13	30-Sep-14
ST4170	Establish Baseline Colonization Rates	334d	02-Apr-13	30-Sep-14
ST4180	Data Analysis & Reporting	347d	01-Jul-13*	24-Feb-15
ST4210	Initial Study Report Prep	90d	01-Oct-13*	03-Feb-14
ST4230	Initial Study Report	0d		03-Feb-14
ST4240	Updated Study Report Prep	90d	22-Oct-14	24-Feb-15*
ST4250	Updated Study Report	0d		24-Feb-15
Characterization and Mapping of Aquatic Habitats Study (9.9)		**606d**	**03-Apr-12**	**02-Feb-15**
ST3460	Data Collection - 2012-13	333d	03-Apr-12*	30-Sep-13
ST3520	Initial Study Report Prep	23d	01-Jan-14*	31-Jan-14
ST3530	Initial Study Report	0d		03-Feb-14*
ST3600	Data Collection - 2014	121d	01-Apr-14*	30-Sep-14
ST3610	Updated Study Report Prep	89d	01-Oct-14*	02-Feb-15
ST3640	Updated Study Report	0d		02-Feb-15*
Future Watana Reservoir Fish Community and Risk of Entrainment Study (9.10)		**335d**	**01-Jul-13**	**02-Feb-15**
ST1729	Reservoir Habitat Scenarios	110d	01-Jul-13*	31-Dec-13



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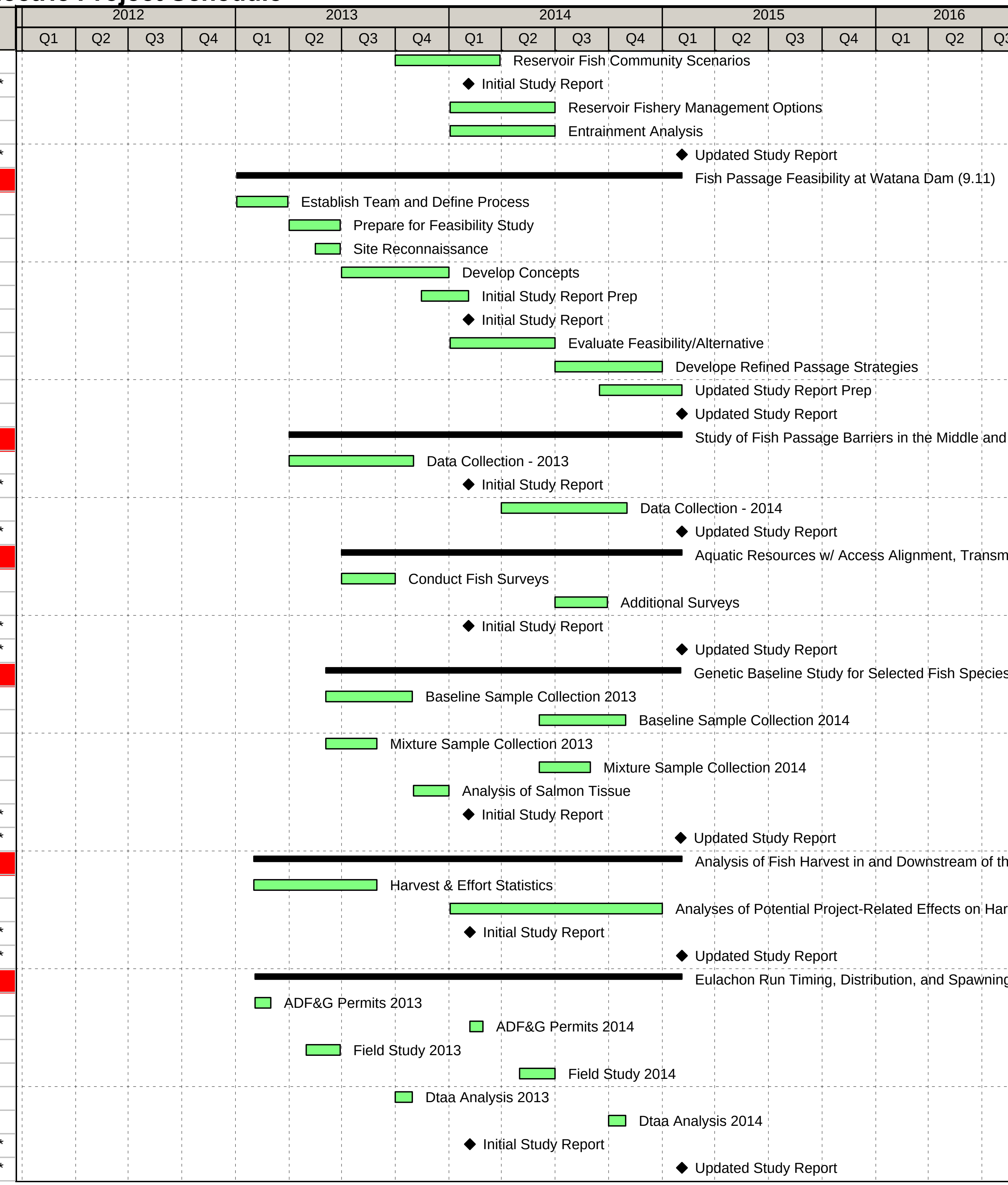
Note: Please refer to the individual study plans in Sections 4 through 16 for a discussion and figures explaining the relationship between studies.

SUSITNA-WATANA HYDRO

Susitna-Watana Hydroelectric Project Schedule

Activity ID	Activity Name	Rem Duration	Start	Finish
ST1730	Reservoir Fish Community Scenarios	93d	01-Oct-13*	28-Mar-14
ST1731	Initial Study Report	0d		03-Feb-14*
ST2010	Reservoir Fishery Management Options	103d	02-Jan-14*	30-Jun-14
ST2210	Entrainment Analysis	103d	02-Jan-14*	30-Jun-14
ST2460	Updated Study Report	0d		02-Feb-15*
Fish Passage Feasibility at Watana Dam (9.11)		**438d**	**02-Jan-13**	**02-Feb-15**
ST1109	Establish Team and Define Process	45d	02-Jan-13*	29-Mar-13
ST1110	Prepare for Feasibility Study	58d	02-Apr-13	28-Jun-13
ST1111	Site Reconnaissance	30d	16-May-13	28-Jun-13
ST1112	Develop Concepts	110d	01-Jul-13	31-Dec-13
ST1113	Initial Study Report Prep	57d	15-Nov-13*	03-Feb-14
ST1114	Initial Study Report	0d		03-Feb-14
ST2670	Evaluate Feasibility/Alternative	103d	02-Jan-14*	30-Jun-14
ST2671	Develope Refined Passage Strategies	110d	01-Jul-14*	31-Dec-14
ST2790	Updated Study Report Prep	101d	15-Sep-14*	02-Feb-15
ST2800	Updated Study Report	0d		02-Feb-15
Study of Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries (9.12)		**393d**	**02-Apr-13**	**02-Feb-15**
ST4260	Data Collection - 2013	141d	02-Apr-13*	31-Oct-13
ST4340	Initial Study Report	0d		03-Feb-14*
ST4410	Data Collection - 2014	142d	01-Apr-14*	31-Oct-14
ST4490	Updated Study Report	0d		02-Feb-15*
Aquatic Resources w/ Access Alignment, Transmission Alignment, and Const. Areas Study (9.13)		**335d**	**01-Jul-13**	**03-Feb-15**
ST2230	Conduct Fish Surveys	62d	01-Jul-13*	30-Sep-13
ST2450	Additional Surveys	62d	01-Jul-14*	29-Sep-14
ST3810	Initial Study Report	0d		03-Feb-14*
ST3820	Updated Study Report	0d		03-Feb-15*
Genetic Baseline Study for Selected Fish Species (9.14)		**354d**	**04-Jun-13**	**02-Feb-15**
ST1230	Baseline Sample Collection 2013	101d	04-Jun-13*	30-Oct-13
ST1450	Baseline Sample Collection 2014	103d	03-Jun-14*	30-Oct-14
ST1670	Mixture Sample Collection 2013	62d	04-Jun-13*	30-Aug-13
ST2000	Mixture Sample Collection 2014	63d	03-Jun-14*	29-Aug-14
ST3730	Analysis of Salmon Tissue	27d	01-Nov-13*	31-Dec-13
ST3740	Initial Study Report	0d		03-Feb-14*
ST3750	Updated Study Report	0d		02-Feb-15*
Analysis of Fish Harvest in and Downstream of the Susitna-Watana Hydroelectric Project Area (9.15)		**424d**	**01-Feb-13**	**04-Feb-15**
ST3920	Harvest & Effort Statistics	132d	01-Feb-13*	30-Aug-13
ST3950	Analyses of Potential Project-Related Effects on Harvest Levels & Opportunity	213d	02-Jan-14*	31-Dec-14
ST3980	Initial Study Report	0d		05-Feb-14*
ST3981	Updated Study Report	0d		04-Feb-15*
Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study (9.16)		**423d**	**01-Feb-13**	**04-Feb-15**
ST3340	ADF&G Permits 2013	14d	01-Feb-13*	28-Feb-13
ST3450	ADF&G Permits 2014	15d	05-Feb-14*	28-Feb-14
ST3560	Field Study 2013	40d	01-May-13*	28-Jun-13
ST3670	Field Study 2014	40d	01-May-14*	30-Jun-14
ST3780	Dtaa Analysis 2013	20d	01-Oct-13*	30-Oct-13
ST3890	Dtaa Analysis 2014	20d	01-Oct-14*	30-Oct-14
ST4220	Initial Study Report	0d		05-Feb-14*
ST5440	Updated Study Report	0d		04-Feb-15*



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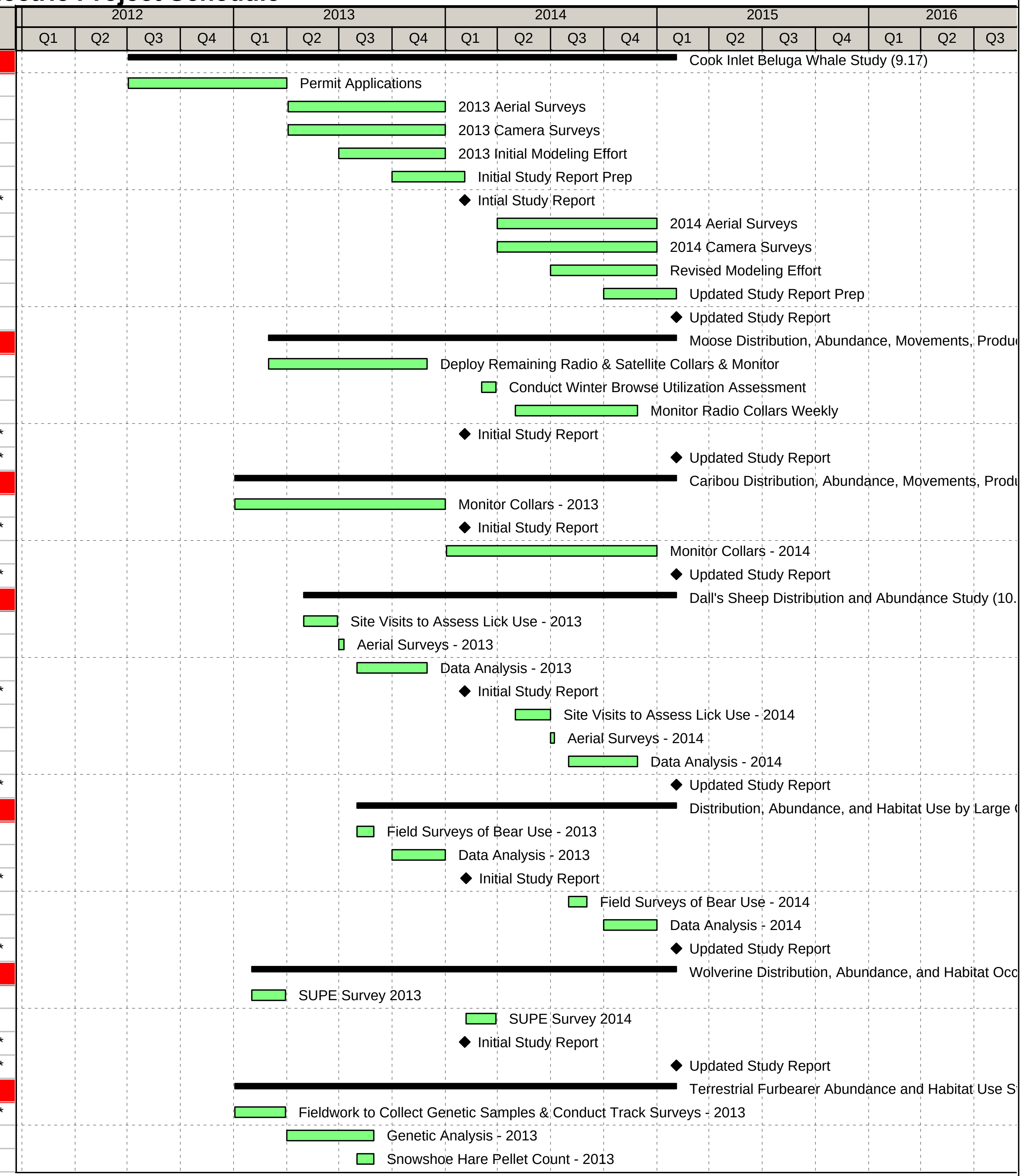
Note: Please refer to the individual study plans in Sections 4 through 16 for a discussion and figures explaining the relationship between studies.

SUSITNA-WATANA HYDRO

Susitna-Watana Hydroelectric Project Schedule

Activity ID	Activity Name	Rem Duration	Start	Finish
Cook Inlet Beluga Whale Study (9.17)		548d	02-Jul-12	02-Feb-15
ST2040	Permit Applications	156d	02-Jul-12*	02-Apr-13
ST2050	2013 Aerial Surveys	167d	03-Apr-13	31-Dec-13
ST2060	2013 Camera Surveys	167d	03-Apr-13	31-Dec-13
ST2070	2013 Initial Modeling Effort	110d	01-Jul-13	31-Dec-13
ST3620	Initial Study Report Prep	90d	01-Oct-13*	03-Feb-14
ST3630	Intial Study Report	0d		03-Feb-14*
ST3649	2014 Aerial Surveys	168d	01-Apr-14*	31-Dec-14
ST3650	2014 Camera Surveys	168d	01-Apr-14	31-Dec-14
ST3652	Revised Modeling Effort	110d	01-Jul-14	31-Dec-14
ST3653	Updated Study Report Prep	89d	01-Oct-14*	02-Feb-15
ST3654	Updated Study Report	0d		02-Feb-15
Moose Distribution, Abundance, Movements, Productivity, and Survival Study (10.5)		409d	01-Mar-13	02-Feb-15
ST2089	Deploy Remaining Radio & Satellite Collars & Monitor	171d	01-Mar-13*	29-Nov-13
ST2090	Conduct Winter Browse Utilization Assessment	16d	04-Mar-14*	28-Mar-14
ST2100	Monitor Radio Collars Weekly	137d	01-May-14*	28-Nov-14
ST5680	Initial Study Report	0d		03-Feb-14*
ST5681	Updated Study Report	0d		02-Feb-15*
Caribou Distribution, Abundance, Movements, Productivity, and Survival Study (10.6)		438d	02-Jan-13	02-Feb-15
ST4670	Monitor Collars - 2013	213d	02-Jan-13*	31-Dec-13
ST4780	Initial Study Report	0d		03-Feb-14*
ST4890	Monitor Collars - 2014	213d	02-Jan-14*	31-Dec-14
ST5000	Updated Study Report	0d		02-Feb-15*
Dall's Sheep Distribution and Abundance Study (10.7)		375d	01-May-13	02-Feb-15
ST5110	Site Visits to Assess Lick Use - 2013	40d	01-May-13*	28-Jun-13
ST5220	Aerial Surveys - 2013	5d	01-Jul-13*	09-Jul-13
ST5330	Data Analysis - 2013	76d	01-Aug-13*	29-Nov-13
ST5620	Initial Study Report	0d		03-Feb-14*
ST5630	Site Visits to Assess Lick Use - 2014	40d	01-May-14*	30-Jun-14
ST5640	Aerial Surveys - 2014	5d	01-Jul-14*	08-Jul-14
ST5650	Data Analysis - 2014	75d	01-Aug-14*	28-Nov-14
ST5660	Updated Study Report	0d		02-Feb-15*
Distribution, Abundance, and Habitat Use by Large Carnivores Study (10.8)		314d	01-Aug-13	02-Feb-15
ST2550	Field Surveys of Bear Use - 2013	22d	01-Aug-13*	30-Aug-13
ST4330	Data Analysis - 2013	48d	01-Oct-13*	31-Dec-13
ST4450	Initial Study Report	0d		05-Feb-14*
ST4600	Field Surveys of Bear Use - 2014	22d	01-Aug-14*	02-Sep-14
ST5610	Data Analysis - 2014	47d	01-Oct-14*	31-Dec-14
ST5611	Updated Study Report	0d		02-Feb-15*
Wolverine Distribution, Abundance, and Habitat Occupancy Study (10.9)		424d	01-Feb-13	02-Feb-15
ST2120	SUPE Survey 2013	31d	01-Feb-13*	29-Mar-13
ST2130	SUPE Survey 2014	31d	05-Feb-14*	28-Mar-14
ST2140	Initial Study Report	0d		03-Feb-14*
ST2150	Updated Study Report	0d		02-Feb-15*
Terrestrial Furbearer Abundance and Habitat Use Study (10.10)		438d	02-Jan-13	02-Feb-15
ST5580	Fieldwork to Collect Genetic Samples & Conduct Track Surveys - 2013	45d	02-Jan-13	29-Mar-13*
ST5600	Genetic Analysis - 2013	101d	02-Apr-13*	30-Aug-13
ST5690	Snowshoe Hare Pellet Count - 2013	22d	01-Aug-13*	30-Aug-13



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Note: Please refer to the individual study plans in Sections 4 through 16 for a discussion and figures explaining the relationship between studies.

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Susitna-Watana Hydroelectric Project Schedule

Activity ID	Activity Name	Rem Duration	Start	Finish
ST5700	Initial Data	19d	03-Sep-13*	30-Sep-13
ST5710	Fieldwork to Collect Genetic Samples & Conduct Track Surveys - 2014	45d	02-Jan-14*	28-Mar-14
ST5840	Genetic Analysis - 2014	142d	01-Apr-14*	31-Oct-14
ST5950	Snowshoe Hare Pellet Count - 2014	21d	01-Aug-14*	29-Aug-14
ST5951	Initial Study Report	0d		03-Feb-14*
ST5952	Updated Study Report	0d		02-Feb-15*
Aquatic Furbearer Abundance & Habitat Use Study (10.11)		**424d**	**01-Feb-13**	**02-Feb-15**
ST3470	Aerial Surveys of River Otter & Mink Tracks	31d	01-Feb-13*	29-Mar-13
ST3480	Aerial Survey of Muskrat Pushups	18d	02-Apr-13*	30-Apr-13
ST3490	Aerial Survey of Beaver Colonies	21d	01-May-13*	30-May-13
ST3500	Aerial Survey of Lodges	21d	01-Oct-13*	31-Oct-13
ST3510	Aerial Track Survey of River Otter & Mink	14d	01-Nov-13*	04-Dec-13
ST3540	Aerial Survey of River Otter & Mink Tracks	49d	05-Feb-14*	30-Apr-14
ST3550	Aerial Survey of Muskrat Pushups	18d	01-Apr-14*	30-Apr-14
ST3570	Aerial Survey of Beaver Colonies	21d	01-May-14*	03-Jun-14
ST3580	Aerial Survey of Lodges	21d	01-Oct-14*	31-Oct-14
ST3590	Aerial Track Survey of River Otter & Mink	14d	05-Nov-14*	03-Dec-14
ST5560	Initial Study Report	0d		03-Feb-14*
ST5570	Updated Study Report	0d		02-Feb-15*
Small Mammal Species Composition and Habitat Use Study (10.12)		**314d**	**01-Aug-13**	**02-Feb-15**
ST1260	Small Mammal Trapping	41d	01-Aug-13*	30-Sep-13
ST1300	Data Management	21d	01-Oct-13*	31-Oct-13
ST1310	Initial Study Report	0d		03-Feb-14*
ST1330	Updated Study Report	0d		02-Feb-15*
Bat Distribution Distribution & Habitat Use Study (10.13)		**366d**	**15-May-13**	**02-Feb-15**
ST3160	Acoustic Monitoring - 2013	100d	15-May-13*	10-Oct-13
ST3170	Data Analysis - 2013	35d	01-Oct-13*	29-Nov-13
ST3180	Intial Study Report	0d		03-Feb-14*
ST3190	Acoustic Monitoring - 2014	100d	15-May-14*	09-Oct-14
ST3200	Data Analysis - 2014	34d	01-Oct-14*	28-Nov-14
ST3210	Updated Study Report	0d		02-Feb-15*
Surveys of Eagles & Other Raptors Study (10.14)		**374d**	**02-May-13**	**02-Feb-15**
ST1350	Field Surveys - 2013	60d	02-May-13*	31-Jul-13
ST1580	Update Regional Database - 2013	22d	01-Aug-13*	30-Aug-13
ST1630	Conduct Roosting & Staging Surveys - 2013	30d	15-Oct-13*	06-Dec-13
ST1680	Initial Study Report	0d		03-Feb-14*
ST1690	Field Surveys - 2014	62d	01-May-14*	31-Jul-14
ST4090	Update Regional Database - 2014	21d	01-Aug-14*	29-Aug-14
ST4130	Conduct Roosting & Staging Surveys - 2014	30d	15-Oct-14*	10-Dec-14
ST4131	Updated Study Report	0d		02-Feb-15*
Waterbird Migration, Breeding & Habitat Study (10.15)		**385d**	**16-Apr-13**	**02-Feb-15**
ST4270	Spring Migration/Breeding-Pair Surveys - 2013	40d	16-Apr-13*	14-Jun-13
ST4280	Brood Surveys - 2013	21d	01-Jul-13*	31-Jul-13
ST4290	Harlequin Duck Brood-Rearing Survey - 2013	22d	01-Aug-13*	30-Aug-13
ST4300	Fall Migration Surveys - 2013	40d	15-Aug-13*	15-Oct-13
ST4310	Data Analysis - 2013	27d	01-Nov-13*	31-Dec-13
ST4420	Spring Migration/Breeding-Pair Surveys - 2014	40d	15-Apr-14*	16-Jun-14
ST4430	Brood Surveys - 2014	22d	01-Jul-14*	31-Jul-14

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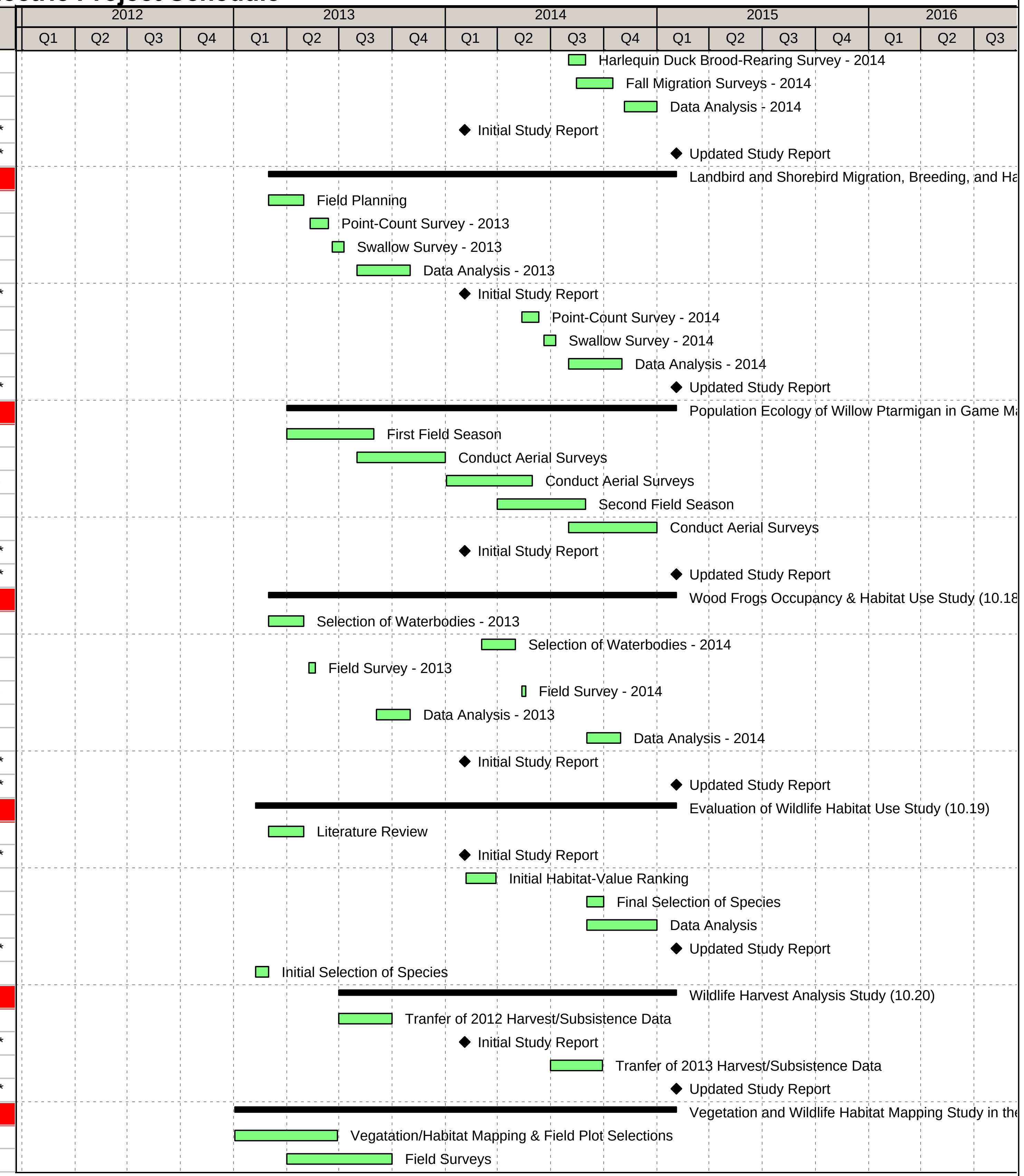
Susitna-Watana Hydroelectric Project Schedule

Activity ID	Activity Name	Rem Duration	Start	Finish
ST4460	Harlequin Duck Brood-Rearing Survey - 2014	21d	01-Aug-14*	29-Aug-14
ST4470	Fall Migration Surveys - 2014	40d	15-Aug-14*	15-Oct-14
ST4480	Data Analysis - 2014	26d	05-Nov-14*	31-Dec-14
ST4481	Initial Study Report	0d		03-Feb-14*
ST4482	Updated Study Report	0d		02-Feb-15*
Landbird and Shorebird Migration, Breeding, and Habitat Use Study (10.16)		409d	01-Mar-13	02-Feb-15
ST1740	Field Planning	34d	01-Mar-13*	30-Apr-13
ST1850	Point-Count Survey - 2013	21d	13-May-13*	12-Jun-13
ST1970	Swallow Survey - 2013	13d	20-Jun-13*	10-Jul-13
ST1990	Data Analysis - 2013	62d	01-Aug-13*	31-Oct-13
ST2020	Initial Study Report	0d		03-Feb-14*
ST2240	Point-Count Survey - 2014	20d	12-May-14*	10-Jun-14
ST2470	Swallow Survey - 2014	14d	20-Jun-14*	10-Jul-14
ST3330	Data Analysis - 2014	62d	01-Aug-14*	31-Oct-14
ST5500	Updated Study Report	0d		02-Feb-15*
Population Ecology of Willow Ptarmigan in Game Management Unit 13 Study (10.17)		393d	02-Apr-13	02-Feb-15
ST1119	First Field Season	101d	02-Apr-13*	30-Aug-13
ST1120	Conduct Aerial Surveys	89d	01-Aug-13*	31-Dec-13
ST1560	Conduct Aerial Surveys	83d	02-Jan-14*	29-May-14
ST1780	Second Field Season	101d	01-Apr-14*	29-Aug-14
ST1890	Conduct Aerial Surveys	88d	01-Aug-14*	31-Dec-14
ST5831	Initial Study Report	0d		03-Feb-14*
ST5832	Updated Study Report	0d		02-Feb-15*
Wood Frogs Occupancy & Habitat Use Study (10.18)		409d	01-Mar-13	02-Feb-15
ST2340	Selection of Waterbodies - 2013	34d	01-Mar-13*	30-Apr-13
ST2540	Selection of Waterbodies - 2014	34d	04-Mar-14*	30-Apr-14
ST2560	Field Survey - 2013	7d	10-May-13*	20-May-13
ST2561	Field Survey - 2014	6d	12-May-14*	19-May-14
ST2890	Data Analysis - 2013	40d	03-Sep-13*	31-Oct-13
ST3130	Data Analysis - 2014	40d	02-Sep-14*	30-Oct-14
ST4000	Initial Study Report	0d		03-Feb-14*
ST4610	Updated Study Report	0d		02-Feb-15*
Evaluation of Wildlife Habitat Use Study (10.19)		423d	06-Feb-13	02-Feb-15
ST3230	Literature Review	34d	01-Mar-13*	30-Apr-13
ST3240	Initial Study Report	0d		03-Feb-14*
ST3250	Initial Habitat-Value Ranking	31d	05-Feb-14*	28-Mar-14
ST3260	Final Selection of Species	20d	02-Sep-14*	30-Sep-14
ST3270	Data Analysis	67d	02-Sep-14*	31-Dec-14
ST3280	Updated Study Report	0d		02-Feb-15*
ST5510	Initial Selection of Species	15d	06-Feb-13*	01-Mar-13
Wildlife Harvest Analysis Study (10.20)		335d	01-Jul-13	02-Feb-15
ST5520	Tranfer of 2012 Harvest/Subsistence Data	62d	01-Jul-13*	30-Sep-13
ST5530	Initial Study Report	0d		03-Feb-14*
ST5540	Tranfer of 2013 Harvest/Subsistence Data	62d	01-Jul-14*	29-Sep-14
ST5550	Updated Study Report	0d		02-Feb-15*
Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin (11.5)		438d	02-Jan-13	02-Feb-15
ST2160	Vegatation/Habitat Mapping & Field Plot Selections	103d	02-Jan-13*	28-Jun-13
ST2170	Field Surveys	120d	02-Apr-13*	30-Sep-13



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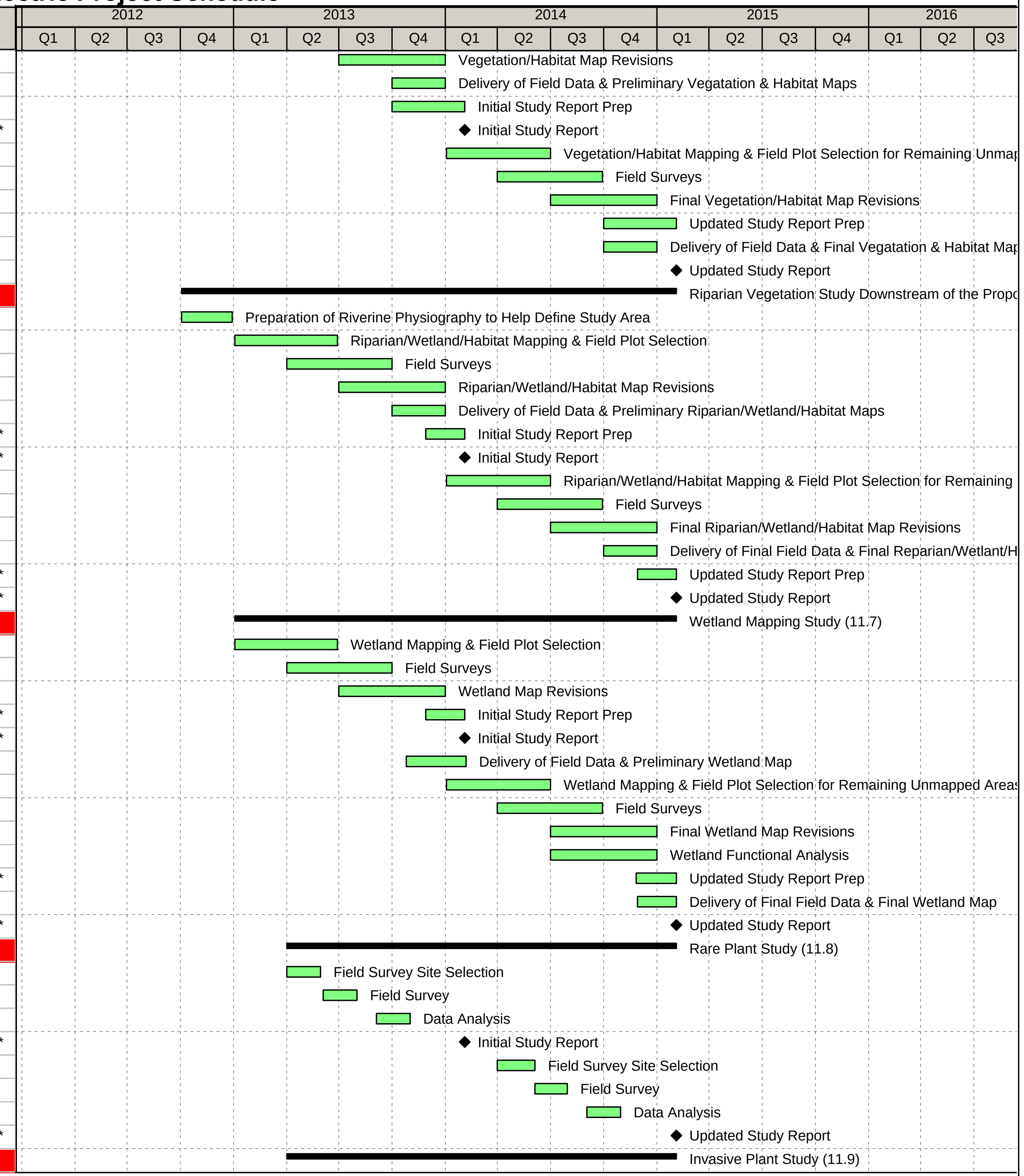
SUSITNA-WATANA HYDRO

Susitna-Watana Hydroelectric Project Schedule

Activity ID	Activity Name	Rem Duration	Start	Finish
ST2180	Vegetation/Habitat Map Revisions	110d	01-Jul-13*	31-Dec-13
ST2181	Delivery of Field Data & Preliminary Vegatation & Habitat Maps	48d	01-Oct-13*	31-Dec-13
ST2190	Initial Study Report Prep	90d	01-Oct-13*	03-Feb-14
ST2200	Initial Study Report	0d		03-Feb-14*
ST4350	Vegetation/Habitat Mapping & Field Plot Selection for Remaining Unmapped Areas	103d	02-Jan-14	30-Jun-14
ST4360	Field Surveys	120d	01-Apr-14*	29-Sep-14
ST4370	Final Vegetation/Habitat Map Revisions	110d	01-Jul-14*	31-Dec-14
ST4380	Updated Study Report Prep	89d	01-Oct-14*	02-Feb-15
ST4390	Delivery of Field Data & Final Vegatation & Habitat Maps	47d	01-Oct-14*	31-Dec-14
ST4400	Updated Study Report	0d		02-Feb-15
Riparian Vegetation Study Downstream of the Proposed Watana Dam (11.5)		**486d**	**02-Oct-12**	**02-Feb-15**
ST2250	Preparation of Riverine Physiography to Help Define Study Area	48d	02-Oct-12*	28-Dec-12
ST2270	Riparian/Wetland/Habitat Mapping & Field Plot Selection	103d	02-Jan-13	28-Jun-13
ST2271	Field Surveys	120d	02-Apr-13*	30-Sep-13
ST2600	Riparian/Wetland/Habitat Map Revisions	110d	01-Jul-13*	31-Dec-13
ST2601	Delivery of Field Data & Preliminary Riparian/Wetland/Habitat Maps	48d	01-Oct-13*	31-Dec-13
ST2610	Initial Study Report Prep	48d	28-Nov-13	03-Feb-14*
ST2620	Initial Study Report	0d		03-Feb-14*
ST5750	Riparian/Wetland/Habitat Mapping & Field Plot Selection for Remaining Unmapped Areas	103d	02-Jan-14	30-Jun-14
ST5760	Field Surveys	120d	01-Apr-14*	29-Sep-14
ST5761	Final Riparian/Wetland/Habitat Map Revisions	110d	01-Jul-14*	31-Dec-14
ST5763	Delivery of Final Field Data & Final Reparian/Wetlant/Habitat Maps	47d	01-Oct-14*	31-Dec-14
ST5764	Updated Study Report Prep	48d	27-Nov-14	02-Feb-15*
ST5765	Updated Study Report	0d		02-Feb-15*
Wetland Mapping Study (11.7)		**438d**	**02-Jan-13**	**02-Feb-15**
ST2810	Wetland Mapping & Field Plot Selection	103d	02-Jan-13*	28-Jun-13
ST2820	Field Surveys	120d	02-Apr-13*	30-Sep-13
ST2830	Wetland Map Revisions	110d	01-Jul-13*	31-Dec-13
ST2840	Initial Study Report Prep	49d	27-Nov-13	03-Feb-14*
ST2850	Initial Study Report	0d		03-Feb-14*
ST2860	Delivery of Field Data & Preliminary Wetland Map	47d	24-Oct-13	05-Feb-14
ST2870	Wetland Mapping & Field Plot Selection for Remaining Unmapped Areas	103d	02-Jan-14*	30-Jun-14
ST2880	Field Surveys	120d	01-Apr-14*	29-Sep-14
ST2900	Final Wetland Map Revisions	110d	01-Jul-14*	31-Dec-14
ST2910	Wetland Functional Analysis	110d	01-Jul-14*	31-Dec-14
ST2920	Updated Study Report Prep	49d	26-Nov-14	02-Feb-15*
ST2930	Delivery of Final Field Data & Final Wetland Map	47d	28-Nov-14	02-Feb-15
ST2940	Updated Study Report	0d		02-Feb-15*
Rare Plant Study (11.8)		**393d**	**02-Apr-13**	**02-Feb-15**
ST5770	Field Survey Site Selection	39d	02-Apr-13*	30-May-13
ST5780	Field Survey	40d	04-Jun-13*	31-Jul-13
ST5790	Data Analysis	40d	03-Sep-13*	31-Oct-13
ST5800	Initial Study Report	0d		03-Feb-14*
ST5810	Field Survey Site Selection	39d	01-Apr-14*	03-Jun-14
ST5820	Field Survey	40d	03-Jun-14*	29-Jul-14
ST5850	Data Analysis	40d	02-Sep-14*	30-Oct-14
ST5860	Updated Study Report	0d		02-Feb-15*
Invasive Plant Study (11.9)		**393d**	**02-Apr-13**	**02-Feb-15**



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SUSITNA-WATANA HYDRO

Susitna-Watana Hydroelectric Project Schedule

Activity ID	Activity Name	Rem Duration	Start	Finish
ST5870	Field Survey Site Selection	39d	02-Apr-13*	30-May-13
ST5880	Field Survey	40d	04-Jun-13*	31-Jul-13
ST5890	Data Analysis	40d	03-Sep-13*	31-Oct-13
ST5900	Initial Study Report	0d		03-Feb-14*
ST5910	Field Survey Site Selection	39d	01-Apr-14*	03-Jun-14
ST5920	Field Survey	40d	03-Jun-14*	29-Jul-14
ST5930	Data Analysis	40d	02-Sep-14*	30-Oct-14
ST5931	Updated Study Report	0d		02-Feb-15*
Recreation Resources Study (12.5)		**548d**	**02-Jul-12**	**02-Feb-15**
ST3410	Initial Study Report Prep	24d	01-Jan-14*	03-Feb-14
ST3420	Initial Study Report	0d		03-Feb-14
ST3430	Updated Study Report Prep	155d	01-Jul-14*	02-Feb-15
ST3440	Updated Study Report	0d		02-Feb-15
ST5960	Data Collection & Baseline Inventory	489d	02-Jul-12*	30-Sep-14
ST5970	Analysis	334d	02-Apr-13*	30-Sep-14
ST5980	Coordination w/ Agencies, Licensing Participants and Other Studies	316d	02-Jan-13*	30-Jun-14
ST5990	Intercept Survey Deployment	358d	15-Feb-13*	30-Sep-14
ST6000	Mail Survey Development	82d	15-Feb-13*	28-Jun-13
ST6010	Exec Interviewing & Web Survey Deployment	278d	15-Nov-12*	28-Mar-14
ST6020	Survey Data Analysis	155d	01-Jul-13*	28-Mar-14
ST6030	Impact Analysis	261d	01-Oct-13*	31-Dec-14
Aesthetic Resources Study (12.6)		**438d**	**02-Jan-13**	**02-Feb-15**
ST1180	Baseline Data Collection	334d	02-Apr-13	30-Sep-14
ST1190	Coordination w/ Agencies, Stakeholders and Disciplines	379d	02-Jan-13	30-Sep-14
ST1200	Simulation Development / Sound Modeling	307d	15-May-13*	30-Sep-14
ST1210	Impact Analysis	245d	15-Aug-13*	30-Sep-14
ST3710	Viewshed Modeling	45d	02-Jan-13*	29-Mar-13
ST3760	Initial Study Report Prep	90d	01-Oct-13*	03-Feb-14
ST3770	Initial Study Report	0d		03-Feb-14
ST3790	Updated Study Report Prep	220d	01-Apr-14*	02-Feb-15
ST3800	Updated Study Report	0d		02-Feb-15
River Recreation Flow and Access Study (12.7)		**438d**	**02-Jan-13**	**02-Feb-15**
ST1130	Field Studies	168d	02-Apr-13*	31-Dec-13
ST1150	Analysis	271d	02-Apr-13*	30-Jun-14
ST1160	Coordination w/ Agencies, Stakeholders & Disciplines	426d	02-Jan-13*	31-Dec-14
ST1170	Impact Analysis	214d	01-Oct-13*	30-Sep-14
ST3660	Initial Study Report Prep	90d	01-Oct-13*	03-Feb-14
ST3680	Initial Study Report	0d		03-Feb-14
ST3690	Updated Study Report Prep	220d	01-Apr-14*	02-Feb-15
ST3700	Updated Study Report	0d		02-Feb-15
ST6040	Baseline Data Collection	213d	02-Jan-13*	31-Dec-13
Cultural Resources Study (13.5)		**548d**	**02-Jul-12**	**02-Feb-15**
ST1370	Reconnaissance Level Field Study	62d	02-Jul-12*	28-Sep-12
ST1380	Modeling & Sample Design Development from 2012 Field Reconnaissance	93d	02-Oct-12	29-Mar-13
ST1390	Pre-Field Prep	52d	15-Feb-13*	15-May-13
ST1400	Additional Modeling from 2013 Field Study Results	93d	01-Oct-13*	28-Mar-14
ST1410	Pre-Field Preparation	52d	18-Feb-14*	15-May-14
ST3990	Archeological Field Studies - Inventory	92d	16-May-13	30-Sep-13

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Susitna-Watana Hydroelectric Project Schedule

Activity ID	Activity Name	Rem Duration	Start	Finish
ST4010	Archeological Field Studies - Initiation of Evaluation	62d	01-Jul-13	30-Sep-13
ST4030	Ethnogeographic Study	73d	02-Jan-13*	15-May-13
ST4040	Ethnogeographic Field Work	121d	16-May-13	15-Nov-13*
ST4050	Draft Ethnogeographic Study Report	48d	01-Oct-13*	31-Dec-13
ST4070	Initial Study Report Prep	90d	01-Oct-13*	03-Feb-14
ST4080	Initial Study Report	0d		03-Feb-14
ST4190	Field Studies - Inventory	63d	16-May-14	15-Aug-14
ST4200	Field Studies - Evaluation	63d	16-May-14	15-Aug-14
ST4201	Updated Study Report Prep	220d	01-Apr-14*	02-Feb-15
ST4202	Updated Study Report	0d		02-Feb-15
Paleontological Resources Study (13.6)		**424d**	**01-Feb-13**	**02-Feb-15**
ST1441	Applying GPS Based Classification	31d	01-Feb-13*	29-Mar-13
ST1460	Systematic Testing in Areas of High Potential	43d	01-Jul-13*	30-Aug-13
ST1470	Initial Study Report	0d		03-Feb-14*
ST1480	Updated Study Report	0d		02-Feb-15*
Subsistence Resources Study (14.5)		**603d**	**03-Apr-12**	**27-Jan-15**
ST1760	Subsistence Study Plan	168d	03-Apr-12*	28-Dec-12
ST1770	Task 1: Compilation of Exis. Data	130d	01-Jun-12*	28-Dec-12
ST1800	Task 2: ADF&G Household Surveys - Year 2	46d	02-Jan-14*	01-Apr-14
ST1810	Task 2: ADF&G Reporting & Community Review - Year 2	213d	02-Jan-14	31-Dec-14
ST2960	Task 2: ADF&G Household Surveys Pre-Field Planning - Year 1	103d	02-Jan-13	28-Jun-13
ST2970	Task 2: ADF&G Household Surveys - Year 1	45d	02-Jan-13	29-Mar-13
ST2980	Task 2: ADF&G Reporting & Community Review - Year 1	213d	02-Jan-13	31-Dec-13
ST2990	Task 2: ADF&G Household Surbeys Pre-Field Planning - Year 2	47d	02-Oct-13	31-Dec-13
ST3010	Task 3: Household Surveys in Nonsubsistence Areas	45d	02-Jan-13	29-Mar-13
ST3020	Task 5:Traditional & Local Knowledge Interviews	103d	02-Jan-13	28-Jun-13
ST3030	Task 1-3, 5: Prepare 2013 Study Report	110d	01-Jul-13*	31-Dec-13
ST3040	Revise Study Plans	41d	15-Nov-13*	14-Feb-14
ST3070	Task 4: Subsistence Mapping Inteviews	73d	02-Jan-14	15-May-14
ST3080	Task 4-5: Additional 2014 Subsistence Data Collection (as needed)	103d	02-Jan-14	30-Jun-14
ST3090	Task 2-5: Prepare 2015 Final Updated Study Report & Community Reviews	110d	01-Jul-14	31-Dec-14
ST3100	Initial Study Report	0d		03-Feb-14*
ST3101	Updated Sudy Report	5d		27-Jan-15*
Regional Economic Evaluation Study (15.5)		**438d**	**02-Jan-13**	**02-Feb-15**
ST1490	Gather/Review Existing Information	45d	02-Jan-13*	29-Mar-13
ST1500	Document Existing Conditions	58d	02-Apr-13	28-Jun-13
ST1510	Develop Reasonable Foreseeable Future Action Assumptions	62d	01-Jul-13	30-Sep-13
ST1520	Inital Regional Economic Evaluation Study Report	48d	01-Oct-13	31-Dec-13
ST1530	Initial Study Report	0d		03-Feb-14*
ST1540	Incorporate Information from Other Studies	135d	02-Jan-14*	14-Aug-14
ST1550	Updated Regional Econoimic Evaluation Study Report	78d	15-Aug-14	31-Dec-14
ST1570	Updated Study Report	0d		02-Feb-15*
Social Conditions & Public Goods & Services Study (15.6)		**438d**	**02-Jan-13**	**04-Feb-15**
ST1590	Gather/Review Existing Information	45d	02-Jan-13*	29-Mar-13
ST1600	Document Existing Conditions	58d	02-Apr-13	28-Jun-13
ST1610	Stakeholder Interviews	110d	01-Jul-13	31-Dec-13
ST1620	Initial Social Conditions & Public Good & Services Study Report	60d	13-Sep-13	31-Dec-13
ST1640	Initial Study Report	0d		03-Feb-14*

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Note: Please refer to the individual study plans in Sections 4 through 16 for a discussion and figures explaining the relationship between studies.

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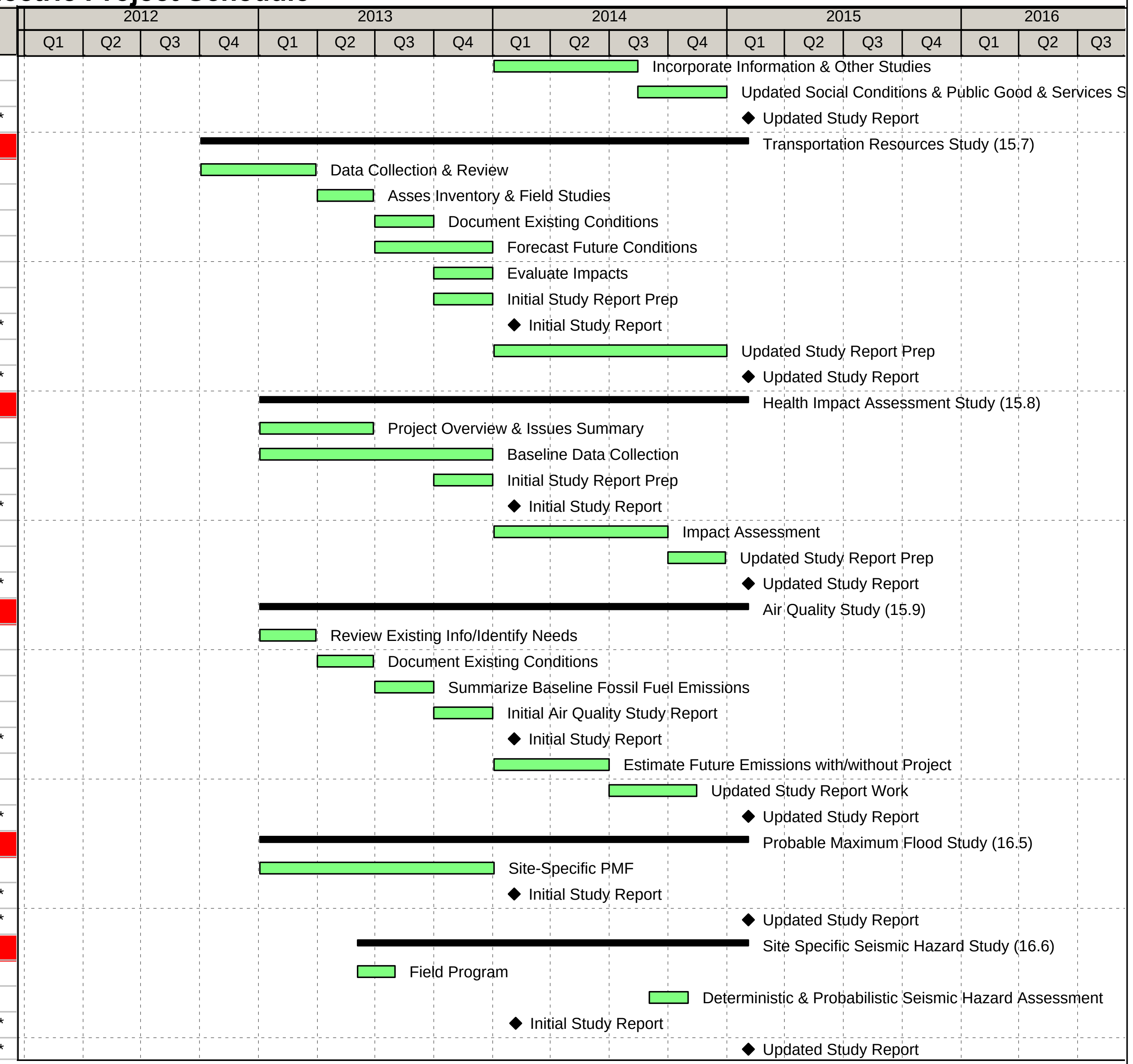
Susitna-Watana Hydroelectric Project Schedule

Activity ID	Activity Name	Rem Duration	Start	Finish
ST1650	Incorporate Information & Other Studies	135d	02-Jan-14*	14-Aug-14
ST1660	Updated Social Conditions & Public Good & Services Study Report	78d	15-Aug-14	31-Dec-14
ST1750	Updated Study Report	0d		04-Feb-15*
Transportation Resources Study (15.7)		486d	02-Oct-12	02-Feb-15
ST1820	Data Collection & Review	93d	02-Oct-12*	29-Mar-13
ST1830	Asses Inventory & Field Studies	58d	02-Apr-13	28-Jun-13
ST1840	Document Existing Conditions	62d	01-Jul-13	30-Sep-13
ST1860	Forecast Future Conditions	110d	01-Jul-13	31-Dec-13
ST1870	Evaluate Impacts	48d	01-Oct-13*	31-Dec-13
ST1880	Initial Study Report Prep	48d	01-Oct-13	31-Dec-13
ST1900	Initial Study Report	0d		03-Feb-14*
ST1910	Updated Study Report Prep	213d	02-Jan-14*	31-Dec-14
ST3300	Updated Study Report	0d		02-Feb-15*
Health Impact Assessment Study (15.8)		438d	02-Jan-13	02-Feb-15
ST1920	Project Overview & Issues Summary	103d	02-Jan-13*	28-Jun-13
ST1930	Baseline Data Collection	213d	02-Jan-13*	31-Dec-13
ST1940	Initial Study Report Prep	48d	01-Oct-13	31-Dec-13
ST1950	Initial Study Report	0d		03-Feb-14*
ST1960	Impact Assessment	166d	02-Jan-14*	30-Sep-14
ST1980	Updated Study Report Prep	46d	01-Oct-14	30-Dec-14
ST2030	Updated Study Report	0d		02-Feb-15*
Air Quality Study (15.9)		438d	02-Jan-13	02-Feb-15
ST1220	Review Existing Info/Identify Needs	45d	02-Jan-13*	29-Mar-13
ST1240	Document Existing Conditions	58d	02-Apr-13	28-Jun-13
ST1250	Summarize Baseline Fossil Fuel Emissions	62d	01-Jul-13	30-Sep-13
ST1270	Initial Air Quality Study Report	48d	01-Oct-13*	31-Dec-13
ST1280	Initial Study Report	0d		03-Feb-14*
ST1290	Estimate Future Emissions with/without Project	103d	02-Jan-14*	30-Jun-14
ST1360	Updated Study Report Work	91d	01-Jul-14	14-Nov-14
ST3860	Updated Study Report	0d		02-Feb-15*
Probable Maximum Flood Study (16.5)		438d	02-Jan-13	02-Feb-15
ST2300	Site-Specific PMF	215d	02-Jan-13*	03-Jan-14
ST2310	Initial Study Report	0d		03-Feb-14*
ST2320	Updated Study Report	0d		02-Feb-15*
Site Specific Seismic Hazard Study (16.6)		354d	04-Jun-13	04-Feb-15
ST2330	Field Program	40d	04-Jun-13*	31-Jul-13
ST2350	Deterministic & Probabilistic Seismic Hazard Assessment	41d	02-Sep-14*	31-Oct-14
ST2360	Initial Study Report	0d		05-Feb-14*
ST2370	Updated Study Report	0d		04-Feb-15*



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SUSITNA-WATANA HYDROELECTRIC PROJECT NO. 14241
Table of Study Predecessor and Successor Activities

Activity ID	Activity Name	Predecessors	Successors
	Geology & Soils Characterization Study (4.5)		
ST4630	Comprehensive Investigations (Dam Site & Reservoir Area)		ST4630 Geology & Soils Characterization Study - Comprehensive Investigations (Dam Site & Reservoir Area) feeds into ST2360 Site Specific Seismic Hazard Study - Initial Study Report on September 30 , 2013. ST4630 Geology & Soils Characterization Study - Comprehensive Investigations (Dam Site & Reservoir Area) feeds into ST1460 Paleontological Resources Study - Systematic Testing in Areas of High Potential on May 31, 2013. ST4630 Geology & Soils Characterization Study - Comprehensive Investigations (Dam Site & Reservoir Area) feeds into ST3160 Bat Distribution & Habitat Use Study - Acoustic Monitoring - 2013 on May 31, 2013. ST4630 Geology & Soils - Comprehensive Investigations feeds into ST4050 Cultural Resources Study - Draft Ethnogeographic Study Report on October 1, 2013. ST4360 Geology & Soils Study Comprehensive Investigations feeds into Vegetation & Wildlife Habitat Mapping Study (Upper & Middle Susitna Basin) on October 1, 2013.
ST4660	Comprehensive Investigations (Access Road & Transmission Line)		ST4660 Geology & Soils Characterization Study - Comprehensive Investigations (Access Road & Transmission Line) feeds into ST1480 Paleontological Resources Study - Updated Study Report on September 1, 2014.
ST4661	Initial Study Report		
ST4662	Updated Study Report		
	Baseline Water Quality Study (5.5)		
ST4680	MET Station Installation & Data Collection		
ST4690	Thermal Imaging		
ST4720	Data Analysis & Management		ST4720 Baseline Water Quality Study - Data Analysis & Management feeds into ST1930 Health Impact Assessment Study - Baseline Data Collection on February 1, 2013.
ST4730	Fish Tissue Sampling		
ST4740	Sediment Sampling		
ST4750	Water Quality Monitoring	ST4860 Water Quality Modeling Study - Coordination w/ Water Quality Data Collection & Analysis is linked to the start of ST4750 Baseline Water Quality Study - Water Quality Monitoring. ST4840 Water Quality Modeling Study - Model Calibration (Water Quality) feeds into ST4750 Baseline Water Quality Study - Water Quality Monitoring at the end of December 2013. ST4960 Mercury Assessment and Potential for Bioaccumulation Study - Water Quality Monitoring (Monthly) is linked to the start of ST4750 Baseline Water Quality Study - Water Quality Monitoring. ST5450 Groundwater Study - Water Quality in Selected Habitats feeds into ST4750 Baseline Water Quality Study - Water Quality Monitoring.	ST4750 Baseline Water Quality Study - Water Quality Monitoring feeds into ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 on October 1, 2013. ST4750 Baseline Water Quality Study - Water Quality Monitoring feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on December 31, 2013. ST4750 Baseline Water Quality Study - Water Quality Monitoring feeds into ST4150 River Productivity Study - General Habitat Suitability Criteria and ST1307 on December 31, 2013. ST4750 Baseline Water Quality Study - Water Quality Monitoring feeds into ST4840 Water Quality Monitoring Study - Model Calibration (Water Quality) at the end of September 2013 (1/2 way along the study). ST4750 Baseline Water Quality Study - Water Quality Monitoring feeds into ST5460 Groundwater Study - Aquatic Habitat/Surface Water Interactions on October 31, 2013.
ST4760	Deployment of Temp Monitoring Apparatus		
ST4770	QAPP/SAP Preparation & Review		
ST4771	Initial Study Report		
ST4772	Updated Study Report		
	Water Quality Modeling Study (5.6)		
ST4800	Generate Results for Operational Scenarios	ST4180 River Productivity Study - Data Analysis & Reporting feeds into ST4800 Water Quality Modeling Study - Generate Results for Operational Scenarios on July 1, 2014.	
ST4810	Verification Runs		
ST4820	Re-Calibration Adjustments		

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Activity ID	Activity Name	Predecessors	Successors
ST4840	Model Calibration (Water Quality)	ST4750 Baseline Water Quality Study - Water Quality Monitoring feeds into ST4840 Water Quality Monitoring Study - Model Calibration (Water Quality) at the end of September 2013 (1/2 way along the study). ST4500 Fish & Aquatics Instream Flow Study - Hydraulic Flow Routing feeds into ST4840 Water Quality Monitoring Study - Model Calibration (Water Quality) on July 1, 2013.	ST4840 Water Quality Monitoring Study - Model Calibration (Water Quality) feeds into ST3620 Cook Inlet Beluga Whale Study - Initial Study Report Prep on December 31, 2013. ST4840 Water Quality Monitoring Study - Model Calibration (Water Quality) feeds into ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 on October 1, 2013. ST4840 Water Quality Monitoring Study - Model Calibration (Water Quality) feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on December 31, 2013. ST4840 Water Quality Modeling Study - Model Calibration (Water Quality) feeds into ST4570 Fish & Aquatics Instream Flow Study - Hydraulic Model Integration & Calibration at the end of December 2013. ST4840 Water Quality Modeling Study - Model Calibration (Water Quality) feeds into ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling at the end of December 2013. ST4840 Water Quality Modeling Study - Model Calibration (Water Quality) feeds into ST2530 Ice Processes in the Susitna River Study - Proposed Condition 1D Model Development at the end of December 2013. ST4840 Water Quality Modeling Study - Model Calibration (Water Quality) will feeds into ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results at the end of September 2013.
ST4850	Model Evaluation/Selection		ST4850 Water Quality Modeling Study - Model Evaluation/Selection feeds into ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options on December 31, 2013.
ST4860	Coordination w/ Water Quality Data Collection & Analysis		ST4860 Water Quality Modeling Study - Coordination w/ Water Quality Data Collection & Analysis is linked to the start of ST4750 Baseline Water Quality Study - Water Quality Monitoring.
ST4861	Initial Study Report		
ST4862	Updated Study Report		
	Mercury Assessment and Potential for Bioaccumulation Study (5.7)		
ST4870	Soil Vegetation Sampling		
ST4880	Sediment Sampling		
ST4900	Avian Furbearer Studies		
ST4910	Fish Tissue Sampling		
ST4920	Data Analysis & Management	ST5560 Aquatic Furbearer Abundance & Habitat Use Study - Initial Study Report feeds into ST4920 Mercury Assessment and Potential for Bioaccumulation Study - Data Analysis & Management on March 31, 2014. ST1680 Surveys of Eagles & Other Raptors Study - Initial Study Report feeds into ST4920 Mercury Assessment and Potential for Bioaccumulation Study - Data Analysis & Management on April 1, 2014. ST4310 Waterbird Migration, Breeding & Habitat Study - Data Analysis - 2013 feeds into ST4920 Mercury Assessment and Potential for Bioaccumulation Study - Data Analysis & Management on November 30, 2014. ST1990 Landbird and Shorebird Migration, Breeding, and Habitat Use Study - Data Analysis - 2013 feeds into ST4920 Mercury Assessment and Potential for Bioaccumulation Study - Data Analysis & Management on October 31, 2014.	ST4920 Mercury Assessment and Potential for Bioaccumulation Study - Data Analysis & Management feeds into ST2910 Wetland Mapping Study - Wetland Functional Analysis at the end of March 2014 .
ST4940	Follow Up Studies (as needed)		
ST4960	Water Quality Monitoring (Monthly)		ST4960 Mercury Assessment and Potential for Bioaccumulation Study - Water Quality Monitoring (Monthly) is linked to the start of ST4750 Baseline Water Quality Study - Water Quality Monitoring.
ST4961	Initial Study Report		
ST4962	Updated Study Report		
	Geomorphology Study (6.5)		
ST4970	Initial Geomorphic Reach Delineation/ Finalize Delineation		ST4970 Geomorphology Study - Initial Geomorphic Reach Delineation/Finalize Delineation feeds into ST3460 Characterization & Mapping of Aquatic Habitats Study - Data Collection - 2012-13 on March 1, 2013. ST4970 Geomorphology Study - Initial Geomorphic Reach Delineation/Finalize Delineation feeds into ST3310 Study of Fish Distribution & Abundance (Middle & Lower Susitna River) - Study Site Selection on January 1, 2013. ST4970 Geomorphology Study - Initial Geomorphic Reach Delineation/Finalize Delineation feeds into ST2950 Study of Fish Distribution & Abundance in the Upper Susitna River - Study Site Selection on January 1, 2013. ST4970 Geomorphology Study - Initial Geomorphic Reach Delineation/Finalize Delineation feeds into ST3000 Glacial & Runoff Changes Study - Fish and Aquatics IFS study area selection on January 31, 2013.
ST4980	Identify and Map Paleo Geomorphic Features & Geology		ST4980 Geomorphology Study - Identify and Map Paleo Geomorphic Features & Geology feeds into ST1460 Paleontological Resources Study - Systematic Testing in Areas of High Potential on June 1, 2013.
ST4990	Determine Morphometric Parameters		

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Activity ID	Activity Name	Predecessors	Successors
ST5010	Identify Key Governing Geomorphic Process		ST5010 Geomorphology Study - Identify Key Governing Geomorphic Process feeds into ST4120 Cultural Resources Study - Field Studies - Evaluation on March 31, 2013.
ST5020	Acquire Aerial Photo		
ST5030	Digitize 1980s Habitat and Geomorphic Features		
ST5040	Digitize 2012 Habitat and Geomorphic Features		
ST5050	Assess Habitat Area Change 1980-2012		
ST5060	Assess Channel Change 1980-2012		ST5060 Geomorphology Study - Assess Channel Change 1980-2012 feeds into ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling on March 1, 2014.
ST5070	Initial & Final Flow Assessment		
ST5080	Determine Effective Discharge & Characterization of Bed Mobilization		ST5080 Geomorphology Study - Determine Effective Discharge & Characterization of Bed Mobilization feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on December 31, 2013. ST5080 Geomorphology Study - Determine Effective Discharge & Characterization of Bed Mobilization feeds into ST5270 Fluvial Geomorphology Modeling Below Watana Dam Study - 1D Model Development & Calibration on October 1, 2013.
ST5090	Initial/Detailed Sediment Balance	ST4500 Fish & Aquatics Instream Flow Study - Hydraulic Flow Routing feeds into ST5090 Geomorphology Study - Initial/Detailed Sediment Balance on June 1, 2013. ST5090 Geomorphology Study - Initial/Detailed Sediment Balance feeds into ST5270 Fluvial Geomorphology Modeling Below Watana Dam Study - 1D Model Development & Calibration on October 1, 2013.	
ST5100	Recon. Level Assessment of Potential Lower River Channel Change		
ST5120	Large Woody Debris	ST1080 Riparian Instream Flow Study - Develop Groundwater/Surfacewater Modeling feeds into ST5120 Geomorphology Study - Large Woody Debris on July 1, 2014.	
ST5130	Reservoir Geomorphology	ST5400 Groundwater Study - Watana Dam/Reservoir feeds into ST5130 Geomorphology Study - Reservoir Geomorphology on Nov 1, 2013. ST3930 Glacial & RunOff Changes Study - Hydrological & Glacier Melt Model Development feeds into ST5130 Geomorphology Study - Reservoir Geomorphology at the end of March 2014.	ST5130 Geomorphology Study - Reservoir Geomorphology feeds into ST1400 Cultural Resources Study - Additional Modeling from 2013 Field Study Results on December 31, 2013. ST5130 Geomorphology Study - Reservoir Geomorphology feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on December 31, 2013.
ST5140	Geomorphology of Stream X-ings Along Access & Trans Corridor		
ST5150	Integration & Support of Interpreting Fluv. Geomorphology Modeling Results	ST4840 Water Quality Modeling Study - Model Calibration (Water Quality) will feeds into ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results at the end of September 2013. ST2590 Ice Processes in the Susitna River Study - Freeze Up Reconnaissance feeds into ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results on May 1 2013. ST2580 Ice Processes in the Susitna River Study - Break Up Reconnaissance feeds into ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results on May 1 2013. ST2530 Ice Processes in the Susitna River Study - Proposed Condition 1D Model Development feeds into ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results on March 31, 2014.	ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results feeds into ST3600 Characterization & Mapping of Aquatic Habitats Study - Data Collection - 2014 on April 1, 2014. ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results feeds into ST6030 Recreation Resources Study - Impact Analysis on March 1, 2014. ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results feeds into ST2600 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Riparian/Wetland/Habitat Map Revisions on October 1, 2013. ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results feeds into ST5270 Fluvial Geomorphology Modeling Below Watana Dam Study - 1D Model Development & Calibration on October 1, 2013. ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results feeds into ST1170 River Recreation Flow and Access Study - Impact Analysis on August 1, 2014.
ST5180	Develop Geomorphic System/ Finalize Classification System		
ST5181	Initial Study Report		
ST5182	Updated Study Report		
	Fluvial Geomorphology Modeling Below Watana Dam Study (6.6)		
ST5200	Selection of 1D and 2D Models		
ST5210	Selection of Focus Area		
ST5230	Coordination w/ Other Studies on Modeling Needs Including Focus Areas		
ST5240	2013 Field Data Collection		
ST5250	Supplemental Field Data Collection 2014		
ST5260	Coordinate w/ Other Studies on Processes Modeled		ST5260 Fluvial Geomorphology Modeling Below Watana Dam Study - Coordinate w/ Other Studies on Processes Modeled feeds into ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 on October 1, 2013.

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Activity ID	Activity Name	Predecessors	Successors
ST5270	1D Model Development & Calibration	ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results feeds into ST5270 Fluvial Geomorphology Modeling Below Watana Dam Study - 1D Model Development & Calibration on October 1, 2013. ST5080 Geomorphology Study - Determine Effective Discharge & Characterization of Bed Mobilization feeds into ST5270 Fluvial Geomorphology Modeling Below Watana Dam Study - 1D Model Development & Calibration on October 1, 2013. ST5090 Geomorphology Study - Initial/Detailed Sediment Balance feeds into ST5270 Fluvial Geomorphology Modeling Below Watana Dam Study - 1D Model Development & Calibration on October 1, 2013.	
ST5280	Perform 1D Modeling of Exis Conditions & Initial Proj Run		ST5280 Fluvial Geomorphology Modeling Below Watana Dam Study - Perform 1D Modeling of Exis Conditions & Initial Proj Run feeds into ST3652 Cook Inlet Beluga Whale Study on March 31, 2014. ST5280 Fluvial Geomorphology Modeling Below Watana Dam Study - Perform 1D Modeling of Exis Conditions & Initial Proj Run feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on January 31, 2013. ST5280 Fluvial Geomorphology Modeling Below Watana Dam Study - Perform 1D Modeling of Exis Conditions & Initial Proj Run feeds into ST1080 Riparian Instream Flow Study - Develop Groundwater/Surfacewater Modeling on December 31, 2013. ST5280 Fluvial Geomorphology Modeling Below Watana Dam Study - Perform 1D Modeling of Exis Conditions & Initial Proj Run feeds into ST4570 Fish & Aquatics Instream Flow Study - Hydraulic Model Integration & Calibration on April 1, 2014.
ST5290	Reevaluate D/S Study Limits Based on 1D Results		
ST5300	2D Model Development & Calibration		
ST5310	Perform 2D Modeling Existing Conditions		ST5310 Fluvial Geomorphology Modeling Below Watana Dam Study - Perform 2D Modeling Existing Conditions feeds into ST4570 Fish & Aquatics Instream Flow Study - Hydraulic Model Integration & Calibration on October 1, 2014.
ST5320	Perform 1D Modeling of Alternate Scenarios		
ST5340	Perform 2D Modeling of Alternate Scenarios		
ST5350	Post Process & Provide Model Results to Other Studies		
ST5360	Interpretation of Channel Change & Integration w/ Other Studies		
ST5370	Initial Study Report		
ST5372	Updated Study Report		
		Groundwater Study (7.5)	
ST5380	Existing Data Synthesis		
ST5390	Geohydrologic Process-Domains and Terrain		
ST5400	Watana Dam/Reservoir		ST5400 Groundwater Study - Watana Dam/Reservoir feeds into ST5130 Geomorphology Study - Reservoir Geomorphology on Nov 1, 2013.
ST5410	Upwelling/Springs Broadscale Mapping		ST5410 Groundwater Study - Upwelling/Springs Broadscale Mapping feeds into ST4540 Fish & Aquatics Instream Flow Study - Collect Physical & Hydraulic Data for Habitat Modeling on October 1, 2013.
ST5420	Riparian Veg Dependency on Surface/Groundwater Interactions		ST5420 Groundwater Study - Riparian Veg Dependency on Surface/Groundwater Interactions feeds into ST1030 Riparian Instream Study - Implement Riparian Groundwater/Surfacewater Installation & Sampling on October 1, 2013.
ST5430	Aquatic Habitat/Groundwater/Surface Water Interactions		
ST5450	Water Quality in Selected Habitats		ST5450 Groundwater Study - Water Quality in Selected Habitats feeds into ST4540 Fish & Aquatics Instream Flow Study - Collect Physical & Hydraulic Data for Habitat Modeling on October 1, 2013. ST5450 Groundwater Study - Water Quality in Selected Habitats feeds into ST4750 Baseline Water Quality Study - Water Quality Monitoring.
ST5460	Winter Ground/Surface Water Interactions	ST4750 Baseline Water Quality Study - Water Quality Monitoring feeds into ST5460 Groundwater Study - Aquatic Habitat/Surface Water Interactions on October 31, 2013. ST2630 Ice Processes in the Susitna River Study - Open Lead Surveys, Ice Thickness & Elevation (2013) and ST2730 Ice Processes in the Susitna River Study - Open Lead Surveys, Ice Thickness & Elevation (2014) feeds into ST5460 Groundwater Study - Aquatic Habitat/Surface Water Interactions on March 1, 2013 and March 1, 2014, respectively.	ST5460 Groundwater Study - Winter Ground/Surface Water Interactions feeds into ST1080 Riparian Instream Flow Study - Develop Groundwater/Surfacewater Modeling on July 1, 2014.
ST5470	Shallow Groundwater Users		ST5470 Groundwater Study - Shallow Groundwater Users feeds into ST1960 Health Impact Assessment Study - Impact Assessment on March 1, 2013.
ST5480	Initial Study Plan		
ST5490	Updated Study Report		

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Activity ID	Activity Name	Predecessors	Successors
Ice Processes in the Susitna River Study (7.6)			
ST2510	Existing Condition 1D Model Development		ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST1870 Transportation Resources Study - Evaluate Impacts on December 1, 2013. ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST3040 Subsistence Resources Study - Revise Study Plans on December 31, 2013. ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST1210 Aesthetic Resources Study - Impact Analysis on November 1, 2013. ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST6030 Recreation Resources Study - Impact Analysis on December 31, 2013. ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 on October 1, 2013. ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on December 31, 2013. ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST1080 Riparian Instream Flow Study - Develop Groundwater/Surfacewater Modeling on December 31, 2013. ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling at the end of February 2013.
ST2520	Intensive Site Models		
ST2530	Proposed Condition 1D Model Development	ST4840 Water Quality Modeling Study - Model Calibration (Water Quality) feeds into ST2530 Ice Processes in the Susitna River Study - Proposed Condition 1D Model Development at the end of December 2013.	ST2530 Ice Processes in the Susitna River Study - Proposed Condition 1D Model Development feeds into ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results on March 31, 2014.
ST2570	Open Lead Surveys, Ice Thickness & Elevation (2012)		
ST2580	Break Up Reconnaissance		ST2580 Ice Processes in the Susitna River Study - Break Up Reconnaissance feeds into ST4270 Waterbird Migration, Breeding & Habitat Study - Spring Migration/Breeding-Pair Surveys - 2013 on May 1, 2013. ST2580 Ice Processes in the Susitna River Study -Break Up Reconnaissance feeds into ST1080 Riparian Instream Flow Study - Develop Groundwater/Surfacewater Modeling on March 1, 2013. ST2580 Fluvial Geomorphology Modeling Below Watana Dam Study - Perform 1D Modeling of Exis Conditions & Initial Proj Run feeds into ST5220 Dall's Sheep Distribution and Abundance Study - Aerial Surveys - 2013 on March 1, 2013. ST2580 Fluvial Geomorphology Modeling Below Watana Dam Study - Perform 1D Modeling of Exis Conditions & Initial Proj Run feeds into ST3000 Glacial & Runoff Changes Study - Fish and Aquatics IFS study area selection. ST2580 Ice Processes in the Susitna River Study - Break Up Reconnaissance feeds into ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results on May 1, 2013.
ST2590	Freeze Up Reconnaissance	ST3460 Characterization and Mapping of Aquatic Habitats Study - Data Collection - 2012-13 feeds into ST2950 Ice Processes in the Susitna River Study - Freeze Up Reconnaissance on January 1, 2013. ST4970 Geomorphology Study - Initial Geomorphic Reach Delineation/Finalize Delineation feeds into ST2950 Ice Processes in the Susitna River Study - Freeze Up Reconnaissance on January 1, 2013.	ST2590 Ice Processes in the Susitna River Study - Freeze Up Reconnaissance feeds into ST1080 Riparian Instream Flow Study - Develop Groundwater/Surfacewater Modeling on March 1, 2013. ST2590 Fluvial Geomorphology Modeling Below Watana Dam Study - Reevaluate D/S Study Limits Based on 1D Results feeds into ST5220 Dall's Sheep Distribution and Abundance Study - Aerial Surveys - 2013 on March 1, 2013. ST2590 Fluvial Geomorphology Modeling Below Watana Dam Study - Reevaluate D/S Study Limits Based on 1D Results feeds into ST3000 Glacial & Runoff Changes Study - Fish and Aquatics IFS study area selection. ST2590 Ice Processes in the Susitna River Study - Freeze Up Reconnaissance feeds into ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results on May 1, 2013.
ST2630	Open Lead Surveys, Ice Thickness & Elevation (2013)		ST2630 Ice Processes in the Susitna River Study - Open Lead Surveys, Ice Thickness & Elevation (2013) feeds into ST5460 Groundwater Study - Aquatic Habitat/Surface Water Interactions on March 1, 2013 and March 1, 2014, respectively.
ST2640	Break Up Reconnaissance		
ST2650	Freeze Up Reconnaissance		
ST2710	Initial Study Report Prep		ST2710 Ice Processes in the Susitna River Study - Initial Study Report Prep feeds into ST3652 Cook Inlet Beluga Whale Study on February 2, 2014.
ST2720	Initial Study Report		
ST2730	Open Lead Surveys, Ice Thickness & Elevation 2014		
ST2740	Break Up Reconnaissance		
ST2770	Updated Study Report		
Glacial & RunOff Changes Study (7.7)			
ST3840	Review Existing Literature		

Note: All dates in this table are estimates, subject to change. The dates and relationships, produced from Primavera Software, will be continually updated during study plan implementation.

Activity ID	Activity Name	Predecessors	Successors
ST3850	Process Remote Sensing Imagery		
ST3870	Spring Fieldwork		
ST3880	Fall Fieldwork		
ST3900	Analyze Glacier Mass Balance & Meteorological Data		
ST3910	Glacial Extent Variation		
ST3930	Hydrological & Glacier Melt Model Development		ST3930 Glacial & RunOff Changes Study - Hydrological & Glacier Melt Model Development feeds into ST5130 Geomorphology Study - Reservoir Geomorphology at the end of March 2014.
ST3940	Hydrological & Glacier Melt Model Calibration/Validation		
ST3960	Initial Study Report		
ST3970	Updated Study Report		
Fish & Aquatics Instream Flow Study (8.5)			
ST3000	Study Area Selection	ST2580 fluvial Geomorphology Modeling Below Watana Dam Study - Perform 1D Modeling of Exis Conditions & Initial Proj Run and ST2590 fluvial Geomorphology Modeling Below Watana Dam Study - Reevaluate D/S Study Limits Based on 1D Results feeds into ST3000 Glacial & Runoff Changes Study - Fish and Aquatics IFS study area selection. ST4970 Geomorphology Study - Initial Geomorphic Reach Delineation/Finalize Delineation and ST3460 Characterization and Mapping of Aquatic Habitats Study - Data Collection - 2012-13 feeds into ST3000 Glacial & Runoff Changes Study - Fish and Aquatics IFS study area selection on January 31, 2013.	
ST3110	Review of 1980s Data & Information		
ST3220	Model Selection by Habitat Type		
ST4500	Hydraulic Flow Routing		ST4500 Fish & Aquatics Instream Flow Study - Hydraulic Flow Routing feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on December 31, 2013. ST4500 Fish & Aquatics Instream Flow Study - Hydraulic Flow Routing feeds into ST5090 Geomorphology Study - Initial/Detailed Sediment Balance on June 1, 2013. ST4500 Fish & Aquatics Instream Flow Study - Hydraulic Flow Routing feeds into ST4840 Water Quality Monitoring Study - Model Calibration (Water Quality) on July 1, 2013.
ST4510	Hydrology		
ST4520	Periodicity	ST3460 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Field Surveys feeds into ST4520 Fish & Aquatics Instream Flow Study - Periodicity on August 31, 2013.	ST4520 Fish & Aquatics Instream Flow Study - Periodicity feeds into ST3480 Aquatic Furbearer Abundance & Habitat Use Study - Aerial Survey of Muskrat Pushups on March 31, 2013.
ST4530	HSC/HCI Fish: Field Data Collection	ST5410 Groundwater Study - Upwelling/Springs Broadscale Mapping feeds into ST4530 Fish & Aquatics Instream Flow Study - HSC/HCI Fish: Field Data Collection on October 1, 2013. ST4360 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Field Surveys feeds into ST4530 Fish & Aquatics Instream Flow Study - HSC/HCI Fish: Field Data Collection on December 31, 2013. ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST4530 Fish & Aquatics Instream Flow Study - HSC/HCI Fish: Field Data Collection on December 31, 2013.	ST4530 Fish & Aquatics Instream Flow Study - HSC/HCI Fish: Field Data Collection feeds into ST4540 Fish & Aquatics Instream Flow Study - Collect Physical & Hydraulic Data for Habitat Modeling on April 1, 2013 and December 31, 2013.
ST4540	Collect Physical & Hydraulic Data for Habitat Modeling	ST5450 Groundwater Study - Water Quality in Selected Habitats feeds into ST4540 Fish & Aquatics Instream Flow Study - Collect Physical & Hydraulic Data for Habitat Modeling on October 1, 2013. ST4530 Fish & Aquatics Instream Flow Study - HSC/HCI Fish: Field Data Collection feeds into ST4540 Fish & Aquatics Instream Flow Study - Collect Physical & Hydraulic Data for Habitat Modeling on April 1, 2013 and December 31, 2013. ST5410 Groundwater Study - Upwelling/Springs Broadscale Mapping feeds into ST4540 Fish & Aquatics Instream Flow Study - Collect Physical & Hydraulic Data for Habitat Modeling on October 1, 2013. ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 feeds into ST4540 Fish & Aquatics Instream Flow Study - Collect Physical & Hydraulic Data for Habitat Modeling on May 31, 2014.	Instream Flow Study - Collect Physical & Hydraulic Data for Habitat Modeling feeds into ST4750 Baseline Water Quality Study - Water Quality Monitoring.

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Activity ID	Activity Name	Predecessors	Successors
ST4550	Coordinate with Other Disciplines Quality Data Collection & Modeling	ST4840 Water Quality Modeling Study - Model Calibration (Water Quality) feeds into ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling at the end of December 2013. ST5060 Geomorphology Study - Assess Channel Change 1980-2012 feeds into ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling on March 1, 2014. ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling at the end of February 2013.	ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling feeds into ST1870 Transportation Resources Study - Evaluate Impacts on December 1, 2013. ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling feeds into ST4330 Waterbird Migration, Breeding & Habitat Study - Brood Surveys - 2014 on October 1, 2013. ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling feeds into ST3620 Cook Inlet Beluga Whale Study - Initial Study Report Prep on December 31, 2013. ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling feeds into ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 on October 1, 2013. ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling feeds into ST3950 Analysis of Fish Harvest in (and) D/S of the Susitna-Watana Hydroelectric Project on December 31, 2013. ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling feeds into ST1080 Riparian Instream Flow Study - Develop Groundwater/Surfacewater Modeling on December 31, 2013.
ST4570	Hydraulic Model Integration & Calibration	ST5280 Fluvial Geomorphology Modeling Below Watana Dam Study - Perform 1D Modeling of Exis Conditions & Initial Proj Run feeds into ST4570 Fish & Aquatics Instream Flow Study - Hydraulic Model Integration & Calibration on April 1, 2014. ST5310 Fluvial Geomorphology Modeling Below Watana Dam Study - Perform 2D Modeling Existing Conditions feeds into ST4570 Fish & Aquatics Instream Flow Study - Hydraulic Model Integration & Calibration on October 1, 2014. ST3381 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Final Data Analysis feeds into ST4570 Fish & Aquatics Instream Flow Study - Hydraulic Model Integration & Calibration on October 1, 2014. ST4840 Water Quality Modeling Study - Model Calibration (Water Quality) feeds into ST4570 Fish & Aquatics Instream Flow Study - Hydraulic Model Integration & Calibration at the end of December 2013.	ST4570 Fish & Aquatics Instream Flow Study - Hydraulic Model Integration & Calibration feeds into ST6030 Recreation Resources Study - Impact Analysis on October 1, 2014. ST4570 Fish & Aquatics Instream Flow Study - Hydraulic Model Integration & Calibration feeds into ST4180 River Productivity Study - Data Analysis & Reporting on October 1, 2014. ST4570 Fish & Aquatics Instream Flow Study - Hydraulic Model Integration & Calibration feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on October 1, 2014.
ST4580	Initial Study Report		
ST4590	Updated Study Report		
		Riparian Instream Flow Study (8.6)	
ST1010	Critical Review of 1980s Susitna River Data		
ST1020	Finalize Riparian Groundwater/Surfacewater Field Design		
ST1030	Implement Riparian Groundwater/Surfacewater Installation & Sampling	ST5420 Groundwater Study - Riparian Veg Dependency on Surface/Groundwater Interactions feeds into ST1030 Riparian Instream Study - Implement Riparian Groundwater/Surfacewater Installation & Sampling on October 1, 2013.	
ST1040	Riparian Vegetation: Field Data Collection 2013		
ST1050	Riparian Vegetation: Field Data Collection 2014	ST5560 Aquatic Furbearer Abundance & Habitat Use Study - Initial Study Report feeds into ST1050 Riparian Instream Flow Study - Riparian Vegetation: Field Data Collection - 2014 on March 31, 2014.	
ST1060	Sediment Dating: Sampling & Analysis 2013		
ST1070	Sediment Dating: Sampling & Analysis 2014		
ST1080	Develop Riparian Models	ST2580 Ice Processes in the Susitna River Study - Break Up Reconnaissance and ST2590 Ice Processes in the Susitna River Study - Freeze Up Reconnaissance feeds into ST1080 Riparian Instream Flow Study - Develop Riparian Models on March 1, 2013. ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST1080 Riparian Instream Flow Study - Develop Riparian Models on December 31, 2013. ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling feeds into ST1080 Riparian Instream Flow Study - Develop Riparian Models on December 31, 2013. ST2600 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Riparian/Wetland/Habitat Map Revisions feeds into ST1080 Riparian Instream Flow Study - Develop Riparian Models on December 31, 2013. ST5280 Fluvial Geomorphology Modeling Below Watana Dam Study - Perform 1D Modeling of Exis Conditions & Initial Proj Run feeds into ST1080 Riparian Instream Flow Study - Develop Riparian Models on December 31, 2013. ST5460 Groundwater Study - Winter Ground/Surface Water Interactions feeds into ST1080 Riparian Instream Flow Study - Develop Riparian Models on July 1, 2014.	ST1080 Riparian Instream Flow Study - Develop Riparian Models feeds into ST3790 Aesthetic Resources Study - Updated Study Report Prep on October 1, 2014. ST1080 Riparian Instream Flow Study - Develop Riparian Models feeds into ST5120 Geomorphology Study - Large Woody Debris on July 1, 2014. ST1080 Riparian Instream Flow Study - Develop Riparian Models feeds into ST4180 River Productivity Study - Data Analysis & Reporting on October 1, 2014. ST1080 Riparian Instream Flow Study - Develop Riparian Models feeds into ST5570 Aquatic Furbearer Abundance & Habitat Use Study - Updated Study Report on October 1, 2014.
ST1090	Initial Study Report		
ST1100	Updated Study Report		
		Study of Fish Distribution and Abundance in the Upper Susitna River (9.5)	

Activity ID	Activity Name	Predecessors	Successors
ST2220	Fish Sampling	ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 feeds into ST2220 Study of Fish Distribution & Abundance in the Upper Susitna River - Fish Sampling on October 1, 2013.	ST2220 Study of Fish Distribution & Abundance in the Upper Susitna River - Fish Sampling feeds into ST2560 Wood Frogs Occupancy & Habitat Use Study on May 1, 2013. ST2220 Study of Fish Distribution & Abundance in the Upper Susitna River - Fish Sampling feeds into ST3150 Surveys of Eagles & Other Raptors Study - Field Surveys - 2013 on April 1, 2013. ST2220 Study of Fish Distribution & Abundance in the Upper Susitna River - Fish Sampling feeds into ST3480 Aquatic Furbearer Abundance & Habitat Use Study - Aerial Survey of Muskrat Pushups on March 31, 2013. ST2220 Study of Fish Distribution and Abundance in the Upper Susitna River - Fish Sampling feeds into ST1230 Genetic Baseline Study for Selected Fish Species - Baseline Sample Collection 2013 on June 1, 2013. ST2220 Study of Fish Distribution & Abundance in the Upper Susitna River - Fish Sampling feeds into ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 on June 1, 2013.
ST2950	Study Site Selection	ST4970 Geomorphology Study - Initial Geomorphic Reach Delineation/Finalize Delineation feeds into ST2950 Study of Fish Distribution & Abundance in the Upper Susitna River - Study Site Selection on January 1, 2013. ST3460 Characterization and Mapping of Aquatic Habitats Study - Data Collection - 2012-13 feeds into ST2950 Study of Fish Distribution & Abundance in the Upper Susitna River - Study Site Selection on January 1, 2013.	
ST2951	Data Entry		
ST2952	Preliminary Data Analysis	ST3600 Characterization & Mapping of Aquatic Habitats Study - Data Collection - 2014 feeds into ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis on October 1, 2014.	ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST3950 Analysis of Fish Harvest in (and) D/S of the Susitna-Watana Hydroelectric Project on December 31, 2013. ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST2450 Aquatic Resources w/ Access Alignment, Transmission Alignment, and Cost Areas Study - Additional Surveys on January 31, 2014. ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on December 31, 2013. ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options on December 31, 2013. ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST4150 River Productivity Study - General Habitat Suitability Criteria and ST1307 on December 31, 2013. ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST1730 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fish Community Scenarios on December 31, 2013. ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on December 31, 2013. ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST4530 Fish & Aquatics Instream Flow Study - HSC/HCI Fish: Field Data Collection on December 31, 2013. ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST4330 Waterbird Migration, Breeding & Habitat Study - Brood Surveys - 2014 on October 1, 2013.
ST3050	Initial Study Report Prep		
ST3060	Initial Study Report		
ST3120	Final Data Analysis		
ST3140	Updated Study Report Prep		
ST3150	Updated Study Report		
Study of Fish Distribution and Abundance in the Middle and Lower Susitna River(9.6)			
ST3310	Study Site Selection	ST3460 Characterization and Mapping of Aquatic Habitats Study - Data Collection - 2012-13 feeds into ST3310 Study of Fish Distribution & Abundance (Middle & Lower Susitna River) - Study Site Selection on January 1, 2013. ST4970 Geomorphology Study - Initial Geomorphic Reach Delineation/Finalize Delineation feeds into ST3310 Study of Fish Distribution & Abundance (Middle & Lower Susitna River) - Study Site Selection on January 1, 2013.	
ST3320	Fish Sampling	ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 feeds into ST3320 Study of Fish Distribution & Abundance (Middle & Lower Susitna River) - Fish Sampling on October 1, 2013.	ST3320 Study of Fish Distribution & Abundance (Middle & Lower Susitna River) - Fish Sampling feeds into ST2560 Wood Frogs Occupancy & Habitat Use Study on May 1, 2013. ST3320 Study of Fish Distribution & Abundance (Middle & Lower Susitna River) - Fish Sampling feeds into ST3150 Surveys of Eagles & Other Raptors Study - Field Surveys - 2013 on April 1, 2013. ST3320 Study of Fish Distribution & Abundance (Middle & Lower Susitna River) - Fish Sampling feeds into ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 on June 1, 2013.
ST3350	Data Entry		

Activity ID	Activity Name	Predecessors	Successors
ST3360	Preliminary Data Analysis		ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST4330 Waterbird Migration, Breeding & Habitat Study - Brood Surveys - 2014 on October 1, 2013. ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST3620 Cook Inlet Beluga Whale Study - Initial Study Report Prep on December 31, 2013. ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST3950 Analysis of Fish Harvest in (and) D/S of the Susitna-Watana Hydroelectric Project on December 31, 2013. ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST1230 Genetic Baseline Study for Selected Fish Species - Baseline Sample Collection 2013 on June 1, 2013. ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on December 31, 2013. ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST4150 River Productivity Study - General Habitat Suitability Criteria and ST1307 on December 31, 2013. ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST2440 Salmon Escapement Study - Updated Study Report on October 1, 2014. ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on December 31, 2013.
ST3370	Initial Study Report Prep		
ST3380	Initial Study Report		
ST3381	Final Data Analysis	ST3600 Characterization & Mapping of Aquatic Habitats Study - Data Collection - 2014 feeds into ST3381 Study of Fish Distribution & Abundance in the Middle and Lower Susitna River on October 1, 2014.	ST3381 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Final Data Analysis feeds into ST4570 Fish & Aquatics Instream Flow Study - Hydraulic Model Integration & Calibration on October 1, 2014.
ST3390	Updated Study Report Prep		
ST3400	Updated Study Report		
		Salmon Escapement Study (9.7)	
ST2380	Operate Fishwheels in the Lower Susitna 2013		ST2380 Salmon Escapement Study - Operate Fishwheels in the Lower Susitna -2013 feeds into ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 on October 1, 2013.
ST2390	Operate Fishwheels at Curry 2013	ST3460 Characterization and Mapping of Aquatic Habitats Study - Data Collection - 2012-13 feeds into ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 on June 1, 2013. ST1230 Genetic Baseline Study for Selected Fish Species - Baseline Sample Collection 2013 feeds into ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 on June 1, 2013. ST2220 Study of Fish Distribution & Abundance in the Upper Susitna River - Fish Sampling feeds into ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 on June 1, 2013. ST3320 Study of Fish Distribution & Abundance (Middle & Lower Susitna River) - Fish Sampling feeds into ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 on June 1, 2013.	ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 feeds into ST1230 Genetic Baseline Study for Selected Fish Species - Baseline Sample Collection 2013 on September 1, 2013. ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 feeds into ST3320 Study of Fish Distribution & Abundance (Middle & Lower Susitna River) - Fish Sampling on October 1, 2013. ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 feeds into ST2220 Study of Fish Distribution & Abundance in the Upper Susitna River - Fish Sampling on October 1, 2013. ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 feeds into ST4330 Waterbird Migration, Breeding & Habitat Study - Brood Surveys - 2014 on October 1, 2013.
ST2400	Conduct Aerial Surveys 2013		
ST2410	Initial Study Report	ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 feeds into ST2410 Salmon Escapement Study - Initial Study Report on October 31, 2013. ST3620 Cook Inlet Beluga Whale Study - Initial Study Report Prep feeds into ST2410 Salmon Escapement Study - Initial Study Report on December 31, 2013.	ST2410 Salmon Escapement Study - Initial Study Report feeds into ST1690 Surveys of Eagles & Other Raptors Study - Field Surveys - 2014 on April 1, 2014. ST2410 Salmon Escapement Study - Initial Study Report feeds into ST3950 Analysis of Fish Harvest in (and) D/S of the Susitna-Watana Hydroelectric Project on February 1, 2014. ST2410 Salmon Escapement Study - Initial Study Report feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on February 1, 2014. ST2410 Salmon Escapement Study - Initial Study Report feeds into ST2230 Aquatic Resources w/ Access Alignment, Transmission Alignment, and Const. Areas Study - Conduct Fish Surveys on February 1, 2014. ST2410 Salmon Escapement Study - Initial Study Report feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on February 1, 2014. ST2410 Salmon Escapement Study - Initial Study Report feeds into ST1730 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fish Community Scenarios on February 1, 2014.
ST2420	Operate Fishwheels in the Lower Susitna 2014		
ST2430	Operate Fishwheels at Curry 2014		

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Activity ID	Activity Name	Predecessors	Successors
ST2440	Updated Study Report	ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST2440 Salmon Escapement Study - Updated Study Report on October 1, 2014. ST3600 Characterization & Mapping of Aquatic Habitats Study - Data Collection - 2014 feeds into ST2440 Salmon Escapement Study - Updated Study Report on October 1, 2014.	
River Productivity Study (9.8)			
ST4020	Literature Review on Hydropower Impacts		
ST4060	Sampling Benthic Macroinvertebrate & Algae Communities & Organic Matter	ST3460 Characterization and Mapping of Aquatic Habitats Study - Data Collection - 2012-13 feeds into ST4060 River Productivity Study - Sampling Benthic Macroinvertebrate & Algae Communities & Organic Matter on March 31, 2013.	
ST4100	Invertebrate Drift Sampling		
ST4120	Sampling Talkeetna for Ref. Site & Feasibility Study	ST5010 Geomorphology Study - Identify Key Governing Geomorphic Process feeds into ST4120 Cultural Resources Study - Field Studies - Evaluation on March 31, 2013.	
ST4140	Trophic Analysis w/ Bioenergetics & Stable Isotope Analysis		
ST4150	Generate Habitat Suitability Criteria	ST4750 Baseline Water Quality Study - Water Quality Monitoring feeds into ST4150 River Productivity Study - General Habitat Suitability Criteria and ST1307 on October 31, 2013. ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST4150 River Productivity Study - General Habitat Suitability Criteria and ST1307 on December 31, 2013. ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST4150 River Productivity Study - General Habitat Suitability Criteria and ST1307 on December 31, 2013. ST4750 Baseline Water Quality Study - Water Quality Monitoring feeds into ST4150 River Productivity Study - General Habitat Suitability Criteria and ST1307 on December 31, 2013. ST3600 Characterization & Mapping of Aquatic Habitats Study - Data Collection - 2014 feeds into ST4150 River Productivity Study - General Habitat Suitability Criteria and ST1307 on October 31, 2013.	
ST4160	Conduct a Fish Gut Analysis		
ST4170	Establish Baseline Colonization Rates		
ST4180	Data Analysis & Reporting	ST4570 Fish & Aquatics Instream Flow Study - Hydraulic Model Integration & Calibration feeds into ST4180 River Productivity Study - Data Analysis & Reporting on October 1, 2014. ST1080 Riparian Instream Flow Study - Develop Groundwater/Surfacewater Modeling feeds into ST4180 River Productivity Study - Data Analysis & Reporting on October 1, 2014.	ST4180 River Productivity Study - Data Analysis & Reporting feeds into ST4800 Water Quality Modeling Study - Generate Results for Operational Scenarios on July 1, 2014.
ST4210	Initial Study Report Prep		
ST4230	Initial Study Report		
ST4240	Updated Study Report Prep		
ST4250	Updated Study Report		
Characterization and Mapping of Aquatic Habitats Study (9.9)			
ST3460	Data Collection - 2012-13	ST4970 Geomorphology Study - Initial Geomorphic Reach Delineation/Finalize Delineation feeds into ST3460 Characterization & Mapping of Aquatic Habitats Study - Data Collection - 2012-13 on March 1, 2013.	ST3460 Characterization & Mapping of Aquatic Habitats Study - Data Collection - 2012-13 feeds into ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options on March 1, 2014. ST3460 Characterization and Mapping of Aquatic Habitats Study - Data Collection - 2012-13 feeds into ST4060 River Productivity Study - Sampling Benthic Macroinvertebrate & Algae Communities & Organic Matter on March 31, 2013. ST3460 Characterization and Mapping of Aquatic Habitats Study - Data Collection - 2012-13 feeds into ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 on June 1, 2013. ST3460 Characterization and Mapping of Aquatic Habitats Study - Data Collection - 2012-13 feeds into ST3310 Study of Fish Distribution & Abundance (Middle & Lower Susitna River) - Study Site Selection on January 1, 2013. ST3460 Characterization and Mapping of Aquatic Habitats Study - Data Collection - 2012-13 feeds into ST2950 Study of Fish Distribution & Abundance in the Upper Susitna River - Study Site Selection on January 1, 2013. ST3460 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Field Surveys feeds into ST4520 Fish & Aquatics Instream Flow Study - Periodicity on August 31, 2013.
ST3520	Initial Study Report Prep		
ST3530	Initial Study Report		

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Activity ID	Activity Name	Predecessors	Successors
ST3600	Data Collection - 2014	ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results feeds into ST3600 Characterization & Mapping of Aquatic Habitats Study - Data Collection - 2014 on April 1, 2014.	ST3600 Characterization & Mapping of Aquatic Habitats Study - Data Collection - 2014 feeds into feeds into ST4150 River Productivity Study - General Habitat Suitability Criteria and ST1307 on October 31, 2013. ST3600 Characterization & Mapping of Aquatic Habitats Study - Data Collection - 2014 feeds into ST2440 Salmon Escapement Study - Updated Study Report on October 1, 2014. ST3600 Characterization & Mapping of Aquatic Habitats Study - Data Collection - 2014 feeds into ST3381 Study of Fish Distribution & Abundance in the Middle and Lower Susitna River on October 1, 2014. ST3600 Characterization & Mapping of Aquatic Habitats Study - Data Collection - 2014 feeds into ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis on October 1, 2014
ST3610	Updated Study Report Prep		
ST3640	Updated Study Report		ST3640 Characterization and Mapping of Aquatic Habitats Study - Updated Study Report feeds into ST2450 Aquatic Resources w/ Access Alignment, Transmission Alignment, and Cost Areas Study - Additional Surveys on January 31, 2013.
Future Watana Reservoir Fish Community and Risk of Entrainment Study (9.10)			
ST1729	Reservoir Habitat Scenarios		
ST1730	Reservoir Fish Community Scenarios	ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST1730 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fish Community Scenarios on December 31, 2013. ST2410 Salmon Escapement Study - Initial Study Report feeds into ST1730 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fish Community Scenarios on February 1, 2014.	ST1730 Future Watana Reservoir Fish Community and Risk of Entrainment Study - Reservoir Fish Community Scenarios feeds into ST1650 Social Conditions & Public Goods & Services Study - Incorporate Information & Other Studies on December 31, 2013.
ST1731	Initial Study Report		
ST2010	Reservoir Fishery Management Options	ST3460 Characterization & Mapping of Aquatic Habitats Study - Data Collection - 2012-13 feeds into ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options on March 1, 2014. ST1112 Fish Passage Feasibility at Watana Dam - Develop Concepts feeds into ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options on December 31, 2013. ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options on December 31, 2013. ST4850 Water Quality Modeling Study - Model Evaluation/Selection feeds into ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options on December 31, 2013. ST5970 Recreation Resources Study - Analysis feeds into ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options on December 31, 2013. ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative feeds into ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options on April 1, 2014 .	ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on April 1, 2014. ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options feeds into ST5970 Recreation Resources Study - Analysis on April 1, 2014.
ST2210	Entrainment Analysis		
ST2460	Updated Study Report		
Fish Passage Feasibility at Watana Dam (9.11)			
ST1109	Establish Team and Define Process		
ST1110	Prepare for Feasibility Study		
ST1111	Site Reconnaissance		
ST1112	Develop Concepts		ST1112 Fish Passage Feasibility at Watana Dam - Develop Concepts feeds into ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options on December 31, 2013.
ST1113	Initial Study Report Prep		
ST1114	Initial Study Report		

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Activity ID	Activity Name	Predecessors	Successors
ST2670	Evaluate Feasibility/Alternative	ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on December 31, 2013. ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on December 31, 2013. ST2410 Salmon Escapement Study - Initial Study Report feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on February 1, 2014. ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on April 1, 2014. ST5130 Geomorphology Study - Reservoir Geomorphology feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on December 31, 2013. ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on December 31, 2013. ST4750 Baseline Water Quality Study - Water Quality Monitoring feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on December 31, 2013. ST4840 Water Quality Monitoring Study - Model Calibration (Water Quality) feeds into ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative on December 31, 2013.	ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative feeds into ST6030 Recreation Resources Study - Impact Analysis on June 30, 2014. ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative feeds into ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options on April 1, 2014 .
ST2671	Develop Refined Passage Strategies	ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 feeds into ST2671 Fish Passage Feasibility at Watana Dam - Develop Refined Passage Strategies on June 30, 2014.	
ST2790	Updated Study Report Prep		
ST2800	Updated Study Report		
Study of Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries (9.12)			
ST4260	Data Collection - 2013		ST4260 Study of Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries - Data Collection - 2013 feeds into ST3950 Analysis of Fish Harvest in (and) D/S of the Susitna-Watana Hydroelectric Project on December 31, 2013. ST4260 Study of Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries - Data Collection - 2013 feeds into ST2450 Aquatic Resources w/ Access Alignment, Transmission Alignment, and Cost Areas Study - Additional Surveys on December 31, 2013
ST4340	Initial Study Report		
ST4410	Data Collection - 2014	ST4570 Fish & Aquatics Instream Flow Study - Hydraulic Model Integration & Calibration feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on October 1, 2014. ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on December 31, 2013. ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on December 31, 2013. ST2410 Salmon Escapement Study - Initial Study Report feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on February 1, 2014. ST5080 Geomorphology Study - Determine Effective Discharge & Characterization of Bed Mobilization feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on December 31, 2013. ST4500 Fish & Aquatics Instream Flow Study - Hydraulic Flow Routing feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on December 31, 2013. ST4540 Fish & Aquatics Instream Flow Study - Collect Physical & Hydraulic Data for Habitat Modeling feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on December 31, 2013. ST5280 Fluvial Geomorphology Modeling Below Watana Dam Study - Perform 1D Modeling of Exis Conditions & Initial Proj Run feeds into ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 on January 31, 2013.	ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 feeds into ST2671 Fish Passage Feasibility at Watana Dam - Develop Refined Passage Strategies on June 30, 2014. ST4410 Study of Fish Passage Barriers (Middle & Upper Susitna River) - Data Collection - 2014 feeds into ST4540 Fish & Aquatics Instream Flow Study - Collect Physical & Hydraulic Data for Habitat Modeling on May 31, 2014.
ST4490	Updated Study Report		
Aquatic Resources w/ Access Alignment, Transmission Alignment, and Const. Areas Study (9.13)			
ST2230	Conduct Fish Surveys	ST2410 Salmon Escapement Study - Initial Study Report feeds into ST2230 Aquatic Resources w/ Access Alignment, Transmission Alignment, and Const. Areas Study - Conduct Fish Surveys on February 1, 2014.	

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Activity ID	Activity Name	Predecessors	Successors
ST2450	Additional Surveys	ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST2450 Aquatic Resources w/ Access Alignment, Transmission Alignment, and Cost Areas Study - Additional Surveys on January 31, 2014. ST3640 Characterization and Mapping of Aquatic Habitats Study - Updated Study Report feeds into ST2450 Aquatic Resources w/ Access Alignment, Transmission Alignment, and Cost Areas Study - Additional Surveys on January 31, 2013. ST4260 Study of Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries - Data Collection - 2013 feeds into ST2450 Aquatic Resources w/ Access Alignment, Transmission Alignment, and Cost Areas Study - Additional Surveys on December 31, 2013.	
ST3810	Initial Study Report		
ST3820	Updated Study Report		
		Genetic Baseline Study for Selected Fish Species (9.14)	
ST1230	Baseline Sample Collection 2013	ST2220 Study of Fish Distribution and Abundance in the Upper Susitna River - Fish Sampling feeds into ST1230 Genetic Baseline Study for Selected Fish Species - Baseline Sample Collection 2013 on June 1, 2013. ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST1230 Genetic Baseline Study for Selected Fish Species - Baseline Sample Collection 2013 on June 1, 2013. ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 feeds into ST1230 Genetic Baseline Study for Selected Fish Species - Baseline Sample Collection 2013 on September 1, 2013. ST3560 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Field Study 2013 feeds into ST1230 Genetic Baseline Study for Selected Fish Species - Baseline Sample Collection 2013 on October 31, 2013.	ST1230 Genetic Baseline Study for Selected Fish Species - Baseline Sample Collection 2013 feeds into ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 on June 1, 2013.
ST1450	Baseline Sample Collection 2014		
ST1670	Mixture Sample Collection 2013		
ST2000	Mixture Sample Collection 2014		
ST3730	Analysis of Salmon Tissue		
ST3740	Initial Study Report		
ST3750	Updated Study Report		
		Analysis of Fish Harvest in and Downstream of the Susitna-Watana Hydroelectric Project Area (9.15)	
ST3920	Harvest & Effort Statistics		ST3920 Analysis of Fish Harvest in and Downstream of the Susitna-Watana Hydroelectric Project Area - Harvest & Effort Statistics feeds into ST1650 Social Conditions & Public Goods & Services Study - Incorporate Information & Other Studies on December 31, 2013. ST3920 Analysis of Fish Harvest in and Downstream of the Susitna-Watana Hydroelectric Project Area - Harvest & Effort Statistics feeds into ST6030 Recreation Resources Study - Impact Analysis on December 31, 2013.
ST3950	Analyses of Potential Project-Related Effects on Harvest Levels & Opportunity	ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST3950 Analysis of Fish Harvest in (and) D/S of the Susitna-Watana Hydroelectric Project on December 31, 2013. ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST3950 Analysis of Fish Harvest in (and) D/S of the Susitna-Watana Hydroelectric Project on December 31, 2013. ST2410 Salmon Escapement Study - Initial Study Report feeds into ST3950 Analysis of Fish Harvest in (and) D/S of the Susitna-Watana Hydroelectric Project on February 1, 2014. ST4260 Study of Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries - Data Collection - 2013 feeds into ST3950 Analysis of Fish Harvest in (and) D/S of the Susitna-Watana Hydroelectric Project on December 31, 2013. ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling feeds into ST3950 Analysis of Fish Harvest in (and) D/S of the Susitna-Watana Hydroelectric Project on December 31, 2013. ST3030 Subsistence Resources Study - Task 1-3, 5: Prepare 2013 Study Report feeds into ST3950 Analysis of Fish Harvest in (and) D/S of the Susitna-Watana Hydroelectric Project on December 31, 2013.	ST3950 Analysis of Fish Harvest in (and) D/S of the Susitna-Watana Hydroelectric Project feeds into ST6030 Recreation Resources Study - Impact Analysis on September 30, 2014.
ST3980	Initial Study Report		
ST3981	Updated Study Report		
		Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study (9.16)	
ST3340	ADF&G Permits 2013		
ST3450	ADF&G Permits 2014		

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Activity ID	Activity Name	Predecessors	Successors
ST3560	Field Study 2013		ST3560 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Field Study 2013 feeds into ST1230 Genetic Baseline Study for Selected Fish Species - Baseline Sample Collection 2013 on October 31, 2013.
ST3670	Field Study 2014		
ST3780	Data Analysis 2013	ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling feeds into ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 on October 1, 2013. ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 on October 1, 2013. ST4750 Baseline Water Quality Study - Water Quality Monitoring feeds into ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 on October 1, 2013. ST4840 Water Quality Monitoring Study - Model Calibration (Water Quality) feeds into ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 on October 1, 2013. ST2380 Salmon Escapement Study - Operate Fishwheels in the Lower Susitna -2013 feeds into ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 on October 1, 2013. ST5260 Fluvial Geomorphology Modeling Below Watana Dam Study - Coordinate w/ Other Studies on Processes Modeled feeds into ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 on October 1, 2013.	ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 feeds into ST3620 Cook Inlet Beluga Whale Study - Initial Study Report Prep on November 1, 2013. ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 feeds into ST3652 Cook Inlet Beluga Whale Study on December 31, 2013. ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 feeds into ST2410 Salmon Escapement Study - Initial Study Report on October 31, 2013. ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 feeds into ST3660 River Recreation Flow & Access Study - Initial Study Report Prep on October 31, 2013.
ST3890	Data Analysis 2014		
ST4220	Initial Study Report		
ST5440	Updated Study Report		
Cook Inlet Beluga Whale Study (9.17)			
ST2040	Permit Applications		
ST2050	2013 Aerial Surveys		
ST2060	2013 Camera Surveys		
ST2070	2013 Initial Modeling Effort		
ST3620	Initial Study Report Prep	ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 feeds into ST3620 Cook Inlet Beluga Whale Study - Initial Study Report Prep on November 1, 2013. ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST3620 Cook Inlet Beluga Whale Study - Initial Study Report Prep on December 31, 2013. ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling feeds into ST3620 Cook Inlet Beluga Whale Study - Initial Study Report Prep on December 31, 2013. ST4840 Water Quality Monitoring Study - Model Calibration (Water Quality) feeds into ST3620 Cook Inlet Beluga Whale Study - Initial Study Report Prep on December 31, 2013.	ST3620 Cook Inlet Beluga Whale Study - Initial Study Report Prep feeds into ST2410 Salmon Escapement Study - Initial Study Report on December 31, 2013.
ST3630	Initial Study Report		
ST3649	2014 Aerial Surveys		
ST3650	2014 Camera Surveys		
ST3652	Revised Modeling Effort	ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 feeds into ST3652 Cook Inlet Beluga Whale Study on December 31, 2013. ST5280 Fluvial Geomorphology Modeling Below Watana Dam Study - Perform 1D Modeling of Exis Conditions & Initial Proj Run feeds into ST3652 Cook Inlet Beluga Whale Study on March 31, 2014. ST2710 Ice Processes in the Susitna River Study - Initial Study Report Prep feeds into ST3652 Cook Inlet Beluga Whale Study on February 2, 2014.	
ST3653	Updated Study Report Prep		
ST3654	Updated Study Report		
Moose Distribution, Abundance, Movements, Productivity, and Survival Study (10.5)			
ST2089	Deploy Remaining Radio & Satellite Collars & Monitor	ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST2089 Moose Distribution, Abundance, Movements, Productivity, and Survival Study - Deploy Remaining Radio & Satellite Collars & Monitor on February 1, 2013.	
ST2090	Conduct Winter Browse Utilization Assessment		
ST2100	Monitor Radio Collars Weekly		

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Activity ID	Activity Name	Predecessors	Successors
ST5680	Initial Study Report		ST5680 Moose Distribution, Abundance, Movements, Productivity, and Survival Study - Initial Study Report feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on February 2, 2014.
ST5681	Updated Study Report		
Caribou Distribution, Abundance, Movements, Productivity, and Survival Study (10.6)			
ST4670	Monitor Collars - 2013		
ST4780	Initial Study Report		ST4780 Caribou Distribution, Abundance, Movements, Productivity, and Survival Study - Initial Study Report feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on August 31, 2014.
ST4890	Monitor Collars - 2014		
ST5000	Updated Study Report		
Dall's Sheep Distribution and Abundance Study (10.7)			
ST5110	Site Visits to Assess Lick Use - 2013		
ST5220	Aerial Surveys - 2013	ST2580 Fluvial Geomorphology Modeling Below Watana Dam Study - Perform 1D Modeling of Exis Conditions & Initial Proj Run and ST2590 Fluvial Geomorphology Modeling Below Watana Dam Study - Reevaluate D/S Study Limits Based on 1D Results feeds into ST5220 Dall's Sheep Distribution and Abundance Study - Aerial Surveys - 2013 on March 1, 2013.	
ST5330	Data Analysis - 2013		
ST5620	Initial Study Report		
ST5630	Site Visits to Assess Lick Use - 2014		
ST5640	Aerial Surveys - 2014		
ST5650	Data Analysis - 2014		ST5650 Dall's Sheep Distribution and Abundance Study - Data Analysis - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014.
ST5660	Updated Study Report		
Distribution, Abundance, and Habitat Use by Large Carnivores Study (10.8)			
ST2550	Field Surveys of Bear Use - 2013		
ST4330	Data Analysis 2013	ST3360 Study of Fish Distribution and Abundance in the Middle and Lower Susitna River - Preliminary Data Analysis feeds into ST4330 Waterbird Migration, Breeding & Habitat Study - Brood Surveys - 2014 on October 1, 2013. ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling feeds into ST4330 Waterbird Migration, Breeding & Habitat Study - Brood Surveys - 2014 on October 1, 2013. ST2181 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Delivery of Field Data & Preliminary Vegetation & Habitat Maps feeds into ST4330 Waterbird Migration, Breeding & Habitat Study - Brood Surveys - 2014 on October 1, 2013. ST2952 Study of Fish Distribution and Abundance in the Upper Susitna River - Preliminary Data Analysis feeds into ST4330 Waterbird Migration, Breeding & Habitat Study - Brood Surveys - 2014 on October 1, 2013. ST2390 Salmon Escapement Study - Operate Fishwheels at Curry - 2013 feeds into ST4330 Waterbird Migration, Breeding & Habitat Study - Brood Surveys - 2014 on October 1, 2013.	
ST4450	Initial Study Report		
ST4600	Field Surveys of Bear Use 2014		
ST5610	Data Analysis 2014		ST5610 Distribution, Abundance, and Habitat Use by Large Carnivores Study - Data Analysis - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014.
ST5611	Updated Study Report		
Wolverine Distribution, Abundance, and Habitat Occupancy Study (10.9)			
ST2120	SUPE Survey 2013		
ST2130	SUPE Survey 2014		ST2130 Wolverine Distribution, Abundance, and Habitat Occupancy Study - SUPE Survey 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014.
ST2140	Initial Study Report		
ST2150	Updated Study Report		
Terrestrial Furbearer Abundance and Habitat Use Study (10.10)			

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Activity ID	Activity Name	Predecessors	Successors
ST5580	Fieldwork to Collect Genetic Samples & Conduct Track Surveys - 2013	ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST5580 Terrestrial Furbearer Abundance and Habitat Use Study - Fieldwork to Collect Genetic Samples & Conduct Track Surveys - 2013 on February 1, 2013.	
ST5600	Genetic Analysis - 2013		
ST5690	Snowshoe Hare Pellet Count - 2013		
ST5700	Initial Data		ST5700 Terrestrial Furbearer Abundance and Habitat Use Study - Initial Data feeds into ST1300 Small Mammal Species Composition and Habitat Use Study - Data Management on September 30, 2013.
ST5710	Fieldwork to Collect Genetic Samples & Conduct Track Surveys - 2014		
ST5840	Genetic Analysis - 2014		ST5840 Terrestrial Furbearer Abundance and Habitat Use Study - Genetic Analysis - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014.
ST5950	Snowshoe Hare Pellet Count - 2014		
ST5951	Initial Study Report		
ST5952	Updated Study Report		
		Aquatic Furbearer Abundance & Habitat Use Study (10.11)	
ST3470	Aerial Surveys of River Otter & Mink Tracks		
ST3480	Aerial Survey of Muskrat Pushups	ST2270 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Riparian/Wetland/Habitat Mapping & Field Plot Selection feeds into ST3480 Aquatic Furbearer Abundance & Habitat Use Study - Aerial Survey of Muskrat Pushups on March 31, 2013. ST2810 Wetland Mapping Study - Wetland Mapping & Field Plot Selection feeds into ST3480 Aquatic Furbearer Abundance & Habitat Use Study - Aerial Survey of Muskrat Pushups on March 31, 2013. ST2220 Study of Fish Distribution & Abundance in the Upper Susitna River - Fish Sampling feeds into ST3480 Aquatic Furbearer Abundance & Habitat Use Study - Aerial Survey of Muskrat Pushups on March 31, 2013. ST4520 Fish & Aquatics Instream Flow Study - Periodicity feeds into ST3480 Aquatic Furbearer Abundance & Habitat Use Study - Aerial Survey of Muskrat Pushups on March 31, 2013.	
ST3490	Aerial Survey of Beaver Colonies		
ST3500	Aerial Survey of Lodges		
ST3510	Aerial Track Survey of River Otter & Mink		
ST3540	Aerial Survey of River Otter & Mink Tracks		
ST3550	Aerial Survey of Muskrat Pushups		
ST3570	Aerial Survey of Beaver Colonies		
ST3580	Aerial Survey of Lodges		
ST3590	Aerial Track Survey of River Otter & Mink		ST3590 Aquatic Furbearer Abundance & Habitat Use Study - Aerial Track Survey of River Otter & Mink feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014.
ST5560	Initial Study Report		ST5560 Aquatic Furbearer Abundance & Habitat Use Study - Initial Study Report feeds into ST4920 Mercury Assessment and Potential for Bioaccumulation Study - Data Analysis & Management on March 31, 2014. ST5560 Aquatic Furbearer Abundance & Habitat Use Study - Initial Study Report feeds into ST1050 Riparian Instream Flow Study - Riparian Vegetation: Field Data Collection - 2014 on March 31, 2014.
ST5570	Updated Study Report	ST1080 Riparian Instream Flow Study - Develop Groundwater/Surfacewater Modeling feeds into ST5570 Aquatic Furbearer Abundance & Habitat Use Study - Updated Study Report on October 1, 2014.	
		Small Mammal Species Composition and Habitat Use Study (10.12)	
ST1260	Small Mammal Trapping	ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST1260 Small Mammal Species Composition & Habitat Use Study - Small Mammal Trapping on June 30, 2013.	
ST1300	Data Management	ST5700 Terrestrial Furbearer Abundance and Habitat Use Study - Initial Data feeds into ST1300 Small Mammal Species Composition and Habitat Use Study - Data Management on September 30, 2013.	
ST1310	Initial Study Report		ST1310 Small Mammal Species Composition and Habitat Use Study - Initial Study Report feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014.
ST1330	Updated Study Report		

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Activity ID	Activity Name	Predecessors	Successors
Bat Distribution & Habitat Use Study (10.13)			
ST3160	Acoustic Monitoring - 2013	ST4630 Geology & Soils Characterization Study - Comprehensive Investigations (Dam Site & Reservoir Area) feeds into ST3160 Bat Distribution & Habitat Use Study - Acoustic Monitoring - 2013 on May 31, 2013. ST1380 Cultural Resources Study - Modeling & Sample Design Development from 2012 Field Reconnaissance feeds into ST3160 Bat Distribution & Habitat Use Study - Acoustic Monitoring - 2013 on March 31, 2013. ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST3160 Bat Distribution & Habitat Use Study - Acoustic Monitoring - 2013 on May 31, 2013. ST2810 Wetland Mapping Study - Wetland Mapping & Field Plot Selection feeds into ST3160 Bat Distribution & Habitat Use Study - Acoustic Monitoring - 2013 on May 31, 2013.	
ST3170	Data Analysis - 2013		
ST3180	Initial Study Report		
ST3190	Acoustic Monitoring - 2014		
ST3200	Data Analysis - 2014	ST1680 Surveys of Eagles & Other Raptors Study - Initial Study Report feeds into ST3200 Bat Distribution & Habitat Use Study - Data Analysis - 2014 on October 1, 2014.	ST3200 Bat Distribution & Habitat Use Study - Data Analysis - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014.
ST3210	Updated Study Report		
Surveys of Eagles & Other Raptors Study (10.14)			
ST1350	Field Surveys - 2013	ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST3150 Surveys of Eagles & Other Raptors Study - Field Surveys - 2013 on April 1, 2013. ST2810 Wetland Mapping Study - Wetland Mapping & Field Plot Selection feeds into ST3150 Surveys of Eagles & Other Raptors Study - Field Surveys - 2013 on April 1, 2013. ST2220 Study of Fish Distribution & Abundance in the Upper Susitna River - Fish Sampling feeds into ST3150 Surveys of Eagles & Other Raptors Study - Field Surveys - 2013 on April 1, 2013. ST3320 Study of Fish Distribution & Abundance (Middle & Lower Susitna River) - Fish Sampling feeds into ST3150 Surveys of Eagles & Other Raptors Study - Field Surveys - 2013 on April 1, 2013.	
ST1580	Update Regional Database - 2013		
ST1630	Conduct Roosting & Staging Surveys - 2013		
ST1680	Initial Study Report		ST1680 Surveys of Eagles & Other Raptors Study - Initial Study Report feeds into ST3200 Bat Distribution & Habitat Use Study - Data Analysis - 2014 on October 1, 2014. ST1680 Surveys of Eagles & Other Raptors Study - Initial Study Report feeds into ST4920 Mercury Assessment and Potential for Bioaccumulation Study - Data Analysis & Management on April 1, 2014.
ST1690	Field Surveys - 2014	ST2410 Salmon Escapement Study - Initial Study Report feeds into ST1690 Surveys of Eagles & Other Raptors Study - Field Surveys - 2014 on April 1, 2014.	
ST4090	Update Regional Database - 2014		
ST4130	Conduct Roosting & Staging Surveys - 2014		ST4130 Surveys of Eagles & Other Raptors Study - Conduct Roosting & Staging Surveys - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on November 1, 2014.
ST4131	Updated Study Report		
Waterbird Migration, Breeding & Habitat Study (10.15)			
ST4270	Spring Migration/Breeding-Pair Surveys - 2013	ST2580 Ice Processes in the Susitna River Study - Break Up Reconnaissance feeds into ST4270 Waterbird Migration, Breeding & Habitat Study - Spring Migration/Breeding-Pair Surveys - 2013 on May 1, 2013.	
ST4280	Brood Surveys - 2013		
ST4290	Harlequin Duck Brood-Rearing Survey - 2013		
ST4300	Fall Migration Surveys - 2013		
ST4310	Data Analysis - 2013		ST4310 Waterbird Migration, Breeding & Habitat Study - Data Analysis - 2013 feeds into ST2240 Landbird and Shorebird Migration, Breeding, and Habitat Use Study - Point-Count Survey - 2014 on December 31, 2013. ST4310 Waterbird Migration, Breeding & Habitat Study - Data Analysis - 2013 feeds into ST4920 Mercury Assessment and Potential for Bioaccumulation Study - Data Analysis & Management on November 30, 2014.

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Activity ID	Activity Name	Predecessors	Successors
ST4420	Spring Migration/Breeding-Pair Surveys - 2014		
ST4430	Brood Surveys - 2014		
ST4460	Harlequin Duck Brood-Rearing Survey - 2014		
ST4470	Fall Migration Surveys - 2014		
ST4480	Data Analysis - 2014		ST4480 Waterbird Migration, Breeding & Habitat Study - Data Analysis - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on November 30, 2014.
ST4481	Initial Study Report		
ST4482	Updated Study Report		
Landbird and Shorebird Migration, Breeding, and Habitat Use Study (10.16)			
ST1740	Field Planning	ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST1740 Landbird and Shorebird Migration, Breeding, and Habitat Use Study - Field Planning on April 1, 2013.	
ST1850	Point-Count Survey - 2013		
ST1970	Swallow Survey - 2013		
ST1990	Data Analysis - 2013		ST1990 Landbird and Shorebird Migration, Breeding, and Habitat Use Study - Data Analysis - 2013 feeds into ST4920 Mercury Assessment and Potential for Bioaccumulation Study - Data Analysis & Management on October 31, 2014.
ST2020	Initial Study Report		
ST2240	Point-Count Survey - 2014	ST4310 Waterbird Migration, Breeding & Habitat Study - Data Analysis - 2013 feeds into ST2240 Landbird and Shorebird Migration, Breeding, and Habitat Use Study - Point-Count Survey - 2014 on December 31, 2013.	
ST2470	Swallow Survey - 2014		
ST3330	Data Analysis - 2014		ST3330 Landbird and Shorebird Migration, Breeding, and Habitat Use Study - Data Analysis - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014.
ST5500	Updated Study Report		
Population Ecology of Willow Ptarmigan in Game Management Unit 13 Study (10.17)			
ST1119	First Field Season		
ST1120	Conduct Aerial Surveys		
ST1560	Conduct Aerial Surveys		
ST1780	Second Field Season		
ST1890	Conduct Aerial Surveys		ST1890 Population Ecology of Willow Ptarmigan in Game Management Unit 13 Study - Conduct Aerial Surveys feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014.
ST5831	Initial Study Report		
ST5832	Updated Study Report		
Wood Frogs Occupancy & Habitat Use Study (10.18)			
ST2340	Selection of Waterbodies - 2013	ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST2340 Wood Frogs Occupancy & Habitat Use Study on February 28, 2013. ST2810 Wetland Mapping Study - Wetland Mapping & Field Plot Selection feeds into ST2340 Wood Frogs Occupancy & Habitat Use Study on February 28, 2013.	
ST2540	Selection of Waterbodies - 2014		
ST2560	Field Survey - 2013	ST2220 Study of Fish Distribution & Abundance in the Upper Susitna River - Fish Sampling feeds into ST2560 Wood Frogs Occupancy & Habitat Use Study on May 1, 2013. ST3320 Study of Fish Distribution & Abundance (Middle & Lower Susitna River) - Fish Sampling feeds into ST2560 Wood Frogs Occupancy & Habitat Use Study on May 1, 2013.	
ST2561	Field Survey - 2014		
ST2890	Data Analysis - 2013		

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Activity ID	Activity Name	Predecessors	Successors
ST3130	Data Analysis - 2014		ST3130 Wood Frogs Occupancy & Habitat Use Study - Data Analysis - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014.
ST4000	Initial Study Report		
ST4610	Updated Study Report		
Evaluation of Wildlife Habitat Use Study (10.19)			
ST3230	Literature Review		
ST3240	Initial Study Report		
ST3250	Initial Habitat-Value Ranking		
ST3260	Final Selection of Species		
ST3270	Data Analysis	ST5680 Moose Distribution, Abundance, Movements, Productivity, and Survival Study - Initial Study Report feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on February 2, 2014. ST4780 Caribou Distribution, Abundance, Movements, Productivity, and Survival Study - Initial Study Report feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on August 31, 2014. ST5650 Dall's Sheep Distribution and Abundance Study - Data Analysis - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014. ST5610 Distribution, Abundance, and Habitat Use by Large Carnivores Study - Data Analysis - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014. ST2130 Wolverine Distribution, Abundance, and Habitat Occupancy Study - SUPE Survey 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014. ST5840 Terrestrial Furbearer Abundance and Habitat Use Study - Genetic Analysis - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014. ST3590 Aquatic Furbearer Abundance & Habitat Use Study - Aerial Track Survey of River Otter & Mink feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014. ST1310 Small Mammal Species Composition and Habitat Use Study - Initial Study Report feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014. ST4130 Surveys of Eagles & Other Raptors Study - Conduct Roosting & Staging Surveys - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on November 1, 2014. ST4480 Waterbird Migration, Breeding & Habitat Study - Data Analysis - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on November 30, 2014. ST3330 Landbird and Shorebird Migration, Breeding, and Habitat Use Study - Data Analysis - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014. ST1890 Population Ecology of Willow Ptarmigan in Game Management Unit 13 Study - Conduct Aerial Surveys feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014. ST3130 Wood Frogs Occupancy & Habitat Use Study - Data Analysis - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014. ST4370 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Final Vegetation/Habitat Map Revisions feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 1, 2014. ST5761 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Final Riparian/Wetland/Habitat Map Revisions feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 1, 2014. ST4390 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Delivery of Field Data & Final Vegetation & Habitat Maps feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014. ST5763 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Delivery of Final Field Data & Final Riparian/Wetland/Habitat Maps feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014. ST3200 Bat Distribution & Habitat Use Study - Data Analysis - 2014 feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014. .	
ST3280	Updated Study Report		
ST5510	Initial Selection of Species		
Wildlife Harvest Analysis Study (10.20)			

Activity ID	Activity Name	Predecessors	Successors
ST5520	Transfer of 2012 Harvest/Subsistence Data		ST5520 Wildlife Harvest Analysis Study - Transfer of 2012 Harvest/Subsistence Data feeds into ST1650 Social Conditions & Public Goods & Services Study - Incorporate Information & Other Studies on December 31, 2013. ST5520 Wildlife Harvest Analysis Study - Transfer of 2012 Harvest/Subsistence Data feeds into ST6030 Recreation Resources Study - Impact Analysis on September 30, 2013. ST5520 Wildlife Harvest Analysis Study - Transfer of 2012 Harvest/Subsistence Data feeds into ST5970 Recreation Resources Study - Analysis on October 1, 2013. ST5520 Wildlife Harvest Analysis Study - Transfer of 2012 Harvest/Subsistence Data feeds into ST3030 Subsistence Resources Study - Task 1-3, 5: Prepare 2013 Study Report on October 1, 2013.
ST5530	Initial Study Report	ST3030 Subsistence Resources Study - Task 1-3, 5: Prepare 2013 Study Report feeds into ST5530 Wildlife Harvest Analysis Study - Initial Study Report on November 30, 2013.	
ST5540	Transfer of 2013 Harvest/Subsistence Data		
ST5550	Updated Study Report		
Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin (11.5)			
ST2160	Vegetation/Habitat Mapping & Field Plot Selections		ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST5870 Invasive Plant Study - Field Survey Site Selection on March 31, 2013. ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST5770 Rare Plant Study - Field Survey Site Selection on March 31, 2013. ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST2340 Wood Frogs Occupancy & Habitat Use Study on February 28, 2013. ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST1740 Landbird and Shorebird Migration, Breeding, and Habitat Use Study - Field Planning on April 1, 2013. ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST3150 Surveys of Eagles & Other Raptors Study - Field Surveys - 2013 on April 1, 2013. ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST3160 Bat Distribution & Habitat Use Study - Acoustic Monitoring - 2013 on May 31, 2013. ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST5580 Terrestrial Furbearer Abundance and Habitat Use Study - Fieldwork to Collect Genetic Samples & Conduct Track Surveys - 2013 on February 1, 2013. ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST2089 Moose Distribution, Abundance, Movements, Productivity, and Survival Study - Deploy Remaining Radio & Satellite Collars & Monitor on February 1, 2013. ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST1260 Small Mammal Species Composition & Habitat Use Study - Small Mammal Trapping on June 30, 2013.
ST2170	Field Surveys	ST4360 Geology & Soils Study Comprehensive Investigations feeds into Vegetation & Wildlife Habitat Mapping Study (Upper & Middle Susitna Basin) on October 1, 2013.	
ST2180	Vegetation/Habitat Map Revisions		
ST2181	Delivery of Field Data & Preliminary Vegetation & Habitat Maps		ST2181 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Delivery of Field Data & Preliminary Vegetation & Habitat Maps feeds into ST2600 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Riparian/Wetland/Habitat Map Revisions on October 1, 2013. ST2181 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Delivery of Field Data & Preliminary Vegetation & Habitat Maps feeds into ST4330 Waterbird Migration, Breeding & Habitat Study - Brood Surveys - 2014 on October 1, 2013.
ST2190	Initial Study Report Prep		
ST2200	Initial Study Report		
ST4350	Vegetation/Habitat Mapping & Field Plot Selection for Remaining Unmapped Areas		

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Activity ID	Activity Name	Predecessors	Successors
ST4360	Field Surveys		ST4360 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Field Surveys feeds into ST4530 Fish & Aquatics Instream Flow Study - HSC/HCI Fish: Field Data Collection on December 31, 2013.
ST4370	Final Vegetation/Habitat Map Revisions		ST4370 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Final Vegetation/Habitat Map Revisions feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 1, 2014.
ST4380	Updated Study Report Prep		
ST4390	Delivery of Field Data & Final Vegetation & Habitat Maps		ST4390 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Delivery of Field Data & Final Vegetation & Habitat Maps feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014.
ST4400	Updated Study Report		
Riparian Vegetation Study Downstream of the Proposed Watana Dam (11.6)			
ST2250	Preparation of Riverine Physiography to Help Define Study Area		
ST2270	Riparian/Wetland/Habitat Mapping & Field Plot Selection		ST2270 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Riparian/Wetland/Habitat Mapping & Field Plot Selection feeds into ST5870 Invasive Plant Study - Field Survey Site Selection on March 31, 2013. ST2270 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Riparian/Wetland/Habitat Mapping & Field Plot Selection feeds into ST5770 Rare Plant Study - Field Survey Site Selection on March 31, 2013. ST2270 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Riparian/Wetland/Habitat Mapping & Field Plot Selection feeds into ST3480 Aquatic Furbearer Abundance & Habitat Use Study - Aerial Survey of Muskrat Pushups on March 31, 2013.
ST2271	Field Surveys		
ST2600	Riparian/Wetland/Habitat Map Revisions	ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results feeds into ST2600 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Riparian/Wetland/Habitat Map Revisions on October 1, 2013. ST2181 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Delivery of Field Data & Preliminary Vegetation & Habitat Maps feeds into ST2600 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Riparian/Wetland/Habitat Map Revisions on October 1, 2013. ST2830 Wetland Mapping Study - Wetland Map Revisions feeds into ST2600 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Riparian/Wetland/Habitat Map Revisions on October 1, 2013.	ST2600 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Riparian/Wetland/Habitat Map Revisions feeds into ST1080 Riparian Instream Flow Study - Develop Groundwater/Surfacewater Modeling on December 31, 2013.
ST2601	Delivery of Field Data & Preliminary Riparian/Wetland/Habitat Maps		
ST2610	Initial Study Report Prep		
ST2620	Initial Study Report		
ST5750	Riparian/Wetland/Habitat Mapping & Field Plot Selection for Remaining Unmapped Areas		
ST5760	Field Surveys		
ST5761	Final Riparian/Wetland/Habitat Map Revisions		ST5761 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Final Riparian/Wetland/Habitat Map Revisions feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 1, 2014.
ST5763	Delivery of Final Field Data & Final Riparian/Wetland/Habitat Maps		ST5763 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Delivery of Final Field Data & Final Riparian/Wetland/Habitat Maps feeds into ST3270 Evaluation of Wildlife Habitat Use Study - Data Analysis on October 31, 2014.
ST5764	Updated Study Report Prep		
ST5765	Updated Study Report		
Wetland Mapping Study (11.7)			

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Activity ID	Activity Name	Predecessors	Successors
ST2810	Wetland Mapping & Field Plot Selection		ST2810 Wetland Mapping Study - Wetland Mapping & Field Plot Selection feeds into ST5870 Invasive Plant Study - Field Survey Site Selection on March 31, 2013. ST2810 Wetland Mapping Study - Wetland Mapping & Field Plot Selection feeds into ST5770 Rare Plant Study - Field Survey Site Selection on March 31, 2013. ST2810 Wetland Mapping Study - Wetland Mapping & Field Plot Selection feeds into ST2340 Wood Frogs Occupancy & Habitat Use Study on February 28, 2013. ST2810 Wetland Mapping Study - Wetland Mapping & Field Plot Selection feeds into ST3150 Surveys of Eagles & Other Raptors Study - Field Surveys - 2013 on April 1, 2013. ST2810 Wetland Mapping Study - Wetland Mapping & Field Plot Selection feeds into ST3160 Bat Distribution & Habitat Use Study - Acoustic Monitoring - 2013 on May 31, 2013. ST2810 Wetland Mapping Study - Wetland Mapping & Field Plot Selection feeds into ST3480 Aquatic Furbearer Abundance & Habitat Use Study - Aerial Survey of Muskrat Pushups on March 31, 2013.
ST2820	Field Surveys		
ST2830	Wetland Map Revisions		ST2830 Wetland Mapping Study - Wetland Map Revisions feeds into ST2600 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Riparian/Wetland/Habitat Map Revisions on October 1, 2013.
ST2840	Initial Study Report Prep		
ST2850	Initial Study Report		
ST2860	Delivery of Field Data & Preliminary Wetland Map	ST5970 Recreation Resources Study - Analysis feeds into ST2860 Wetland Mapping Study - Delivery of Field Data & Preliminary Wetland Map on December 31, 2013.	
ST2870	Wetland Mapping & Field Plot Selection for Remaining Unmapped Areas		
ST2880	Field Surveys		
ST2900	Final Wetland Map Revisions		
ST2910	Wetland Functional Analysis	ST4920 Mercury Assessment and Potential for Bioaccumulation Study - Data Analysis & Management feeds into ST2910 Wetland Mapping Study - Wetland Functional Analysis at the end of March 2014 . ST3030 Subsistence Resources Study - Task 1-3, 5: Prepare 2013 Study Report feeds into ST2910 Wetland Mapping Study - Wetland Functional Analysis October 1, 2013.	
ST2920	Updated Study Report Prep		
ST2930	Delivery of Final Field Data & Final Wetland Map		
ST2940	Updated Study Report		
Rare Plant Study (11.8)			
ST5770	Field Survey Site Selection	ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST5770 Rare Plant Study - Field Survey Site Selection on March 31, 2013. ST2270 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Riparian/Wetland/Habitat Mapping & Field Plot Selection feeds into ST5770 Rare Plant Study - Field Survey Site Selection on March 31, 2013. ST2810 Wetland Mapping Study - Wetland Mapping & Field Plot Selection feeds into ST5770 Rare Plant Study - Field Survey Site Selection on March 31, 2013.	
ST5780	Field Survey		
ST5790	Data Analysis		
ST5800	Initial Study Report		
ST5810	Field Survey Site Selection		
ST5820	Field Survey		
ST5850	Data Analysis		
ST5860	Updated Study Report		
Invasive Plant Study (11.9)			

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Activity ID	Activity Name	Predecessors	Successors
ST5870	Field Survey Site Selection	ST2160 Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin - Vegetation/Habitat Mapping & Field Plot Selections feeds into ST5870 Invasive Plant Study - Field Survey Site Selection on March 31, 2013. ST2270 Riparian Vegetation Study Downstream of the Proposed Watana Dam - Riparian/Wetland/Habitat Mapping & Field Plot Selection feeds into ST5870 Invasive Plant Study - Field Survey Site Selection on March 31, 2013. ST2810 Wetland Mapping Study - Wetland Mapping & Field Plot Selection feeds into ST5870 Invasive Plant Study - Field Survey Site Selection on March 31, 2013.	
ST5880	Field Survey		
ST5890	Data Analysis		
ST5900	Initial Study Report		
ST5910	Field Survey Site Selection		
ST5920	Field Survey		
ST5930	Data Analysis		
ST5931	Updated Study Report		
		Recreation Resources Study (12.5)	
ST3410	Initial Study Report Prep		
ST3420	Initial Study Report		
ST3430	Updated Study Report Prep		
ST3440	Updated Study Report		
ST5960	Data Collection & Baseline Inventory		
ST5970	Analysis	ST5520 Wildlife Harvest Analysis Study - Transfer of 2012 Harvest/Subsistence Data feeds into ST5970 Recreation Resources Study - Analysis on October 1, 2013. ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options feeds into ST5970 Recreation Resources Study - Analysis on April 1, 2014.	ST5970 Recreation Resources Study - Analysis feeds into ST1650 Social Conditions & Public Goods & Services Study - Incorporate Information & Other Studies on December 31, 2013. ST5970 Recreation Resources Study - Analysis feeds into ST1400 Cultural Resources Study - Additional Modeling from 2013 Field Study Results on December 31, 2013. ST5970 Recreation Resources Study - Analysis feeds into ST1210 Aesthetic Resources Study - Impact Analysis on November 1, 2013. ST5970 Recreation Resources Study - Analysis feeds into ST2860 Wetland Mapping Study - Delivery of Field Data & Preliminary Wetland Map on December 31, 2013. ST5970 Recreation Resources Study - Analysis feeds into ST2010 Future Watana Reservoir Fish Community & Risk of Entrainment Study - Reservoir Fishery Management Options on December 31, 2013.
ST5980	Coordination w/ Agencies, Licensing Participants and Other Studies		
ST5990	Intercept Survey Deployment		
ST6000	Mail Survey Development		
ST6010	Exec Interviewing & Web Survey Deployment		
ST6020	Survey Data Analysis		
ST6030	Impact Analysis	ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results feeds into ST6030 Recreation Resources Study - Impact Analysis on March 1, 2014. ST4570 Fish & Aquatics Instream Flow Study - Hydraulic Model Integration & Calibration feeds into ST6030 Recreation Resources Study - Impact Analysis on October 1, 2014. ST2670 Fish Passage Feasibility at Watana Dam - Evaluate Feasibility/Alternative feeds into ST6030 Recreation Resources Study - Impact Analysis on June 30, 2014. ST3950 Analysis of Fish Harvest in (and) D/S of the Susitna-Watana Hydroelectric Project feeds into ST6030 Recreation Resources Study - Impact Analysis on September 30, 2014. ST3920 Analysis of Fish Harvest in and Downstream of the Susitna-Watana Hydroelectric Project Area - Harvest & Effort Statistics feeds into ST6030 Recreation Resources Study - Impact Analysis on December 31, 2013. ST5520 Wildlife Harvest Analysis Study - Transfer of 2012 Harvest/Subsistence Data feeds into ST6030 Recreation Resources Study - Impact Analysis on September 30, 2013. ST1520 Regional Economic Evaluation Study - Initial Regional Economic Evaluation Study Report feeds into ST6030 Recreation Resources Study - Impact Analysis on December 31, 2013. ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST6030 Recreation Resources Study - Impact Analysis on December 31, 2013.	
		Aesthetic Resources Study (12.6)	

Activity ID	Activity Name	Predecessors	Successors
ST1180	Baseline Data Collection		
ST1190	Coordination w/ Agencies, Stakeholders and Disciplines		
ST1200	Simulation Development / Sound Modeling		
ST1210	Impact Analysis	ST5970 Recreation Resources Study - Analysis feeds into ST1210 Aesthetic Resources Study - Impact Analysis on November 1, 2013. ST1620 Social Conditions & Public Goods & Services Study - Initial Social Conditions & Public Good & Services Study Report feeds into ST1210 Aesthetic Resources Study - Impact Analysis on November 1, 2013. ST4040 Cultural Resources Study - Ethnogeographic Field Work feeds into ST1210 Aesthetic Resources Study - Impact Analysis on November 1, 2013. ST3030 Subsistence Resources Study - Task 1-3, 5: Prepare 2013 Study Report feeds into ST1210 Aesthetic Resources Study - Impact Analysis on November 1, 2013. ST1860 Transportation Resources Study - Forecast Future Conditions feeds into ST1210 Aesthetic Resources Study - Impact Analysis on November 1, 2013. ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST1210 Aesthetic Resources Study - Impact Analysis on November 1, 2013. ST1270 Air Quality Study - Initial Air Quality Study Report feeds into ST1210 Aesthetic Resources Study - Impact Analysis on December 31, 2013.	
ST3710	Viewshed Modeling		
ST3760	Initial Study Report Prep		
ST3770	Initial Study Report		
ST3790	Updated Study Report Prep	ST1080 Riparian Instream Flow Study - Develop Groundwater/Surfacewater Modeling feeds into ST3790 Aesthetic Resources Study - Updated Study Report Prep on October 1, 2014.	
ST3800	Updated Study Report		
River Recreation Flow and Access Study (12.7)			
ST1130	Field Studies		
ST1150	Analysis		ST1150 River Recreation Flow and Access Study - Analysis feeds into ST1650 Social Conditions & Public Goods & Services Study - Incorporate Information & Other Studies on December 31, 2013.
ST1160	Coordination w/ Agencies, Stakeholders & Disciplines		
ST1170	Impact Analysis	ST5150 Geomorphology Study - Integration & Support of Interpreting Fluv. Geomorphology Modeling Results feeds into ST1170 River Recreation Flow and Access Study - Impact Analysis on August 1, 2014. ST4500 Fish & Aquatics Instream Flow Study - Hydraulic Flow Routing feeds into ST1170 River Recreation Flow and Access Study - Impact Analysis on August 1, 2014.	ST1170 River Recreation Flow and Access Study - Impact Analysis feeds into ST1930 Health Impact Assessment Study - Baseline Data Collection on July 1, 2013. ST1170 River Recreation Flow and Access Study - Impact Analysis feeds into ST1870 Transportation Resources Study - Evaluate Impacts on December 1, 2013.
ST3660	Initial Study Report Prep	ST3780 Eulachon Run Timing, Distribution, and Spawning in the Susitna River Study - Data Analysis 2013 feeds into ST3660 River Recreation Flow & Access Study - Initial Study Report Prep on October 31, 2013.	
ST3680	Initial Study Report		
ST3690	Updated Study Report Prep		
ST3700	Updated Study Report		
ST6040	Baseline Data Collection		
Cultural Resources Study (13.5)			
ST1370	Reconnaissance Level Field Study		
ST1380	Modeling & Sample Design Development from 2012 Field Reconnaissance		ST1380 Cultural Resources Study - Modeling & Sample Design Development from 2012 Field Reconnaissance feeds into ST3160 Bat Distribution & Habitat Use Study - Acoustic Monitoring - 2013 on March 31, 2013.
ST1390	Pre-Field Prep		
ST1400	Additional Modeling from 2013 Field Study Results	ST5130 Geomorphology Study - Reservoir Geomorphology feeds into ST1400 Cultural Resources Study - Additional Modeling from 2013 Field Study Results on December 31, 2013. ST5970 Recreation Resources Study - Analysis feeds into ST1400 Cultural Resources Study - Additional Modeling from 2013 Field Study Results on December 31, 2013.	
ST1410	Pre-Field Preparation		
ST3990	Archeological Field Studies - Inventory		
ST4010	Archeological Field Studies - Initiation of Evaluation		
ST4030	Ethnogeographic Study		

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Activity ID	Activity Name	Predecessors	Successors
ST4040	Ethnogeographic Field Work	ST3020 Subsistence Resources Study - Task 5:Traditional & Local Knowledge Interviews feeds into ST4040 Cultural Resources Study - Ethnogeographic Field Work on July 1, 2013.	ST4040 Cultural Resources Study - Ethnogeographic Field Work feeds into ST1210 Aesthetic Resources Study - Impact Analysis on November 1, 2013.
ST4050	Draft Ethnogeographic Study Report	ST4630 Geology & Soils - Comprehensive Investigations feeds in to ST4050 Cultural Resources Study - Draft Ethnogeographic Study Report on October 1, 2013. ST3020 Subsistence Resources Study - Task 5:Traditional & Local Knowledge Interviews feeds intoST4050 Cultural Resources Study - Draft Ethnogeographic Study Report on September 30, 2013.	ST4050 Cultural Resources Study - Draft Ethnogeographic Study Report feeds into ST3020 Subsistence Resources Study - Task 5:Traditional & Local Knowledge Interviews on December 31, 2013.
ST4070	Initial Study Report Prep		
ST4080	Initial Study Report		
ST4190	Field Studies - Inventory		
ST4200	Field Studies - Evaluation		
ST4201	Updated Study Report Prep		
ST4202	Updated Study Report		
		Paleontological Resources Study (13.6)	
ST1441	Applying GPS Based Classification		
ST1460	Systematic Testing in Areas of High Potential	ST4630 Geology & Soils Characterization Study - Comprehensive Investigations (Dam Site & Reservoir Area) feeds into ST1460 Paleontological Resources Study - Systematic Testing in Areas of High Potential on May 31, 2013. ST4980 Geomorphology Study - Identify and Map Paleo Geomorphic Features & Geology feeds into ST1460 Paleontological Resources Study - Systematic Testing in Areas of High Potential on June 1, 2013.	
ST1470	Initial Study Report		
ST1480	Updated Study Report	ST4660 Geology & Soils Characterization Study - Comprehensive Investigations (Access Road & Transmission Line) feeds into ST1480 Paleontological Resources Study - Updated Study Report on September 1, 2014.	
		Subsistence Resources Study (14.5)	
ST1760	Subsistence Study Plan		
ST1770	Task 1: Compilation of Exis. Data		
ST1800	Task 2: ADF&G Household Surveys - Year 2		
ST1810	Task 2: ADF&G Reporting & Community Review - Year 2		
ST2960	Task 2: ADF&G Household Surveys Pre-Field Planning - Year 1		
ST2970	Task 2: ADF&G Household Surveys - Year 1		
ST2980	Task 2: ADF&G Reporting & Community Review - Year 1		
ST2990	Task 2: ADF&G Household Surveys Pre-Field Planning - Year 2		
ST3010	Task 3: Household Surveys in Nonsubsistence Areas		
ST3020	Task 5:Traditional & Local Knowledge Interviews	ST4050 Cultural Resources Study - Draft Ethnogeographic Study Report feeds into ST3020 Subsistence Resources Study - Task 5:Traditional & Local Knowledge Interviews on December 31, 2013.	ST3020 Subsistence Resources Study - Task 5:Traditional & Local Knowledge Interviews feeds into ST4040 Cultural Resources Study - Ethnogeographic Field Work on July 1, 2013. ST3020 Subsistence Resources Study - Task 5:Traditional & Local Knowledge Interviews feeds into ST4050 Cultural Resources Study - Draft Ethnogeographic Study Report on September 30, 2013.

Note: All dates in this table are estimates, subject to change. The dates and relationships, produced from Primavera Software, will be continually updated during study plan implementation.

Activity ID	Activity Name	Predecessors	Successors
ST3030	Task 1-3, 5: Prepare 2013 Study Report	ST5520 Wildlife Harvest Analysis Study - Transfer of 2012 Harvest/Subsistence Data feeds into ST3030 Subsistence Resources Study - Task 1-3, 5: Prepare 2013 Study Report on October 1, 2013.	ST3030 Subsistence Resources Study - Task 1-3, 5: Prepare 2013 Study Report feeds into ST1960 Health Impact Assessment Study - Impact Assessment on December 31, 2012. ST3030 Subsistence Resources Study - Task 1-3, 5: Prepare 2013 Study Report feeds into ST1650 Social Conditions & Public Goods & Services Study - Incorporate Information & Other Studies on December 31, 2013. ST3030 Subsistence Resources Study - Task 1-3, 5: Prepare 2013 Study Report feeds into ST5530 Wildlife Harvest Analysis Study - Initial Study Report on November 30, 2013. ST3030 Subsistence Resources Study - Task 1-3, 5: Prepare 2013 Study Report feeds into ST3950 Analysis of Fish Harvest in (and) D/S of the Susitna-Watana Hydroelectric Project on December 31, 2013. ST3030 Subsistence Resources Study - Task 1-3, 5: Prepare 2013 Study Report feeds into ST1210 Aesthetic Resources Study - Impact Analysis on November 1, 2013. ST3030 Subsistence Resources Study - Task 1-3, 5: Prepare 2013 Study Report feeds into ST2910 Wetland Mapping Study - Wetland Functional Analysis October 1, 2013.
ST3040	Revise Study Plans	ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST3040 Subsistence Resources Study - Revise Study Plans on December 31, 2013.	
ST3070	Task 4: Subsistence Mapping Interviews		
ST3080	Task 4-5: Additional 2014 Subsistence Data Collection (as needed)	ST1860 Transportation Resources Study - Forecast Future Conditions feeds into ST3080 Subsistence Resources Study - Task 4-5: Additional 2014 Subsistence Data Collection (as needed) on December 31, 2013.	
ST3090	Task 2-5: Prepare 2015 Final Updated Study Report & Community Reviews		
ST3100	Initial Study Report		
ST3101	Updated Study Report		
ST6070	Consultation		
Regional Economic Evaluation Study (15.5)			
ST1490	Gather/Review Existing Information		
ST1500	Document Existing Conditions		
ST1510	Develop Reasonable Foreseeable Future Action Assumptions		
ST1520	Initial Regional Economic Evaluation Study Report		ST1520 Regional Economic Evaluation Study - Initial Regional Economic Evaluation Study Report feeds into ST6030 Recreation Resources Study - Impact Analysis on December 31, 2013.
ST1530	Initial Study Report		
ST1540	Incorporate Information from Other Studies		
ST1550	Updated Regional Economic Evaluation Study Report	ST1620 Social Conditions & Public Goods & Services Study - Initial Social Conditions & Public Good & Services Study Report feeds into ST1550 Regional Economic Evaluation Study -Updated Regional Economic Evaluation Study Report .	
ST1570	Updated Study Report		
Social Conditions & Public Goods & Services Study (15.6)			
ST1590	Gather/Review Existing Information		
ST1600	Document Existing Conditions		
ST1610	Stakeholder Interviews		

Note: All dates in this table are estimates, subject to change. The dates and relationships, produced from Primavera Software, will be continually updated during study plan implementation.

Activity ID	Activity Name	Predecessors	Successors
ST1620	Initial Social Conditions & Public Good & Services Study Report		ST1620 Social Conditions & Public Goods & Services Study - Initial Social Conditions & Public Good & Services Study Report feeds into ST1870 Transportation Resources Study - Evaluate Impacts on December 1, 2013. ST1620 Social Conditions & Public Goods & Services Study - Initial Social Conditions & Public Good & Services Study Report feeds into ST1910 Transportation Resource Study - Updated Study Report Prep on December 31, 2013. ST1620 Social Conditions & Public Goods & Services Study - Initial Social Conditions & Public Good & Services Study Report feeds into ST1550 Regional Economic Evaluation Study -Updated Regional Economic Evaluation Study Report . ST1620 Social Conditions & Public Goods & Services Study - Initial Social Conditions & Public Good & Services Study Report feeds into ST1210 Aesthetic Resources Study - Impact Analysis on November 1, 2013. ST1620 Social Conditions & Public Goods & Services Study - Initial Social Conditions & Public Good & Services Study Report feeds into ST1960 Health Impact Assessment Study - Impact Assessment on December 31, 2013.
ST1640	Initial Study Report		
ST1650	Incorporate Information & Other Studies	ST3030 Subsistence Resources Study - Task 1-3, 5: Prepare 2013 Study Report feeds into ST1650 Social Conditions & Public Goods & Services Study - Incorporate Information & Other Studies on December 31, 2013. ST3920 Analysis of Fish Harvest in and Downstream of the Susitna-Watana Hydroelectric Project Area - Harvest & Effort Statistics feeds into ST1650 Social Conditions & Public Goods & Services Study - Incorporate Information & Other Studies on December 31, 2013. ST5520 Wildlife Harvest Analysis Study - Transfer of 2012 Harvest/Subsistence Data feeds into ST1650 Social Conditions & Public Goods & Services Study - Incorporate Information & Other Studies on December 31, 2013. ST1150 River Recreation Flow and Access Study - Analysis feeds into ST1650 Social Conditions & Public Goods & Services Study - Incorporate Information & Other Studies on December 31, 2013. ST1730 Future Watana Reservoir Fish Community and Risk of Entrainment Study - Reservoir Fish Community Scenarios feeds into ST1650 Social Conditions & Public Goods & Services Study - Incorporate Information & Other Studies on December 31, 2013. ST5970 Recreation Resources Study - Analysis feeds into ST1650 Social Conditions & Public Goods & Services Study - Incorporate Information & Other Studies on December 31, 2013. ST1870 Transportation Resources Study - Evaluate Impacts feeds into ST1650 Social Conditions & Public Goods & Services Study - Incorporate Information & Other Studies on December 31, 2013.	
ST1660	Updated Social Conditions & Public Good & Services Study Report		
ST1750	Updated Study Report		
		Transportation Resources Study (15.7)	
ST1820	Data Collection & Review		
ST1830	Assess Inventory & Field Studies		
ST1840	Document Existing Conditions		ST1840 Transportation Resources Study - Document Existing Conditions feeds into ST1960 Health Impact Assessment Study - Impact Assessment on August 31, 2013.
ST1860	Forecast Future Conditions		ST1860 Transportation Resources Study - Forecast Future Conditions feeds into ST3080 Subsistence Resources Study - Task 4-5: Additional 2014 Subsistence Data Collection (as needed) on December 31, 2013. ST1860 Transportation Resources Study - Forecast Future Conditions feeds into ST1210 Aesthetic Resources Study - Impact Analysis on November 1, 2013.
ST1870	Evaluate Impacts	ST4550 Fish & Aquatics Instream Flow Study - Coordinate with Other Disciplines Quality Data Collection & Modeling feeds into ST1870 Transportation Resources Study - Evaluate Impacts on December 1, 2013. ST1170 River Recreation Flow and Access Study - Impact Analysis feeds into ST1870 Transportation Resources Study - Evaluate Impacts on December 1, 2013. ST2510 Ice Processes in the Susitna River Study - Existing Condition 1D Model Development feeds into ST1870 Transportation Resources Study - Evaluate Impacts on December 1, 2013. ST1620 Social Conditions & Public Goods & Services Study - Initial Social Conditions & Public Good & Services Study Report feeds into ST1870 Transportation Resources Study - Evaluate Impacts on December 1, 2013.	ST1870 Transportation Resources Study - Evaluate Impacts feeds into ST1270 Air Quality Study - Initial Air Quality Study Report on December 1, 2013. ST1870 Transportation Resources Study - Evaluate Impacts feeds into ST1960 Health Impact Assessment Study - Impact Assessment on December 31, 2013. ST1870 Transportation Resources Study - Evaluate Impacts feeds into ST1650 Social Conditions & Public Goods & Services Study - Incorporate Information & Other Studies on December 31, 2013. ST1870 Transportation Resources Study - Evaluate Impacts feeds into ST1290 Air Quality Study - Estimate Future Emissions with/without Project on December 31, 2013.
ST1880	Initial Study Report Prep		

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Activity ID	Activity Name	Predecessors	Successors
ST1900	Initial Study Report		
ST1910	Updated Study Report Prep	ST1620 Social Conditions & Public Goods & Services Study - Initial Social Conditions & Public Good & Services Study Report feeds into ST1910 Transportation Resource Study - Updated Study Report Prep on December 31, 2013.	
ST3300	Updated Study Report		
Health Impact Assessment Study (15.8)			
ST1920	Project Overview & Issues Summary		
ST1930	Baseline Data Collection	ST4720 Baseline Water Quality Study - Data Analysis & Management feeds into ST1930 Health Impact Assessment Study - Baseline Data Collection on February 1, 2013. ST1170 River Recreation Flow and Access Study - Impact Analysis feeds into ST1930 Health Impact Assessment Study - Baseline Data Collection on July 1, 2013.	
ST1940	Initial Study Report Prep		
ST1950	Initial Study Report		
ST1960	Impact Assessment	ST3030 Subsistence Resources Study - Task 1-3, 5: Prepare 2013 Study Report feeds into ST1960 Health Impact Assessment Study - Impact Assessment on December 31, 2012. ST1870 Transportation Resources Study - Evaluate Impacts feeds into ST1960 Health Impact Assessment Study - Impact Assessment on December 31, 2013. ST1840 Transportation Resources Study - Document Existing Conditions feeds into ST1960 Health Impact Assessment Study - Impact Assessment on August 31, 2013. ST5470 Groundwater Study - Shallow Groundwater Users feeds into ST1960 Health Impact Assessment Study - Impact Assessment on March 1, 2013. ST1270 Air Quality Study - Initial Air Quality Study Report feeds into ST1960 Health Impact Assessment Study - Impact Assessment on December 31, 2013. ST1620 Social Conditions & Public Goods & Services Study - Initial Social Conditions & Public Good & Services Study Report feeds into ST1960 Health Impact Assessment Study - Impact Assessment on December 31, 2013.	
ST1980	Updated Study Report Prep		
ST2030	Updated Study Report		
Air Quality Study (15.9)			
ST1220	Review Existing Info/Identify Needs		
ST1240	Document Existing Conditions		
ST1250	Summarize Baseline Fossil Fuel Emissions		
ST1270	Initial Air Quality Study Report	ST1870 Transportation Resources Study - Evaluate Impacts feeds into ST1270 Air Quality Study - Initial Air Quality Study Report on December 1, 2013.	ST1270 Air Quality Study - Initial Air Quality Study Report feeds into ST1960 Health Impact Assessment Study - Impact Assessment on December 31, 2013. ST1270 Air Quality Study - Initial Air Quality Study Report feeds into ST1210 Aesthetic Resources Study - Impact Analysis on December 31, 2013.
ST1280	Initial Study Report		
ST1290	Estimate Future Emissions with/without Project	ST1870 Transportation Resources Study - Evaluate Impacts feeds into ST1290 Air Quality Study - Estimate Future Emissions with/without Project on December 31, 2013.	
ST1360	Updated Study Report Work		
ST3860	Updated Study Report		
Probable Maximum Flood Study (16.5)			
ST2300	Site-Specific PMF		
ST2310	Initial Study Report		
ST2320	Updated Study Report		
Site Specific Seismic Hazard Study (16.6)			
ST2330	Field Program		
ST2350	Deterministic & Probabilistic Seismic Hazard Assessment		
ST2360	Initial Study Report	ST4630 Geology & Soils Characterization Study - Comprehensive Investigations (Dam Site & Reservoir Area) feeds into ST2360 Site Specific Seismic Hazard Study - Initial Study Report on September 30 , 2013.	
ST2370	Updated Study Report		

Note: All dates in this table are estimates, subject to change. The dates and relationships, produced from Primavera Software, will be continually updated during study plan implementation.

3. STUDIES NOT PROPOSED

Under FERC's ILP regulations, if a prospective applicant does not adopt a requested study, it must provide an explanation of why the request was not adopted, with reference to the criteria set forth in 18 CFR § 5.9(b). 18 CFR § 5.13(a). In total, licensing participants filed 52 formal study requests with FERC that adhered to the study request format set forth in FERC's regulations. As outlined in Section 2, AEA intends to perform studies relating to each of the study topics requested, except for one study request that is for a National-Level Economic Valuation Study. This section describes that study request and AEA's rationale for not adopting the study.

3.1. Requested Study Not Adopted in the RSP

3.1.1. Information Regarding Study Request

Several licensing participants, including Natural Heritage Institute *et al.*, American Whitewater, Alaska Hydro Project, Alaska Survival, and Coalition for Susitna Dam Alternatives (collectively, Study Proponents),[14] have submitted a proposed National-Level Economic Valuation Study (Proposed Study). The following three subsections provide information directly from the study requests and these extracts are taken directly from those study requests.

3.1.2. Requester's Description of Study Goals and Objectives

The Proposed Study's objectives are stated as follows:

"*The study will identify and analyze the economic values associated with constructing and operating project compared to alternatives, including the no-action alternative, at the national scale. If it were to be licensed by the Federal Energy Regulatory Commission (FERC), the proposed 700-foot-high Susitna River dam, with an installed capacity of 600 MW, will significantly change the hydrograph of the Susitna watershed for 220 miles upstream from its mouth at Cook Inlet and transform an unregulated river into a regulated one. The construction of the project will preclude, limit, or otherwise change the existing uses of the river and other extant attributes of the river and its watershed that people value. The study will obtain information to ascertain the value of the change from the proposed project is more or less than the value of an undammed watershed the no-action alternative and in the public interest.*"

3.1.3. Relevant Resource Agency Management Goals

The Proposed Study's relevant resource management goals are stated as follows:

"*The U.S. Fish and Wildlife Service and National Marine Fisheries Service have stewardship responsibilities for public-trust fish and wildlife resources in the basin.*

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[14] *See* Letter from Jan Konisberg, Natural Heritage Institute, *et al.*, to Kimberly D. Bose, Federal Energy Regulatory Commission, at 4, Project No. 14241-000 (filed May 31, 2012); Letter from Thomas O'Keefe, American Whitewater, to Kimberly D. Bose, Federal Energy Regulatory Commission, at 8, Project No. 14241-000 (filed May 31, 2012); Letter from Jan Konisberg, Alaska Hydro Project, *et al.*, to Kimberly D. Bose, Federal Energy Regulatory Commission, at 1, Project No. 14241-000 (filed Nov. 14, 2012).

The resource management goal of the Fish and Wildlife Service is no net loss of fish and wildlife resources, to conserve the nation's existing fish and wildlife and their habitats in the Susitna River Basin, and to prescribe fishways pertaining to this project pursuant to Section 18 of the Federal Power Act.

National Marine Fisheries Service has jurisdiction over the nation's marine, estuarine and anadromous fishery resources, with the goal of maintaining native and natural aquatic communities for their intrinsic and ecological value and their benefits to people, including the authority to prescribe fishways pertaining to this project pursuant to Section 18 of the Federal Power Act.

The applicant should confer with resources agencies, tribes, nongovernmental organizations to develop this study."

3.1.4. Sponsor's Description of Existing Information and Need for Additional Information

The Proposed Study's description of existing information and need for additional information is stated as follows:

"*The PAD (Section 4.12 "Socioeconomic Resources) contains no information relating to value of products and services that businesses, such as tourism and sport and commercial fisheries, extract from the existing ecosystem, which would be useful for designing the research instruments (e.g. surveys, focus groups) to ascertain the value that the broader American public (a statistically significant sample of the national population) places on the extant watershed in comparison to the changes to the watershed that would result from the proposed project.*

This information is necessary for the Commission to give equal consideration to non-power and power values."

3.1.5. AEA's Rationale for Not Adopting the Proposed Study in the PSP

Several organizations and individuals requested that the socioeconomic study plan address the economic value of environmental goods and services provided by the Susitna River system, including non-market benefits. In fact, the Social Conditions and Public Goods and Services Study, as proposed by AEA in this RSP, includes analyses that will evaluate a number of the potential changes in the environmental goods and services derived from the river system and surrounding areas in dollar terms. That study will not, however, include a national level economic valuation study.

As described below, AEA's proposed analyses address both market (e.g. jobs, revenue) and non-market (e.g. recreation, aesthetics) values. However, economic (i.e., monetary) valuations of environmental goods and services are not required, nor may they be sufficient, in order for the positive value of the environmental assets of the Susitna River system to be given full and equal consideration in the licensing decision making process for the proposed Project.

As some commenters noted, there are significant challenges and obstacles to the quantification of environmental values of river systems in dollar terms. Consequently, the environmental review will incorporate a variety of qualitative and quantitative measures of impacts to the physical, biological, and socioeconomic environment. These multiple measures will be obtained through an array of biological, physical, socioeconomic, transportation, recreational, aesthetics, subsistence and cultural studies.

As demonstrated below, this approach does not preclude the monetization of some impacts to environmental goods and services. Rather, a combination of monetized and non-monetized measures offers the advantage of bringing a wide range of insights to the licensing decision. In accordance with FERC guidelines and practice, the environmental review will focus on reasonably foreseeable significant impacts on the human environment; remote and highly speculative consequences will not be considered.

Data Collection and Analysis for Social Conditions and Public Goods and Services Study

The Social Conditions and Public Goods and Services Study proposed by AEA will use a variety of methods to derive estimates of the value of affected environmental goods and services, including goods and services that are not priced in conventional markets. Methods will be used to monetize the value of some goods and service, while the value of others will be expressed in qualitative terms.

The proposed Project would not start operations until 2023 under the current schedule. The Project is anticipated to operate for more than 50 years, similar to other large hydroelectric developments around the world. Given the long time frame for construction of the Project and its operations, the Project's socioeconomic effects will be estimated by comparing future socioeconomic conditions with and without the Project.

The forecast of socioeconomic conditions with and without the Project will be based in part on estimates derived from the REMI model described for the Regional Economic Analysis. While the REMI model provides a wide range of output variables, the variables of interest in the socioeconomic impact analysis for the proposed Project are population, employment, labor income, output (sales), and housing. The REMI model extends economic and demographic forecasts through 2060, which is consistent with the temporal scope of the socioeconomic impact analysis. The REMI model can provide projections for all of the boroughs and census areas within the Railbelt, including the MOA, FNSB, KPB, MSB, and Denali Borough. The current REMI model also includes the Yukon-Koyukuk Census Area and Valdez-Cordova Census Area.

The forecast analysis performed by the REMI model will be guided by assumptions about reasonably foreseeable future actions that would have an important and measurable effect on Alaska's economy. As the Project design becomes more developed, specific requirements for the types of construction specialties (e.g., firms with roller-compacted concrete experience) will be identified and compared with current expertise of regional construction companies to see which opportunities can be filled by Alaska firms. This evaluation would improve the model estimates of future economic activity, and provide recommendations to increase the percentage of these opportunities captured by Alaska businesses.

Here is a summary description of other AEA efforts pertinent to the planned socioeconomics study that will evaluate a number of the potential changes in the environmental goods and services derived from the river system and surrounding areas in dollar terms.

- The effect of potential immigration during Project construction and operations on municipal and state services, such as police, fire protection, medical facilities and schools, will be assessed. If projected immigration would potentially burden existing municipal and state services, proposed plans to alleviate this impact will be identified.

- A fiscal impact analysis will be conducted to evaluate incremental local government expenditures in relation to incremental local government revenues that would result from construction and operation of the Project. Incremental expenditures include, but are not limited to, school operating costs, road maintenance and repair, public safety, and public utility costs. Incremental revenues include, but are not limited to, property taxes and hotel/motel occupancy taxes.
- Transportation of construction equipment and materials through communities on the transportation routes to and from the Project could result in increased traffic volumes, and associated noise and congestion effects. Such conditions might require additional police and emergency response calls for traffic accidents and other incidents. These impacts will be assessed based on the results of the Transportation Resources Study.
- Utilizing the results of the Recreation and Aesthetics Study (Section 10), AEA will analyze the economic impact of the Project on local tourism establishments (e.g., river sport fishing, whitewater boating) and the regional economy. Calculations will be based on information obtained from the recreation survey, including the estimated recreation-related expenditures per recreational day or trip and changes in the number of days or trips per year. Utilizing the results of the Subsistence Study (Section 12), the regional economic impact of changes in subsistence-related expenditures due to the proposed Project will be estimated. The approximate cash expenses to generate each pound of subsistence harvest will be based on information in Goldsmith (1998). Changes in spending for recreational or subsistence related goods and services will become inputs to the REMI model to calculate regional economic impacts.
- The Project, including access roads, could affect surrounding property uses and values. These effects will be described identifying the properties that are on, or in close proximity to the Project area, including the access road(s) that will be built; determining the degree to which the use of the properties would change as a result of the Project; and estimating the extent that properties' values will change as a result of the change in use.
- If Project features (i.e., reservoir and access roads) stimulate residential location, spending by new residents in the local economy will generate new economic activity, including additional jobs and labor income. Interviews will be conducted with regional businesses to identify potential opportunities for residential development and estimate the economic impacts should this development occur.

  To the extent that Project construction and operations will change the level of production of commercial farming, grazing, logging, mining, and fishing operations, these effects will be approximated by the change in production multiplied by the market price of the resource in question. Information on the quantity and value of market-based natural resources is available through state and federal resource management agencies. Changes that result in increases or decreases in commercial resource extraction will become inputs to the REMI model to calculate regional economic impacts.
- AEA will utilize random utility model combining existing data, recreation preference functions from the published literature and new data collected to estimate changes in recreational use values associated with sport fishing, sport hunting, boating, wildlife viewing, hiking, and camping in the study area. The basis of the method is the

assumption that the recreational experience is enhanced by high quality sites (e.g., clean water, abundant recreational fisheries), hence the net willingness to pay for—and value of—recreational trips depends on site quality. Different model specifications can be used to value specific qualities of the resource and attributes of the recreational experience. To value these types of amenities, economists typically rely on a variant of the basic travel cost model referred to as a discrete choice or random utility model. In addition, the benefits transfer approach will be used to supplement or compare unit values (e.g., value per-day of sport fishing) for recreational goods and services obtained from primary valuation methods. Benefits transfer involves the application of unit value estimates, functions, data, and/or models from one or more previously conducted valuation studies to estimate benefits associated with the resource under consideration (Black et al. 1998). For example, an extensive number of previously conducted studies estimated the value of sport fishing in various regions of Alaska. Similarly, several existing reports estimated the value of Alaska wildlife.

- The value of changes in subsistence activities in the study area will be estimated by applying a wage compensating differential model that examines tradeoffs between time spent on subsistence and cash employment (Duffield 1997). The advantage of latter method is that it captures the cultural and social value of participating in subsistence activities as well as the product value. It requires community-specific per capita income levels and subsistence harvest per capita data, both of which will be obtained from the subsistence survey conducted for the Subsistence study.

  Following the methodology of Braund and Lonner (1982), information on the values, attitudes, and lifestyle preferences of residents in the Talkeetna, Trapper Creek, and Cantwell areas will be collected through informal interviews with community residents, Matanuska-Susitna Borough officials, and other knowledgeable people. Interview questions will be oriented toward identifying how the Susitna River corridor and upper basin is used and valued by local residents to identify the importance of the various bio-physical aspects important to area residents. Once the types of Project-induced changes in riverine and basin resources are known, a further analysis will be undertaken to identify how such changes might alter the resources used and valued by area residents. The results of the Project effects on subsistence, recreation and transportation can be used to further evaluate the overall effects on the residents of the region.

<u>Proposed National-Level Economic Valuation</u>

By contrast, the Study Proponents request that AEA conduct a "National-Level Economic Valuation" study in order to "identify and analyze the economic values associated with constructing and operating project compared to alternatives, including the no-action alternative, at the national scale" [sic].[15] AEA disagrees. AEA's proposed Social Conditions and Public Goods and Services Study is more than adequate and, as set out above, more closely tracks FERC's study request standards in 18 CFR § 5.9.

The Study Proponents reason that "[t]he requirement of the Federal Power Act (FPA) that FERC give equal consideration to non-power values affirms the Commission's duty to evaluate the

[15] *Comments of American Whitewater on the PAD, Scoping Document 1, and Study Requests*, at 7 Docket No. P-14241-000 (filed May 31, 2012) (hereinafter, AWA Comments).

trade-offs that would be involved in authorizing" the Project.[16] The Study Proponents further argue that, "[t]o ensure a reliable comparison of all relevant values, the Commission should use economic valuation as a means of evaluating the trade-offs involved in the licensing action; an assessment of benefits and costs should be part of the information-set available to FERC in deciding among alternatives."[17]

The Commission should reject this request. FERC has consistently found that the monetization of non-market goods and services is inadequate in the context of assessing non-power values under Sections 4(e) and 10(a)(1) of the FPA. As explained by the Commission in *Great Northern Paper, Inc.*[18] and *City of Tacoma, Washington*:[19]

> The public-interest balancing of environmental and economic impacts cannot be done with mathematical precision, nor do we think our statutory obligation to weigh and balance all public interest considerations is served by trying to reduce it to a mere mathematical exercise. Where the dollar cost of enhancement measures, such as diminished power production, can be reasonably ascertained, we will do so. However, for non-power resources such as aquatic habitat, fish and wildlife, recreation, and cultural and aesthetic values, to name just a few, the public interest cannot be evaluated adequately only by dollars and cents.[20]
>
> . . .
>
> In the context of public interest balancing for long-term authorizations, it is inappropriate to rely too heavily on the accuracy of current dollar estimates of nonpower resource values, calculated using any number of reasonably disputable assumptions and methods.[21]

Specifically, the Study Proponents' request fails to meet the Commission's requirements for requesting additional information gathering and study requests under FERC's Integrated License Application Process. 18 CFR § 5.9(b)(6) requires that any information gathering or study requests be "consistent with generally accepted practice[s] in the scientific community . . . ." Economic valuation of non-developmental values, however, while obviously having some

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[16] *Id.* at 8.

[17] *Id.*

[18] 85 FERC ¶ 61,316 (1998), *reconsideration denied*, 86 FERC ¶ 61,184 (1999*), aff'd*, *Conservation Law Foundation v. FERC*, 216 F.3d 41 (D.C. Cir. 2000) (nothing in the FPA requires the Commission to place a dollar value on nonpower benefits; nor does the fact that the Commission assigned dollar figures to the licensee's economic costs require it to do the same for nonpower benefits.). *See also*, *Namekegon Hydro Co.,* 12 FPC 203, 206 (1953), *aff'd*, *Namekegon Hydro Co. v. FPC*, 216 F.2d 509 (7th Cir. 1954) (when unique recreational or other environmental values are present such as here, the public interest cannot be evaluated adequately only by dollars and cents); and *Eugene Water & Electric Board*, 81 FERC ¶ 61,270 (1997)*, aff'd, American Rivers v. FERC*, 187 F.3d 1007 (9th Cir. 1999) (rejecting request for economic valuation of environmental resources that were the subject of 10(j) recommendations).

[19] 84 FERC ¶ 61,107 (1998), *order on reh'g*, 86 FERC ¶ 61,311 (1999), *City of Tacoma v. FERC*, 460 F.3d 53 (D.C. Cir. 2006).

[20] 85 FERC at p. 62,244-245.

[21] 84 FERC at pp. 61,571-72.

support, is not generally accepted within the scientific community.[22] Further, the Study Proponents have not demonstrated why a national economic valuation study is necessary under 18 CFR § 5.9(a) (7)[23] to augment or supplant FERC's NEPA evaluation of the Project's impacts on aesthetics, cultural, and socioeconomic resources, among others.[24] The Study Proponents argue that FERC's proposal is inadequate because it will only assess the regional, as opposed to the national impacts of the Project. On this point, AEA strongly disagrees. FERC's inquiry under the FPA focuses on the waterway as a starting point and extends to reasonably connected interests in a manner consistent with the revised plan for the Social Conditions and Public Goods and Services Study. There is simply no support for the Study Proponents' assertion that public-interest balancing of environmental and economic impacts requires a national perspective to weigh and balance all public interest considerations consistent with FERC's statutory obligations under FPA.

Finally, the Proposed Study does not meet criteria (6) and (7) of 18 CFR § 5.9 by failing to describe the methodology to implement the proposed study[25] and by ignoring the requirement to describe either the level of effort and cost, as applicable, of the Proposed Study[26] and not addressing how or why the proposed Social Conditions and Public Goods and Services Study would not be sufficient to meet the stated information needs.[27] It is well settled that contingent value surveys are expensive, subject to bias[28] and even "[s]tudies conducted in controlled experimental settings suggest that . . . contingent valuation . . . methods may overestimate values[29] producing "implausible" results[30] that fail by trying to reduce FERC's public interest test to a mere mathematical exercise. The proposed National-Level Economic Valuation study should not be adopted.

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[22] *See, e.g.,* Steven Shavell, Contingent Valuation: A Critical Assessment at 372 (1993). "Contingent valuation should not now be used to attempt to measure nonuse values of natural resources, either in public decision making or in liability assessment. In these contexts, society is likely to be better off not seeking to estimate nonuse values with contingent valuation because of the serious problems that this would engender."

[23] 18 CFR 5.9(a)(7) provides that "[a]ny information or study request must . . . [d]escribe considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs."

[24] *See Scoping Document 1 for Susitna-Watana Hydroelectric Project*, Docket No P-14241-000 at §§ 4.2.7-9 (filed Feb.2 2012).

[25] AWA Comments at 9 "We describe the necessary elements of the study . . . but do not explain how the study would be designed and implemented."

[26] AWA states only that "the level of effort is significant, as the study will likely require focus groups and survey instruments." AWA Comments at 11. American Whitewater ignores cost projections entirely.

[27] AWA does not address the revised plan for the Social Conditions and Public Goods and Services Study, but only generally states that a regional study is not appropriate for the project.

[28] Peter A. Diamond, and Jerry A. Hausman, *Contingent Valuation: Is Some Number Better than No Number?,* Journal of Economic Perspectives, Volume 8, Number 4, Fall 1994, pp 45-64 at 45,46.

[29] National Research Council, Committee on Assessing and Valuing Aquatic and Related Terrestrial Ecosystems, *Valuing Ecosystem Services: Toward Better Environmental Decision-Making*, 2004, at 122.

[30] Kenneth Arrow et alia, *Report of the NOAA Panel on Contingent Valuation*, 1993 at 12, 13.

4. GEOLOGY AND SOILS

This study plan will review the existing information on the Susitna-Watana Project (Project) area regarding geology and soils and gather additional information in order to define the geologic, geotechnical, seismic, and foundation conditions at the sites of Project works (e.g., dam, reservoir, access road and T-Line corridors, construction camps, and materials borrow sites). This information will be used to support development of the Project design, with an emphasis on minimizing risks to dam safety. In general, the study tasks will include field investigations, laboratory testing, instrumentation, review of existing studies, studies and assessments, use of digital imagery, and engineering analyses to characterize the conditions, limitations, and constraints for the Susitna-Watana Project in the Project area. The study will also identify impacts of Project construction and operation, such as reservoir impoundment, thawing of frozen soils and bedrock, soil erosion along the reservoir rim, slope stability, excavation, and spoil disposal, on environmental resources.

4.1. Introduction

A Susitna Hydroelectric Project was proposed by the Alaska Power Authority (now the Alaska Energy Authority [AEA]) in the early 1980s. That project was to be composed of two major dams (the Watana Dam and Devils Canyon Dam) constructed in three stages. A draft Environmental Impact Statement was prepared by the Federal Energy Regulatory Commission (FERC), but the application was subsequently withdrawn. The current proposed Project dam is located at river mile (RM) 184, the same location as that of the previously proposed Watana Dam.

The Project is anticipated to include a high concrete arch dam constructed using roller-compacted concrete (RCC) construction methods. The Project will also include a large reservoir, a spillway, cofferdams, diversion tunnels, integrated penstocks and powerhouse, construction and permanent housing, borrow and quarry areas, transmission lines, access roads, and staging and stockpile areas. Each of these features will have an impact on, or will be impacted by, geology and soils over the course of design, construction, and operation of the Project.

4.2. Nexus Between Project Construction / Existence / Operations and Effects on Resources to be Studied

The soil and geological characteristics of the Project area will affect Project design, construction, operation, and maintenance because the Project facility foundations are integral to the soil and rock features of the area and also will serve as raw materials for some Project components. Also, Project design, construction, and operation, including the dam and reservoir, access road, transmission line, and construction camp/village, may affect geological resources by exposing soils and rock to new surface erosional forces, could change the stability of soil and rock slopes, change river sediment load, trigger seismic events earlier, and/or the reservoir could impound potential mineral resources, if present.

Considerations of geology and soil conditions in planning for Project construction, operation, and maintenance will include, but are not limited to the following:

- Proper disposal of spoils from the excavations.
- Geologic features in the foundation that may require additional excavation and foundation treatment.
- Identification of poor rock conditions or the presence of geologic features in the diversion tunnel excavation that may require support and/or lining (e.g., type and thickness).
- Design of rock cut-slopes on the right abutment, particularly in the downstream portal area.
- Identification of seismic sources and design of structures for seismic loading.
- Ice-filled discontinuities in the rock foundation beneath and in the abutments of the dam.
- Design of cut-off walls in the cobble and boulder alluvium beneath the cofferdams.
- Road, transmission tower footing, or camp foundation design to address subsidence due to poor soil conditions or thawing soil.
- Triggering of seismic events in the reservoir proper due to load of the reservoir on the landscape.
- Reservoir sedimentation due to glacial melt and possible surging glacier event.
- Changes to sediment load in the tailwater, downstream of the proposed dam.
- Stability of reservoir slopes due to mass wasting potential, thawing permafrost, and higher pore pressures.

Potential impact mechanisms for soils and geologic features are as follows:

- Soil erosion from slope instability along the reservoir rim due to presence of fine-grained soils and thawing permafrost (discontinuous).
- Seismic activity due to the deep, large reservoir.
- Changes to river channel geomorphology based on reservoir operation.
- Seepage through abutments just upstream of the dam causing piping and soil erosion.
- Soil erosion and slope instability along access road cuts and stream/creek crossings.
- Impoundment of mineral resources.

4.3. Resource Management Goals and Objectives

No Alaskan Native resource management goals have been identified other than the provisions identified under the Alaskan Native Claims Settlement Act (ANCSA) dealing with provision of access to mineral resources. FERC's regulations require the Exhibit E environmental document to include a detailed description of the project's impacts on affected resources, including the information included in the Pre-Application Document (PAD) and developed under the applicant's approved study plan (18 CFR 5.18(b)(5)(ii)(A)). The PAD must include a description of the geology and soils "of the proposed project and surrounding area" and a description of "mineral resources at the project site" (18 CFR 5.6(d)(3)(ii)(A)). The environmental analysis must also include an evaluation of beneficial and adverse effects of the proposed project on affected resources and mitigation measures if appropriate (18 CFR 5.18(b)(5)(ii)(B) and (C)). FERC's Scoping Document 2 (SD2) states that its Environmental Impact Statement (EIS) will include evaluation of the "effects of project construction and operation on access to proven or probable mineral deposits" (SD2, Section 4.2.1). FERC's regulations also require the License Application to include Exhibit F, the supporting design report to show that the project structures are safe and adequate to fulfill their stated functions (18 CFR 5,18(a)(5)(ii) and 4.41(g)(3)).

4.4. Summary of Consultation with Agencies, Alaska Native Entities, and Other Licensing Participants

Specific consultation regarding geology and soils study planning has been limited to informal discussion with the Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, during 2011 as part of planning the geotechnical and seismic investigations for the Project and the Alaska Earthquake Information Center for monitoring and detection of local earthquakes in the state seismograph network. Soil erosion and the potential for reservoir sedimentation and other issues have been discussed in Technical Workgroup (TWG) meetings, and the aquatic aspects of sediments are being addressed in the Geomorphology Study (Section 6.5). In FERC's May 31, 2012 filing of requests for studies and comments on preliminary study plan, a geology and soils assessment study was requested. In addition, Cook Inlet Region, Inc. (CIRI) has submitted a study request (filed May 30, 2012) for a minerals resource assessment that states that "CIRI owns or is entitled to receive conveyance of significant subsurface interests with the area that would be affected by the proposed Project." Both the FERC and CIRI study requests correspond to AEA's proposed geology and soils characterization study, and through this study plan AEA is attempting to meet the expectations and objectives of those study requests.

Summary tables of comments and responses from formal comment letters filed with FERC through November 14, 2012 are provided in Appendix 1. Copies of the formal FERC-filed comment letters are included in Appendix 2. In addition, a single comprehensive summary table of comments and responses from consultation, dated from Proposed Study Plan (PSP filing) (July 16, 2012) through release of Interim Draft RSPs, is provided in Appendix 3. Copies of relevant informal consultation documentation are included in Appendix 4, grouped by resource area.

4.5. Geology and Soils Characterization Study

4.5.1. General Description of the Proposed Study

The overall goals of this study are to conduct a geology and soils evaluation to define the existing geological conditions at the dam site, reservoir, and access and T-line corridors, and to develop design criteria to ensure that the proposed Project facilities and structures will be safe and adequate to fulfill their stated functions. The general objectives of the study plan are as follows:

- Identify the existing soil and geology at the proposed construction site, reservoir area, and access and T-line corridors.
- Determine the potential effects of Project construction, operation, and maintenance activities on the geology and soil resources (including mineral resources) in the Project area including identification and potential applicability of protection, mitigation, and enhancement (PM&E) measures.
- Identify known mineral resources and mineral potential of the Project area.

- Acquire soils and geologic information for the Project area for use in the preparation of a supporting design report that demonstrates that the proposed structures are safe and adequate to fulfill their stated functions.

The field investigation activities for each season will be coordinated with resource agencies and ANCSA Corporation landowners. Geotechnical Exploration Program Work Plans (Work Plans) will be developed that outline the field programs and information needed for submitting applications and obtaining land access permits from applicable agencies and ANCSA Corporation landowners. The Work Plans will identify known impacts to geology and soil resources in the Project area, including the dam, reservoir, and access and T-line corridors. FERC regulations require "evaluation of unconsolidated deposits, and mineral resources at the project site" (18 CFR 5.6(d)(3)(ii)(A)). For the Exhibit E, AEA must provide a report on the geological and soil resources in the proposed Project area and other lands that would be directly or indirectly affected by the proposed action and the impacts of the proposed Project on those resources. This study report will provide the basis of the information needed for the Exhibit E.

4.5.2. Existing Information and Need for Additional Information

Extensive field investigations and studies were undertaken during the 1970s and 1980s for the Watana Dam Site to characterize the geologic, seismic, and foundation conditions for a different type of dam (earthfill embankment) with a much larger footprint and a higher normal mean reservoir operating level.

These studies included the following:

- Regional mapping of surficial deposits (rock and soil) using aerial photography and geologic reconnaissance (Acres 1982b).
- Studies of reservoir slope stability (Acres 1982a, 1982b).
- Subsurface explorations through geophysical surveys, borings, test pits, and trenches (USACE 1975, 1979; Acres 1982b, 1982c; Harza-Ebasco 1983, 1984).
- Preliminary evaluations of borrow and quarry sites (USACE 1979; Acres 1982b, 1982c).
- In situ hydraulic testing and downhole geophysical surveys of rock and soil (Acres 1982b, 1982c; Harza-Ebasco 1983, 1984).
- Instrumentation (groundwater and ground temperature observations and monitoring [USACE 1979; Acres 1982b, 1982c; Harza-Ebasco 1983, 1984]).
- Laboratory testing of physical properties of rock and soil (USACE 1979; Acres 1982b, 1982c; Harza-Ebasco 1983, 1984).
- Site-specific seismic hazard evaluations, including lineament, fault and ground motion evaluations; monitoring of local seismic events (WCC 1980, 1982).
- Evaluation of reservoir induced seismicity (RIS) (WCC 1982).
- Geology and soil resources (Harza-Ebasco 1985).

In summary, the following geotechnical investigations and testing were performed prior to 1986 and in 2011–2012:

- Geologic interpretation (e.g., terrain unit mapping) and seismic source identification using aerial photography and satellite imagery.
- Geologic mapping of dam site and reservoir areas.

- Drilling at the dam site, construction materials source areas, geologic features (i.e., relict channel near dam site), proposed permanent camp/village, access road corridor, etc.
- Instrumentation monitoring (groundwater and ground temperature).
- Seismic refraction surveys, wih some electrical resistivity and ground-penetrating radar (GPR) surveys.
- Test trenches and pits (Borrow Areas D, E, I, J).
- Site-specific seismic hazard investigations and evaluations.
- Trenching of lineaments and faults.

For this study, the existing information, coupled with new field investigations and studies, geologic mapping, and Light Detection and Ranging (LiDAR) and Interferometric Synthetic Aperture Radar (InSAR) imagery data, will provide specific information on the properties of Project-site-specific rock and soil units that would be affected by the newly proposed Project.

4.5.3. Study Area

The study area will include the dam site area, reservoir area, construction material sources, tailwater downstream of the dam, access road and transmission line corridors, airport facilities, and construction camp and permanent village sites (Figure 1.2-1).

4.5.4. Study Methods

The study of geology and soils resources for supporting licensing and detailed design will include a number of components:

- Develop an understanding of geologic and foundation conditions for the dam site area and specifically for each of the surface and underground components of the Project.
- Evaluate abutment stability.
- Develop an understanding and characterize the geology and soil resources in the Project area (dam and reservoir areas and access and T-line corridors.
- Evaluate the mineral resource potential in the impoundement area, reservoir area up to approximately elevation 2,075 feet, and dam and camp facilities area.
- Evaluate major geologic features, rock structure, weathering/alteration zones, etc. in the dam site and reservoir areas.
- Delineate and characterize construction material sources for the dam and appurtenant structures, access road, transmission line, and construction camp.
- Evaluate the surficial geology, mass wasting features, and potential thawing of localized permafrost on reservoir slope stability.
- Seismic source characterization, site-specific ground motion evaluation, and probabilistic seismic hazard assessment (see Section 16).
- Evaluate reservoir leakage and piping.

Study methods are discussed below.

Review of Project Documentation

The existing documentation from the 1970s and 1980s will be brought into geo-referenced, geotechnical databases to build new information on the earlier studies in digital formats.

Regional Geologic Analysis and Mineral Resources Assessment

Existing published information, air photo interpretation and reconnaissance mapping, and new LiDAR survey data will be used to: (1) update information about the geology at the proposed Project and in the surrounding area, including surficial and bedrock geology, geologic structure, seismicity and tectonics, mass wasting, and mineral resources; (2) determine siting of Project components or structures; (3) identify geologic features of significance; and (4) assess potential impacts and potential mitigation measures to address impacts (e.g., erosion) on geology and soil resources and Project construction. A survey of the mineral resources will be performed to assess proven and probable mineral resources potential and mining activity in the impoundment area using existing data. The impoundment area is the area where access to mineral resources may be affected by the Project. In addition to the impoundment area, the road and transmission corridors will be evaluated for potential quarry and aggregate sites and known mineral deposits to identify if access to mineral resources may be adversely or beneficially affected by the Project. The survey will entail mapping of known mineral deposits, identification of likely areas of mineral resources, plus field reconnaissance of selected areas of high mineral potential, review of area mining claims, and analysis of mineral potential from borings and other sampling work done for the dam and other facilities ongoing geotechnical investigations. AEA will consult with the Bureau of Land Management (BLM) and the U.S. Geological Survey (USGS) on this study plan to determine that appropriate methods and evaluation techniques are used for the mineral resource investigation.

Recently-acquired LiDAR and InSAR data in the region will be used to identify lineaments of faults for evaluation of activity and Project significance. Field reconnaissance, geologic mapping, and subsurface investigations, if necessary, will be performed and the data will be used to update the seismic source characterization, site-specific ground motion evaluations, and probabilistic seismic hazard assessment (PSHA) (see Section 16).

Geologic and Geotechnical Investigation and Testing Program Development

The development of a geologic and geotechnical exploration and testing program Work Plan for completion of geologic field studies for final design and ultimately for construction will be undertaken. Based on review of the existing data including previous geologic mapping, subsurface investigations, and laboratory testing from the 1970s and 1980s, and recent studies (2011–2012), additional investigations and testing will be conducted as described below:

- Delineate and characterize geology and soil resources including geologic features, rock structure, weathering/alteration zones.
- Undertake physical and chemical testing, as well as petrographic analysis, to characterize the geology and soils materials, as appropriate.
- Evaluate lineaments and faults relative level of activity and significance to site-specific ground motion evaluations for the Project.
- Delineate and characterize construction material sources for the dam and appurtenant structures, access road, and construction camp.
- Determine the effects of discontinuous permafrost on the dam foundation and abutments relative to foundation treatment, grouting, and drainage, as well as reservoir slope stability and access road and T-line construction.

- Evaluate the effect of Project features on permafrost and periglacial features (thawing of permafrost), as well as the impact of these features on permanent structures, work camps, temporary construction areas, road corridors, transmission lines, etc.
- Evaluate the need for, and potential sources of, borrow for ancillary facilities including upland structures, access roads, and transmission lines.
- Evaluate potential waste stockpiles and storage sites including plans to help reduce the impact of these facilities on adjacent areas.
- Evaluate plans and methods for the reclamation of borrow area and quarry sites.
- Evaluate the Project's impact on access to geologic resources (mineral resources) by reviewing existing state and federal databases, as well as readily available geologic maps and surveys.
- Conduct a preliminary evaluation of the effect of soils composition in the Project area on construction, operation, and maintenance of the proposed Project.
- Evaluate potential reservoir leakage on the right abutment just upstream of the dam site (e.g., relict channel).
- Establish seismic monitoring stations in the Project area to augment the stations in the Alaska Earthquake Information Center network to monitor and detect any local earthquakes.

Field Geologic and Geotechnical Investigations

Geologic and geotechnical field investigations will be carried out in phases (2011–2015) with portions of that work contributing to the report on geology and soils in 2013 and updates in 2014. The geotechnical investigations and testing undertaken as part of the Project feasibility and design effort will include geologic mapping, drilling, sampling and in situ testing, test trenches, pump tests, test adit, laboratory testing, instrumentation monitoring, etc. Initial and limited geologic exploration and testing programs were undertaken in the 2011–2012 seasons to investigate the dam foundation and a new quarry site for concrete aggregate material, installation and monitoring of geotechnical instrumentation, and reconnaissance geologic mapping.

Reservoir-Triggered Seismicity

Seismic evaluations are being undertaken for the Project under a separate study (see Section 16) and will include installation of a long-term earthquake monitoring system. The Geology and Soils and Seismic Characterization Studies would contribute information to that study.

Reservoir Slope Stability Study

An assessment will be made of reservoir rim stability based on the geologic conditions in the reservoir area, particularly in the reservoir drawdown zone. Geologic information from the previous study on reservoir slope stability (Acres 1982a) as well as LiDAR imagery, geologic mapping, field investigations, and instrumentation monitoring will be used to assess the stability concerns of the reservoir rim area. Key factors in this study are the planned reservoir level and anticipated range of drawdown, rock and soil type and conditions, presence of permafrost, topography, and slope aspect and conditions.

Geologic and Engineering Analyses

The analysis will identify and evaluate construction material sources to provide adequate quantities for construction, suitable alignments and foundation design for the access road, construction, permanent camps, and transmission lines; and identify re-use of excavated materials and/or disposal areas. The study will also assess the soil erosion potential along the transmission and road corridors, along with other effects of design and construction on geology and soils, and identify the suitability of measures to reduce and mitigate impacts.

Additionally, a number of geologic, seismic, and engineering analyses will be undertaken to develop the geologic model and to assess foundation design, abutment stability, seepage and piping potential, slope stability, ground motion evaluations, and site-specific probabilistic seismic hazard assessment for the dam site area. The study will also identify impacts and measures to mitigate impacts to geology and soil resources.

4.5.5. Consistency with Generally Accepted Scientific Practice

Studies, field investigations, laboratory testing, engineering analysis, etc. will be performed in accordance with general industry accepted scientific and engineering practices. The methods and work efforts outlined in this study plan are the same or consistent with analyses used by applicants and licensees and relied upon by FERC in other hydroelectric licensing proceedings.

4.5.6. Schedule

The proposed study includes a limited field investigation program in 2012 for interpretation of digital imagery, reconnaissance geologic mapping, drilling, paleoseismic or lineament analysis, installation of a long-term earthquake monitoring system, assessment of slope stability for the reservoir rim, and reservoir triggered seismicity study. For 2013–2015, comprehensive investigations will focus on the dam site, reservoir area, and access road and transmission line corridors. Initial and Updated Study Reports explaining actions taken and information collected to date will be issued within 1 and 2 years, respectively, of FERC’s Study Plan Determination (i.e., February 1, 2013). Updates on the study progress will be provided during Technical Workgroup meetings which will be held quarterly in 2013 and 2014.

The primary activities and planned schedule are shown in Table 4.5-1.

Table 4.5-1. Schedule for implementation of the Geology and Soils Study.

Activity	2012				2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1Q
Geo-Reference 1980s Investigations	—	—	—	—									
Regional Geologic and Mineral Assessment			—	—									
Field Investigations		—	—		—	—	—	—	—	—	—	—	
Geology and Soils Mapping			—	—	—	—	—						
Reservoir Slope Stability Analysis				—	—		—	—					
Initial Study Report								—Δ					
Follow-on Investigations as Needed									- - -	- - -	- - -	- - -	- - -
Updated Study Report							—	—	▲				

Legend:

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

4.5.7. Relationship with Other Studies

The Geology and Soils Study will provide information that will be used in several other studies, as shown in Figure 4.5-1. The geology and soils mapping will be important to complete in 2013 to provide the baseline spatial data to the cultural and botanical resources studies. The reservoir slope stability analysis will take place in 2013, which will then feed into the geomorphology study using the initial reconnaissance-level information as input into the geomorphology analysis.

4.5.8. Level of Effort and Cost

The study plan will involve a phased, multiple-year approach that will include field investigations from 2012 through 2015 with associated studies and engineering analysis. The estimated level of effort is estimated to be in excess of 4,500 hours plus expenses. The total cost of the study will be between an estimated $1,000,000 and $1,500,000. This work is part of a much larger geotechnical investigation program for the Project that will be undertaken through the engineering design activities.

4.5.9. Literature Cited

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USACE (U.S. Army Corps of Engineers). 1975. Hydroelectric Power and Related Purposes, Southcentral Railbelt Area, Alaska Upper Susitna River Basin. Department of the Army, Alaska District, Corps of Engineers. December 12, 1975.

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WCC. 1982. Final Report on Seismic Studies for Susitna Hydroelectric Project. Prepared for Acres American, Inc.

4.5.10. Figures

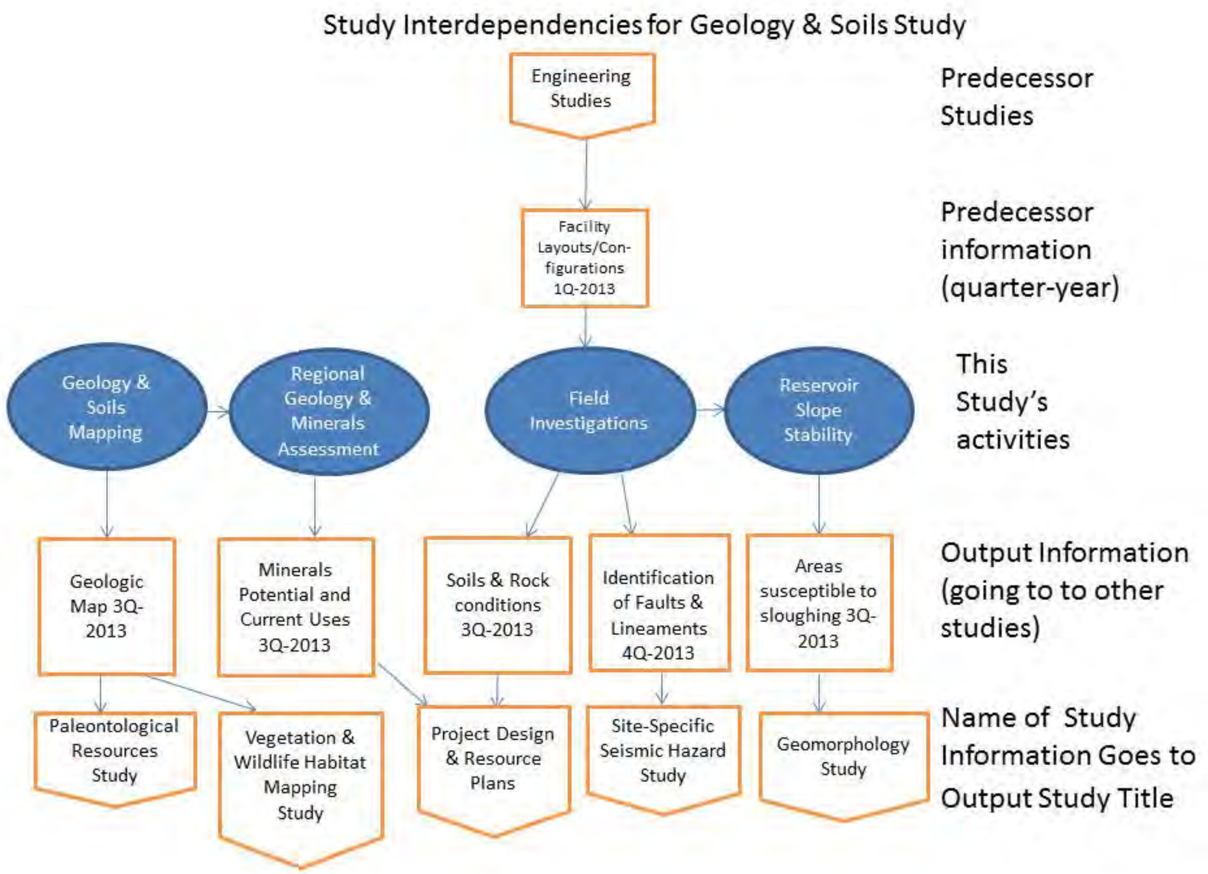

Figure 4.5-1. Interdependencies for Geology and Soils Study.

5. WATER QUALITY

5.1. Introduction

Construction and operation of the Susitna-Watana Project (Project) will change the Susitna River reach inundated by the Project reservoir, as well as portions of the drainage down-gradient. Changes will include flow, water depth, surface water elevation, water chemistry, channel characteristics, and sediment deposition. The potential effects of the Project need to be carefully evaluated as part of the licensing process because changes to these parameters may adversely affect aquatic and riparian habitat quality, which can in turn affect fish populations, riparian-dependent species, and recreation opportunities along the river corridor.

This section of the RSP describes the water quality studies that will be conducted to characterize and evaluate these effects. These studies will be subject to revision and refinements with input from licensing participants as part of the continuing study program identified in the (Integrated Licensing Process (ILP). The impact assessments will inform development of any protection, mitigation, and enhancement measures to be presented in the draft and final License Applications, as appropriate. A glossary of commoly used terms and acronyms is included in Attachment 5-4.

Water quality studies each generate data that will be used to assess current conditions, calibrate a predictive water quality model, and assess presence and potential impact of toxics (e.g., mercury) on aquatic life. The three water quality studies are integrated by using products from each (e.g., water quality data, predicted water quality conditions under various operational scenarios, and evaluation of potential toxics effects on aquatic life) and then combined to assess potential for water quality impacts from an ecosystem perspective. Objectives described for Study Plan 5.5 (Baseline Water Quality Monitoring), Study Plan 5.6 (Water Quality Modeling), and Study Plan 5.7 (Mercury Assessment and Potential for Bioaccumulation) reflect the focus on establishing a baseline description of pre-dam water quality and evaluation of water quality conditions and impacts during a post-dam period.

5.2. Nexus Between Project Construction / Existence / Operations and Effects on Resources to be Studied

As discussed above, the Project will change elements of the physical environment, which in turn will affect other resources (riparian communities, biological resources, recreational opportunities). Having a clear understanding of Project effects on water quality allow a better analysis of impacts to the physical environment within the Susitna River corridor, which will be critical to the environmental analysis of the Project.

5.3. Resource Management Goals and Objectives

Water quality in Alaska is regulated by a number of state and federal regulations. This includes the federal Clean Water Act (CWA), and the State of Alaska Title 18, Chapter 70, of the Alaska Administrative Code (18 AAC 70). Aquatic resources including fish and their habitats, and wildlife resources, are generally protected by a variety of state and federal mandates. In addition, various land management agencies, local jurisdictions, and non-governmental interest groups have specific goals related to their land management responsibilities or special interests. These goals are expressed in various statutes, plans, and directives.

In addition to providing information needed to characterize the potential Project effects, these water resources studies will inform the evaluation of possible conditions for inclusion in the Project license. These studies are designed to meet Federal Energy Regulatory Commission (FERC) licensing requirements and also to be relevant to recent, ongoing, and/or planned resource management activities by other agencies.

5.4. Summary of Consultation with Agencies, Alaska Native Entities, and Other Licensing Participants

These study plans have been modified in response to comments from various agency reviewers, including the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS); the Alaska Department of Environmental Conservation (ADEC); and the U.S. Fish and Wildlife Service (USFWS). Consultation on the study plan occurred during licensing participant meetings on April 6, 2012, and during the June 14, 2012 Water Resources Technical Workgroup (TWG) meeting. At the June 2012 TWG meeting, study requests and comments from the various licensing participants were presented and discussed, and refinements were determined to address agreed-upon modifications to the draft study plans. Additional comments were received during the August 17 and October 23, 2012 TWG meetings.

Summary tables of comments and responses from formal comment letters filed with FERC through November 14, 2012, are provided in RSP Appendix 1. Copies of the formal FERC-filed comment letters are included in RSP Appendix 2. In addition, a single comprehensive summary table of comments and responses from consultation, dated from Proposed Study Plan (PSP) filing (July 16, 2012) through release of Interim Draft RSPs, is provided in RSP Appendix 3. Copies of relevant informal consultation documentation are included in RSP Appendix 4, grouped by resource area.

5.5. Baseline Water Quality Study

5.5.1. General Description of the Proposed Study

The collective goal of the water quality studies is to assess the effects of the proposed Project and its operations on water quality in the Susitna River basin, which will inform development of any appropriate conditions for inclusion in the Project license. The Project is expected to change some of the water quality characteristics of the resulting riverine portion of the drainage once the dam is in place as well as the inundated area that will become the reservoir.

The objectives of the Baseline Water Quality Study are as follows:

- Document historical water quality data and combine with data generated from this study. The combined data set will be used in the water quality modeling study to predict Project impacts under various operations (Section 5.6).
- Add three years of current stream temperature and meteorological data to the existing data. An effort will be made to collect continuous water temperature data year-round, with the understanding that records may be interrupted by equipment damage during river floods, ice formation around the monitoring devices, ice break-up and physical damage to the anchoring devices, or removal by unauthorized visitors to a site.
- Develop a monitoring program to adequately characterize surface water physical, chemical, and bacterial conditions in the Susitna River within and downstream of the proposed Project area.
- Measure baseline metals concentrations in sediment and fish tissue for comparison to state criteria.
- Perform a pilot thermal imaging assessment of a portion (between Talkeetna and Devils Canyon) of the Susitna River. Discussion of thermal refugia data collection is located in Section 5.5.4.9.

5.5.2. Existing Information and Need for Additional Information

Historical water quality data available for the study area includes water temperature data, some general water quality data, and limited metals data primarily collected during the 1980s (URS 2011). Additional data has been recently collected by the U.S. Geological Survey (USGS) at limited mainstem Susitna sites describing flow, in situ, general, and metals parameters. The following is a summary of existing water quality data:

Lower Susitna from Cook Inlet to the Susitna – Chulitna –Talkeetna confluence (River Mile 0-98)

- Large amounts of data were collected in this reach during the 1980s. Very little data are available that describe current water quality conditions.
- Metals data are not available for the mouth of the Chulitna River. The influence of major tributaries (Chulitna and Talkeetna rivers) on Susitna River water quality conditions is unknown. There are no monitoring stations in receiving water at these mainstem locations.
- Metals data are not available for the Skwentna River or the Yentna River.

- Continuous temperature data, general water quality data, and metals data are not available for the Susitna River mainstem and sloughs potentially used for spawning and rearing habitat.

Middle Susitna River and tributaries from the Susitna – Chulitna–Talkeetna confluence to the mouth of Devils Canyon (River Mile 98-150)

- The source(s) for metals detected at high concentrations in the mainstem Susitna River is unknown.
- Current data reflects large spatial data gaps between the upper river and the mid to lower portions of the river.
- Continuous temperature data are not available for the Susitna River mainstem, tributary, and sloughs potentially used for spawning and rearing.

Middle Susitna River from Devils Canyon to the proposed Watana Dam site (River Mile 150-184)

- Temperature data are not available above and below most tributaries on the mainstem Susitna River.
- Overall, very limited surface water data are available for this reach.
- Metals monitoring data do not exist or are limited.
- Concentrations of metals in sediment immediately below the proposed Project are unknown. Metals in these sediments may become mobile once the Project begins operation.
- Monitoring of Susitna River mainstem and sloughs (ambient conditions and metals) is needed for determining the potential for metal bioaccumulation in fishes.

Upper Susitna River including headwaters and tributaries above the proposed Watana Dam site (River Mile 184-313)

- Surface water and sediment analysis for metals are not available for the Susitna River mainstem, only for one tributary.
- Information on concentrations of metals in media and current water quality conditions is needed to predict if toxics can be released in a reservoir environment.
- Continuous temperature data are not available for Susitna River mainstem, tributary, and sloughs potentially used for spawning and rearing.

Overall

- Limited fish tissue sampling has been performed in the Susitna River by ADEC and USGS (ADEC 2012; Frenzel 2000).

A large-scale assessment of water quality conditions throughout the Susitna River drainage has not been completed. The proposed overall assessment will be used to establish background water quality parameters. This need was identified in the Data Gap Analysis for Water Quality (URS 2011).

Water temperature monitoring was primarily done in the middle river portion of the Project area during the 1980s. The purpose for collection of this data was to model post-dam temperature conditions and to predict the potential for impact on thermal refugia for fish downstream of the proposed dam site. An expanded network of continuous temperature monitoring data and water quality data (including sediment, surface water, and potentially pore water) collection is required for the Project because of the following:

- More information is needed to define existing thermal refugia throughout the Susitna drainage.
- Limited information is available on natural, background conditions for water quality.
- It is unknown if seasonal patterns exist for select water quality parameters.
- Additional information is required for calibrating the water quality model to be used (Section 5.6). More recent water quality data will be used for predicting reservoir conditions and predicting riverine conditions downstream of the proposed dam.

The current proposal includes expansion of the temperature monitoring effort from river mile (RM) 15.1 to 233.4, encompassing both the lower end of the riverine portion of the Project area and above the proposed area of inundation by the reservoir. Monitoring sites are located at the same sites characterized during the 1980s studies, as well as at additional sites. Monitoring of areas of the mainstem Susitna River or tributaries with high metals concentrations or temperature measurements (based on the Data Gap Analysis for Water Quality (URS 2011) will confirm previous observations and will describe the persistence of any water quality exceedances that might exist.

Locations in the mainstem Susitna River and tributaries where high metals concentrations were historically identified in surface water lack sediment analysis data to determine potential sources that can be mobilized. The linkage between sediment sources, mobilization into the water column (dissolved form), and the potential for bioaccumulation in fish tissue presents a potential human health concern with respect to mercury contamination. The consumption of mercury in fish tissue will be addressed by co-locating a limited number of surface water, sediment, and fish tissue monitoring sites (and sampling events) where there is the greatest likelihood for bioaccumulation. The proposed Project may have the potential to exacerbate bioaccumulation of toxics beyond that occurring under current conditions. The initial monitoring will identify select monitoring locations and media (e.g., surface water, pore water, and sediment) for sampling and suggest the need for more detailed, site-specific sampling if a potential risk from bioaccumulation is found.

The available historical data are not continuous over time or over spatial areas of the Susitna drainage. The discontinuities in the data record limit the opportunity for conducting a complete assessment of current water quality conditions that define natural background, the spatial extent of higher than expected concentrations of metals (and select parameters), and identification of source and timing of pollutant entry into the Susitna drainage. The expanded data record beyond existing information will be used to develop a model of the proposed reservoir and for evaluating water quality changes in the existing riverine system resulting from reservoir operations.

5.5.3. Study Area

The study area for water quality monitoring includes the Susitna River from RM 15.1 to RM 233.4, and select tributaries within the proposed transmission lines and access corridors. Water quality and water temperature data loggers were installed at 33 of 39 sites identified in Table 5.5-1 and Figure 5.5-1 as part of the 2012 Baseline Water Quality Study.

5.5.4. Study Methods

The Baseline Water Quality Study has several components that address needs for water quality modeling and for detecting the location and magnitude of water quality issues. The proposed water quality monitoring locations and water quality parameter list fill in substantial data gaps throughout the project area from historical data collected beginning 1975 through 2003 (URS 2011). Besides the utility of water quality data in calibrating the water quality model, establishment of a comprehensive baseline of water quality descriptions will be useful for comparison to historical water quality data and future scenarios based on model predictions and with future data collection.

Data will be collected from multiple aquatic media including surface water, sediment, and fish tissue. Continuous temperature monitoring will inform the predictive model on how the mainstem river and tributaries will respond to Project operations and if changes in water quality conditions could affect aquatic life use and survival in the Project area. In addition, several other requirements of the 401 Water Quality Certification Process will be addressed with collection and description of additional data, including the following:

- Conducting a water quality baseline assessment
- Describing how existing and designated uses are met
- Using appropriate field methods and models
- Using acceptable data quality assurance methods
- Scheduling of technical work to meet deadlines
- Deriving load calculations of potential pollutants (pre-Project conditions)

Two types of water quality monitoring activities will be implemented: (1) routine monitoring for characterizing water quality baseline conditions, and (2) a single, comprehensive survey for a larger array of parameters (Section 5.5.4.5). Frequency of sampling water quality parameters varies by category and potential for mobilization and bioavailability. Most of the general water quality parameters and select metals will be sampled on a monthly basis because each parameter has been demonstrated to be present in one or both of surface water and sediment (URS 2011). An initial screening survey has been proposed for several other toxics that might be detected in sediment and tissue samples (Table 5.5-4). The single surveys for toxics in sediment, tissue, or water will trigger additional study for extent of contamination and potential timing of exposure if results exceed criteria or thresholds (e.g., LAETs, LC_{50}s, etc.). The general list of water quality parameters and metals will be used in calibrating the water quality model (Section 5.6) in both a riverine and reservoir environment.

Twelve mainstem Susitna River monitoring sites are located below the proposed dam site and two mainstem sites above this location. Six sloughs will be monitored that represent a combination of physical settings in the drainage and that are known to support important fish-rearing habitat. Tributaries to the Susitna River will be monitored and include those contributing large portions of the lower river flow including the Talkeetna, Chulitna, Deshka, and Yentna rivers. A partial list of the remaining tributaries that will be monitored represent important spawning and rearing habitat for anadromous and resident fisheries and include Gold Creek, Portage Creek, Tsusena Creek, Watana Creek, and Oshetna Creek. The operation of temperature monitoring sites will continue as part of water quality monitoring activities in 2013/2014. These sites were selected based on the following rationale:

- Adequate representation of locations throughout the Susitna River and tributaries above and below the proposed dam site for the purpose of a baseline water quality characterization.
- Location on tributaries where proposed access road-crossing impacts might occur during and after construction (upstream/downstream sampling points on each crossing).
- Preliminary consultation with licensing participants including co-location with other study sites (e.g., instream flow, ice processes).
- Access and land ownership issues.
- Eight of the sites are mainstem monitoring sites that were previously used for SNTEMP modeling (see Section 5.6) in the 1980s. Thirty-one of the sites are Susitna River mainstem, tributary, or slough locations, most of which were monitored in the 1980s.

Monitoring sites are spaced at approximately five-mile intervals so that the various factors that influence water quality conditions are captured and support the development (and calibration) of the water quality model. Frequency of sites along the length of the river is important for capturing localized effects from tributaries and from past and current human activity. Additional sampling to characterize variability in water quality conditions on six cross-sections of the river will be completed. This objective for this sampling strategy will address potential influence of channel complexity (multiple channels, braiding, etc.) on both the Susitna River and tributary water quality. These data will also enable the water quality model (Section 5.6) to predict conditions in 3-dimensions (longitudinally, vertically, and laterally).

5.5.4.1. Water Temperature Data Collection

Water temperatures are being recorded in 15-minute intervals using Onset TidbiT v2 water temperature data loggers (or equivalent instrumentation). Data collection began in late June 2012 and will continue through the winter of 2012/2013. At this time it is unclear if the equipment will survive physical damage or interruption of temperature logging from ice break-up and sedimentation during the winter. Temperature data has been retrieved from 33 of 39 sites representing a partial or whole record from third week in July 2012 through end of September 2012. Deployment and continuous temperature data logging will continue for each of the two following years (2013 and 2014) using the same apparatus and deployment strategy at all 39 sites. The TidbiT v2 (or equivalent) has a precision sensor for plus or minus 0.4 degrees Fahrenheit (°F) (0.2 degrees Celsius [°C]) accuracy over an operational range of -4°F to 158°F (-20°C to 70°C). Data readout is available in less than 30 seconds via an Optic USB interface.

To reduce the possibility of data loss, a redundant set of data loggers will be used at each site (where possible). In general, the two sets of sensors will be installed differently (depending on site characteristics). One logger will be inserted into the bottom of an 8.2-foot (2.5-meter) length of perforated steel pipe housing that is fastened to a large bank structure via clamps and rock bolts. A shorter or longer perforated steel pipe may be used depending on location of suitable anchoring places. The logger will be attached to a cable that allows it to be easily retrieved for downloads. To prevent theft or vandalism, the top pipe cap will contain a locking mechanism that can only be opened using the appropriate Allen key. The second set of temperature loggers will be anchored to a 2-foot section of a steel rail and buoyed to record continuous bottom, mid, and surface temperature conditions throughout the water column. The anchor rail will be placed at a channel location that is accessible during routine site visits and will be attached with a steel cable to a post that is driven into the bank or to some other structure. The proposed installation procedures may require some alteration based on site-specific conditions.

The sensors will be situated in the river to record water temperatures that are representative of the mainstem or slough being monitored, avoiding areas of groundwater upwelling, unmixed tributary flow, direct sun exposure, and isolated pools that may affect the quality of the data.

The 2012 Fish and Aquatics Instream Flow Study installed water-level loggers with temperature recording capability at several study sites and are further described in Section 8.5.4.4 of the Fish and Aquatic Instream Flow Study Plan.

Where these study sites overlap the water temperature monitoring study sites (Figure 5.5-1), the water-level logger temperature sensors may be used. However, a redundant TidbiT v2 would be deployed at these sites for backup temperature recording, especially for year-round temperature monitoring.

5.5.4.2. Meteorological Data Collection

Meteorological (MET) data collection stations were installed in three new locations during 2012. Table 5.5-2 lists those MET station locations as well as three additional MET stations to be installed, if needed, by the Water Quality Modeling Study (Section 5.6).

The three MET stations installed in 2012 are located between RM 136.8 and RM 224.0. One MET station near the Susitna-Watana Dam site was established above the projected height of the pool elevation and proposed dam height. The upland MET station was established at about the 2,300-foot elevation on the north side of the river, in the area of the proposed field camp, and will record snowfall data and precipitation. The near river site MET station was located on the north abutment just above river level based on the suitability of location for establishing the structure.

Existing MET stations were fitted with additional monitoring equipment to expand data collection that meets project needs and to use historical information collected from each of these sites (Table 5.5-2). Data records from other studies will be used, wherever available, to help generate information for the required parameters needed for construction of the water quality models (Section 5.6). The linkage between historical records and continuing data records may be used in evaluating the utility of 1980s temperature data for modeling.

All six possible MET stations are spatially distributed on the Susitna River from RM 25.8 to RM 224.0 and represent a range of distinct physical settings throughout the Project area. MET stations transfer data generated at 15 minute intervals by a telemetry system and stored on a digital server in Talkeetna, AK. The three additional MET station sites may be necessary if current site placement is inadequate to represent the needs of water quality model development. This determination will be made in the spring of 2013. Parameters measured by each of the MET stations will be compared with the nearest down-gradient site and evaluated for adequacy of representation of weather conditions in that reach. If data recorded between successive sites are distinctly different, then additional sites will be proposed so that weather descriptions for use in the water quality model calibration phase (Section 5.6) will be improved with greater detail.

5.5.4.3. MET Station Parameters

MET stations will collect parameters that support the activities of the engineering design team and the development of the water quality temperature model. Snow depth will be estimated from the precipitation gage with the onset of the winter season. Evapotranspiration is measurable within deciduous canopies; however, the MET station placement will not be under vegetation canopies so that parameters (like wind speed, etc.) necessary for establishing conditions on the reservoir can be measured. Precipitation will be an added parameter to each station beginning in 2013 and estimated as snow depth as the season progresses following October 2013. Solar radiation will be measured using proposed meteorological instruments and solar degree days derived from these measurements. The following is a comprehensive list of parameters required for use in this Project and will be measured by each of the MET stations:

- Temperature (maximum, minimum, mean)
- Relative humidity
- Barometric pressure
- Precipitation
- Wind speed (maximum, minimum, mean)
- Wind direction
- Wind gust (maximum)
- Wind gust direction
- Solar degree days (from solar radiation)

5.5.4.3.1 MET Station Installation and Monitoring Protocol

Each MET station will consist of, at a minimum, a 10-foot (3-meter) tripod with mounted monitoring instrumentation to measure the parameters identified above (Figure 5.5-2). The station loggers will have sufficient ports and programming capacity to allow for the installation of instrumentation to collect additional MET parameters as required. Such installation and re-programming can occur at any time without disruption of the data collection program.

MET station installation is intended to provide instrumentation that will work continuously with little maintenance and produce high quality data through a telemetry system.

A Campbell Scientific CR1000 data logger will be used to record data. The archiving interval for all MET parameters will be 15 minutes, with a 2-year storage capacity. The MET station will be powered by a 12 Vdc 8 amp-hour battery and a 20-watt solar panel complete with charge regulator.

To protect the stations from wildlife intrusion and to discourage any potential vandalism, the stations may be protected by fencing as appropriate.

5.5.4.3.2 Satellite or Radio Telemetry Communications System

Real-time data will be downloaded from MET stations using satellite transmission or radio telemetry hardware. This will enable study staff to download, inspect, and archive the data as well as monitor station operational parameters for signs of problems without visiting the site. The communication will ensure that problems, if they occur, are resolved promptly to minimize data loss between service periods.

5.5.4.4. Baseline Water Quality Monitoring

The purpose of the Baseline Water Quality Study is to collect baseline water quality information that will support an assessment of the effects of the proposed Project operations on water quality in the Susitna River basin. Effects of the proposed Project operations will be determined by using baseline water quality monitoring data in the EFDC (Environmental Fluid Dynamics Code) model described in Section 5.6, Water Quality Modeling Study. There are two types of monitoring programs proposed for characterizing surface water conditions that are distinguished by the frequency of water sampling and the density of sampling effort in a localized area (Baseline Water Quality Monitoring and Focus Area Monitoring). The large-scale monitoring program (at sites from RM 15.1 to RM 233.4) will be used to calibrate the Susitna River water quality model.

Baseline water quality collection can be broken into two components: in situ water quality sampling and general water quality sampling. In situ water quality sampling consists of on-site monthly measurements of physical parameters at fixed locations using field equipment. General water quality sampling will consist of monthly grab samples that will be sent to an off-site laboratory for analysis. The laboratory will have at a minimum, National Environmental Laboratory Accreditation Program (NELAP) certification in order to generate credible data for use by state, federal, and tribal regulatory programs for evaluating current and future water quality conditions. In general, these samples represent water quality components that cannot be easily measured in situ, such as metals concentrations, nitrates, etc.

Water quality data collection will be at the locations in bold in Table 5.5-1. The initial sampling will be expanded if general water quality, metals in surface water, or metals in fish tissue exceed criteria or thresholds. Additional contiguous sample sites will be visited on this list beginning the following sampling month wherever criteria or thresholds have been exceeded by individual parameters. This proposed spacing follows accepted practice when segmenting large river systems for development of Total Maximum Daily Load (TMDL) water quality models. Sampling during winter months will be focused on locations where flow data is currently collected (or was historically collected by USGS) and will be used for water quality modeling (Section 5.6).

5.5.4.4.1 Monitoring Parameters

Water quality samples will be analyzed for several parameters reported in Table 5.5-3. Metals monitoring for total and dissolved fractions in surface water include the full set of parameters used by ADEC in fish health consumption screening. The creation of a reservoir and potential alteration of surface water downstream of the proposed dam site may change characteristics of groundwater in the upper and middle Susitna basin. The water quality parameters identified in Table 5.5-3 will address the influence surface water may have on adjoining groundwater supplies in the vicinity of each sampling site. Changes to groundwater quality may have an effect on drinking water supplies, so several parameters included on the inorganic chemical contaminants list have been included as part of this sampling program (ADEC 2003). The criteria that will be used for comparison with sampling results are the drinking water primary maximum contaminant levels.

Additional parameters will be measured from all sites in a single survey that occurs during low water conditions (e.g., August/September) in the Susitna basin. The following is a list of pollutants for which Alaska Water Quality Standards have established water quality criteria (18 ACC 70.020(b)) for protecting designated uses in fresh water:

- Continuous temperature monitoring program
  - Temperature, already included as part of the continuous temperature monitoring program.
- In situ monitoring program
  - pH, included as part of the monthly water quality sampling routine.
  - Color, categorical observation.
  - Residues, categorical assessment (floating solids, debris, sludge, deposits, foam, or scum).
- General water quality program
  - Dissolved gas, included in the monitoring program (dissolved oxygen).
  - Dissolved inorganic substances (total dissolved solids), included in monthly monitoring.
  - Turbidity, already included as part of the monthly water quality sampling routine.
  - Toxic and other deleterious organic and inorganic, already included in monitoring for metals and mercury/methylmercury (organometals).
- One-time survey
  - Fecal coliform bacteria, included in monthly monitoring.
  - Sediment, already included in assessing mercury and other metals from sediments.
  - Petroleum hydrocarbons, oil, and grease, included in a one-time survey.
  - Radioactivity; radionuclide concentrations to be generated from surface water samples.
  - Toxic and other deleterious organic and inorganic, already included in monitoring for metals and mercury/methylmercury (organometals).

Table 5.5-4 lists the water quality parameters to be collected and their frequency of collection.

5.5.4.4.2 Sampling Protocol

Water quality grab samples will be collected during each site visit in a representative portion of the stream channel/water body, using methods consistent with ADEC and U.S. Environmental Protection Agency (EPA) protocols and regulatory requirements for sampling ambient water and trace metal water quality criteria.

Mainstem areas of the river not immediately influenced by a tributary will be characterized with a single grab sample. Areas of the mainstem with an upstream tributary that may influence the nearshore zone or are well-mixed with the mainstem will be characterized by collecting samples at two locations: in the tributary and in the mainstem upstream of the tributary confluence. All samples will be collected from a well-mixed portion of the river/tributary.

These samples will be collected on approximately a monthly basis (four samples from June to September) and used for calibrating the same model framework used for predicting temperature. The period for collecting surface water samples will begin at ice break-up and extend to beginning of ice formation on the river. Limited winter sampling (once in December, and again in March) will be conducted where existing or historic USGS sites are located. Review of existing data (URS 2011) indicated that few criteria exceedances occur with metals concentrations during the winter months. Existing data show that conventional water quality parameters do not change during the winter months and appear to be mediated by constancy in flow and by water temperature. Initial assessment of this existing data suggests that samples be collected twice during the winter months for analysis of early and late season conditions when the hydrograph declines (near the beginning of winter) and when the hydrograph begins to increase (near the beginning of spring). If the 2013 data sets suggest that metals and other general water quality parameters exceed criteria or thresholds, then an expanded 2014 water quality monitoring program will be conducted to characterize conditions on a monthly basis throughout the winter months.

Water quality indicators like conductivity (specific conductance) have been suggested as a surrogate measure for transfer of metals from groundwater to surface water or in mobilization of metals within the river channel. Should the one-time survey for metals at each of the sampling sites show elevated concentrations of select parameters, then sampling of a full list of metals will be conducted one time that analyzes groundwater concentrations in order to adequately characterize current conditions. Available USGS data from select continuous gaging stations will be reviewed for increases in specific conductance during monthly and seasonal intervals, and these results will be used to determine if further metals sampling is warranted during additional winter months.

Water quality grab samples will be collected during each site visit along a transect of the stream channel/water body, using methods consistent with ADEC and EPA protocols and regulatory requirements for sampling ambient water and trace metal water quality criteria.

Mainstem areas of the river not immediately influenced by a tributary will be characterized with a single transect. Areas of the mainstem with an upstream tributary that may influence the nearshore zone or that are well-mixed with the mainstem will be characterized by collecting samples at two transect locations: in the tributary and in the mainstem upstream of the tributary confluence. Samples will be collected at 3 equi-distant locations along each transect (i.e. 25% from left bank, 50% from left bank, and 75% from left bank). Samples will be collected from a depth of 0.5 meters below the surface as well as 0.5 meters above the bottom. This will ensure that variations in concentrations, especially metals, are captured and adequately characterized throughout the study area.

Variation of water quality in a river cross-section is often significant and is most likely to occur because of incomplete mixing of upstream tributary inflows, point-source discharges, or variations in velocity and channel geometry. Water quality profiles at each location on each site transect will be conducted for field water quality parameters (e.g., temperature, pH, dissolved oxygen, and conductivity) to determine the extent of vertical and lateral mixing.

Additional details of the sampling methods will be provided in a combined Sampling and Analysis Plan (SAP) and the Quality Assurance Project Plan (QAPP) for this study. More detail describing study design, field sampling procedures, and evaluation of data quality is provided in the Baseline Water Quality Monitoring QAPP (Attachment 5-1).

In Situ Water Quality Sampling. During each site visit, in situ measurements of dissolved oxygen, pH, specific conductance, redox potential, turbidity, and water temperature will be made. A Hanna Instruments HI 98703 Portable Turbidity Meter will be used to measure turbidity, while a Hydrolab® datasonde (MS5) will be used to measure the remaining field parameters during each site visit. Continuous turbidity measurement may be conducted with the Hydrolab datasonde at select locations (e.g., former/current USGS sites where turbidity data are available from the 1980s) and operated during summer and winter conditions. The following list of former and current USGS mainstem Susitna River monitoring sites will be considered for continuous turbidity monitoring: Susitna Station, Sunshine, Gold Creek, Tsusena Creek, and near Cantwell. These locations have historic and current flow data that will be used in water quality modeling (Section 5.6) of effects on turbidity from Project operations. Continuous logging of water quality parameters using a multi-parameter probe (e.g., temperature, pH, dissolved oxygen, and conductivity) may be placed at Focus Area locations (identified in Section 5.5.4.5). The period of deployment will be focused on summer months June through September (four months) as water conditions permit deployment and routine download of data. Maintenance of a multi-parameter probe and risk from damage is high during winter months. Also, freezing conditions will damage sensor apparatus and the logging unit if enclosed by formation of ice.

Standard techniques for pre- and post-sampling calibration of in situ instrumentation will be used to ensure quality of data generation and will follow accepted practice. If calibration failure is observed during a site visit, field data will be corrected according to equipment manufacturer's instructions.

General Water Quality Sampling. Sampling will avoid eddies, pools, and deadwater. Sampling will avoid unnecessary collection of sediments in water samples, and touching the inside or lip of the sample container. Samples will be delivered to EPA-approved laboratories within the holding time frame. Each batch of samples will have a separate completed chain of custody sheet. A field duplicate will be collected for 10 percent of samples (i.e., 1 for every 10 water grab samples). Laboratory quality control samples including duplicate, spiked, and blank samples will be prepared and processed by the laboratory.

Quality Assurance/Quality Control (QA/QC) samples will include field duplicates, matrix spikes, duplicate matrix spikes, and rinsate blanks for non-dedicated field sampling equipment. The results of the analyses will be used in data validation to determine the quality, bias, and usability of the data generated.

Sample numbers will be recorded on field data sheets immediately after collection. Samples intended for the laboratory will be stored in coolers and kept under the custody of the field team at all times. Samples will be shipped to the laboratory in coolers with ice and cooled to approximately 4°C. Chain of custody records and other sampling documentation will be kept in sealed plastic bags (Ziploc®) and taped inside the lid of the coolers prior to shipment. A temperature blank will accompany each cooler shipped. Packaging, marking, labeling, and shipping of samples will be in compliance with all regulations promulgated by the U. S. Department of Transportation in the Code of Federal Regulations, 49 CFR 171-177.

Water quality samples will be labeled with the date and time that the sample is collected and preserved/filtered (as appropriate), then stored and delivered to a state-certified water quality laboratory for analyses in accordance with maximum holding periods. A chain of custody record will be maintained with the samples at all times.

The state-certified laboratory will report (electronically and in hard copy) each chemical parameter analyzed with the laboratory method detection limit, reporting limit, and practical quantification limit. The laboratory will attempt to attain reporting detection limits that are at or below the applicable regulatory criteria and will provide all laboratory QA/QC documentation.

The procedures used for collection of water quality samples will follow protocols from ADEC and EPA Region 10 (Pacific Northwest). Water samples will be analyzed by a laboratory accredited by ADEC or recognized under NELAP. Water quality data will be summarized in a report with appropriate graphics and tables with respect to Alaska State Water Quality Standards (ADEC 2005) and any applicable federal standards.

Additional details of the sampling procedures and laboratory protocols is included in the SAP and QAPP.

5.5.4.5. Water Quality Characterization in Focus Areas

The second type of water quality monitoring is distinguished from the large-scale program by a higher density of sampling within a pre-defined reach length and a higher frequency of sample collection (greater than once per month). The purpose for the intensive water quality monitoring in select Focus Areas of the proposed Project area is to evaluate effects from dam operations on resident and anadromous fisheries. Potential Focus Areas in the middle river portion of the Susitna drainage have been selected in consultation with the water resources leads. The Focus Area sites are fully discussed in the Instream Flow Study Plan in Section 8.5.4.2.

Changes in water quality conditions from Project operations may influence usable habitat by individual species of fish and various life stages. Water quality conditions influence usability of areas within the river and sloughs by supporting required physicochemical characteristics that range from metabolic needs to predator avoidance. Adequate temperature and dissolved oxygen concentrations are required to sustain basic metabolic needs and these can differ for life stages of a species. Successful predator avoidance improves survivability of a population and this is commonly achieved by using physical structures in the aquatic environment. In the case of water quality, early life stages of a species may benefit from increased turbidity in the water column. Changes to turbidity in the water column may result in increased predation on certain life stages of fish and present a negative impact to a population.

The Focus Areas will have a higher density of sampling locations, in contrast to the mainstem network, so that prediction of change in water quality conditions from Project operations can be made with a higher degree of resolution. The resolution expected for predicting conditions will be as short as 100-meter (m) longitudinal distances within the Focus Areas. Depending on the length of the Focus Area, transects will be spaced every 100 m to 500 m and water quality samples collected at three locations along each transect. The collection locations along a transect will be in open water areas and have 3 to 5 collection points. These will be discrete samples taken at each collection point. The density of monitoring locations within the Focus Areas will be used as a grid to detect and describe groundwater input. Plumes of groundwater input to a Focus Area will be traceable using thermal data or conductivity. The area of groundwater input will be described using the monitoring grid network represented by the transects and sampling points along each transect. The location of open water transects and piezometers will be coordinated with the Instream Flow Study (Section 8) and the Groundwater Study (Section 7.5) to efficiently implement common elements in each of the studies. Piezometers will be installed as part of the Water Quality Monitoring Study so that surface water and groundwater samples are collected at the same time for determination of influence of groundwater on surface water. Collection of groundwater and surface water during each site visit will be used to evaluate the influence of groundwater on surface water quality. Frequency of sampling will be every 2 weeks for a total duration of 6 weeks and coordinated with the Instream Flow and Groundwater studies.

Water quality parameters measured in Focus Areas will be used to calibrate the EFDC model, but at a higher level of resolution than used for the main channel beginning from RM 15.1 and ending at RM 233.4 in the Susitna River. The focus for EFDC model predictions will be on the following parameters that could affect habitat used by anadromous and resident fish in this drainage:

Field Parameters

- Water temperature
- Dissolved oxygen
- Conductivity
- pH

General Chemistry

- Turbidity
- Hardness
- Total nitrogen
- Nitrate+nitrite-nitrogen
- Total phosphorus
- Soluble reactive phosphorus

Metals

- Mercury (total)
- Methylmercury (dissolved)
- Aluminum (dissolved and total)
- Iron (dissolved and total)

The water quality parameter list is divided further into two categories: (1) contaminants of concern (e.g., metals), and (2) general water quality conditions that may adversely affect fish species.

Inclusion of the nutrient parameters will be used to inform the productivity studies and potentially be used to develop habitat suitability criteria (HSC) curves for select aquatic communities. Response of biological communities like periphyton and benthic macroinvertebrates to nutrient concentrations will be predicted for alternative operational scenarios.

5.5.4.6. Sediment Samples for Mercury/Metals in the Reservoir Area

This task is designed to gather specific information on the distribution of Susitna River sediment contaminants of concern in potential source areas. In general, all sediment samples will be taken from sheltered backwater areas, downstream of islands, and in similar riverine locations in which water currents are slowed, favoring accumulation of finer sediment along the channel bottom. Samples will be analyzed for total metals, including aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, and zinc. In addition, sediment size and total organic carbon (TOC) will be included to evaluate whether these parameters are predictors for elevated metal concentrations. Samples will be collected just below and above the proposed dam site. Additional samples will be collected near the mouths of tributaries near the proposed dam site, including Fog, Deadman, Watana, Tsusena, Kosina, Jay, and Goose creeks, and the Oshetna River. The purpose of this sampling will be to determine where metals, if found in the water or sediment, originate in the drainage. Toxics modeling will be conducted to address potential for bioavailability in resident aquatic life. Comparison of bioaccumulation of metals in tissue analysis with results from sediment samples will inform on potential for transfer mechanisms between source and fate.

Two types of modeling analysis will be completed: (1) pathway model analysis, and (2) numerical modeling using EFDC (Section 5.6). First, pathway models will be constructed for preliminary evaluation of potential for transfer between media (e.g., sediment–pore water, pore water–surface water, surface water–fish tissue). Exposure concentrations will be estimated for each toxic within the medium sampled (e.g., sediment, pore water, surface water) and companion parameters (e.g., hardness and pH) will be collected that enable calculation of chronic and acute toxics concentrations to aquatic life. Potential for transfer of toxics between media will be facilitated by surrounding physicochemical conditions like low dissolved oxygen conditions, low pH resulting from low dissolved oxygen concentrations, or low redox potential. These companion field measurements will be made along with all media sampled at each site. Transfer potential of toxics between media will be identified under two conditions: (1) when field parameters listed above are at levels that result in mobilization of toxics between media, and (2) when toxics mobilize along a concentration gradient and transfer from high concentration to media with a lower concentration. Potential for bioaccumulation in aquatic life is determined when chronic thresholds for toxics exposure in a medium are identified. Potential for mortality is determined when acute criteria for toxics in a medium are exceeded.

Most of the contaminants of interest are typically associated with fine sediments, rather than with coarse-grained sandy sediment or rocky substrates. Therefore, the goal of the sampling will be to obtain sediments with at least 5 percent fines (i.e., particle size less than 0.0025 inches [63 micrometers], or passing through a #230 sieve). At some locations, however, larger-sized sediments may be all that are available.

The sediment samples will be collected using an Ekman dredge or a modified Van Veen grab sampler. Sampling devices will be deployed from a boat. Samples may also be collected by wading into shallow nearshore areas. To the extent possible, samples will consist of the top 6 inches (15 centimeters) of sediment. Comparison of results from the Susitna drainage will be made with other studies for Blue Lake, Eklutna Lake, and Bradley Lake when similar data are available and where physical settings are comparable.

5.5.4.7. Baseline Metals Levels in Fish Tissue

Two screening level tasks will be conducted. The first will be for methylmercury in sport fish. Methylmercury bioaccumulates and the highest concentrations are typically in the muscle tissue of adult predatory fish. Final determination of tissue type(s) for analysis will be coordinated with ADEC's Division of Environmental Health and guidance on fish tissue sampling. Results can be shared by ADEC with the State Health Department to develop fish consumption advice, if necessary. Target fish species in the vicinity of the Watana Reservoir will be Dolly Varden, Arctic grayling, whitefish species, long nose sucker, lake trout, burbot, and resident rainbow trout. If possible, filets will be sampled from seven adult individuals from each species. Adult fish from each of the species will be collected in order to estimate the metals concentrations in fish tissue (metals to be analyzed in fish tissue are listed in Table 5.5-3). Collection times for fish samples will occur in late August and early September. Filet samples will be analyzed for methyl and total mercury.

Liver samples will also be collected from burbot and analyzed for mercury, methylmercury, arsenic, cadmium, and selenium.

Field procedures will be consistent with those outlined in applicable Alaska state and/or EPA sampling protocols (USEPA 2000). Clean nylon nets and polyethylene gloves will be used during fish tissue collection. The species, fork length, and weight of each fish will be recorded. Fish will be placed in Teflon® sheets and into zipper-closure bags and placed immediately on ice. Fish samples will be submitted to a state-certified analytical laboratory for individual fish muscle tissue analysis. Results will be reported with respect to applicable Alaska and federal standards as well as published scientific literature based on both field observations and controlled laboratory experiments.

Results from fish tissue analysis will also be used as a description of bioaccumulative baseline toxics prior to the proposed Project. Results from the toxics pathways model and from the numeric model will be used to determine how the proposed Project may increase the potential of current metals concentrations to become bioavailable. The projected water conditions in the reservoir will be estimated and current results for metals concentrations re-evaluated for determining potential toxicities to resident and anadromous fish species. Detection of mercury in fish tissue and sediment will prompt further study of naturally occurring concentrations in soils and plants and how parent geology contributes to concentrations of this toxic in both compartments of the landscape. The focused study will estimate the extent and magnitude of mercury contamination so that an estimate of increased bioavailability might be made once the reservoir inundates areas where high concentrations of mercury are sequestered. Detectable concentrations of mercury may prompt additional sampling and analysis of tissues in the benthic macroinvertebrate community. The biomagnification of mercury contamination from sediments and plants to the fish community may be facilitated through consumption of contaminated food sources like the benthic macroinvertebrates. Contamination of this component of a trophic level may also be a conduit for mercury biomagnification in waterfowl and other wildlife that consume this food source.

5.5.4.8. Technical Report on Results

The technical report will include a description of the study goals and objectives, assumptions made, sample methods, analytical results, models used, and other background information. Field data, laboratory report, and quality assurance information will be attached.

A summary data report will be constructed that includes a description of patterns and an explanation for field parameters and general chemistry conditions. The origin of patterns in water quality data sets collected as part of this study may be due to seasonal influence (e.g., changes mediated by climate patterns), influence of tributary water chemistry on mainstem conditions, or in the case of sloughs may be moderated by groundwater influence.

The intensity of sampling effort is expected to be greater at Focus Areas and so resolution of changes in field parameters, general chemistry, and metals chemistry is expected to be described in finer detail. Spatial water quality conditions will be described in greater detail at these Focus Areas (Section 5.5.4.5) and be sampled every two weeks. Select field parameters (water temperature and dissolved oxygen concentration) will be collected on a continuous basis and downloaded during each of the Focus Area visits and will be able to describe daily diurnal patterns from these data.

Comparison of data will be made with existing and appropriate water quality criteria, sediment thresholds, and fish tissue screening levels. Surface water results will be compared to Alaska Water Quality Standards (18 ACC 70.020(b)) for protection of beneficial uses in fresh water. Sediment and fish tissue results will be compared to the Screening Quick Reference Tables (SQuiRTs) used by the National Oceanic and Atmospheric Administration (NOAA) to determine if thresholds for toxicity to aquatic life have been exceeded.

The focused effort in characterizing current mercury conditions through monitoring and modeling in the vicinity of the proposed dam site is described further in Sections 5.6 and 5.7. A general description of the approach and reporting of results for the mercury study is summarized here.

Mercury will be modeled using two methods:

1. Water quality modeling of the reservoir will predict whether the conditions for the formation of methylmercury will be present, and where in the reservoir this may occur.
2. The linear model of Harris and Hutchinson (2008) will provide an initial prediction of peak mercury concentrations in fish.

The phosphorous release model may be used if there is a need to evaluate when peak methylmercury production may occur.

The report will include a conceptual model showing mercury inputs to the reservoir, mercury methylation, mercury circulation among different media (fish, air, water, sediment, etc.), and bioabsorption and transfer. Strategies to manage mercury methylation, bioaccumulation, and biomagnification will be reviewed (Mailman et al. 2006).

Sediment, water, and tissue results from toxics analysis will use NOAA Screening Quick Reference Tables (SQuiRTs). These are thresholds used as screening values for evaluation of toxics and potential effect to aquatic life in several media and will be implemented where ADEC water quality, sediment, or tissue criteria are not available.

An example for SQuiRT values can be found at the following website:

http://mapping2.orr.noaa.gov/portal/sanfranciscobay/sfb_html/pdfs/otherreports/squirt.pdf

Specific thresholds and criteria for toxics in each of the media will be included in a QAPP. The Water Resources Technical Workgroup will be consulted before final criteria and thresholds are finalized and used to interpret toxics monitoring results from sediment, water, and fish tissue.

5.5.4.9. Pilot Thermal Imaging Assessment of a Portion of the Susitna River

Thermal imagery data using Forward Looking Infra-Red (FLIR) technology of the entire middle portion of the Susitna River was collected in October 2012. The data from the thermal imaging will be ground-truthed and the applicability and resolution of the data will be determined in terms of identifying water temperatures and thermal refugia/upwelling. Ground-truthing will occur by using the existing continuous temperature monitoring data from buoy systems and bank installation equipment for the 2012 Temperature Monitoring Study. In coordination with the instream flow and fish studies, a determination will be made as to whether thermal imaging data will be applicable and whether or not additional thermal imagery will be collected during the 2013 field season to characterize river temperature conditions. The results of the thermal imaging pilot test will be available by January 2013.

If the pilot study is successful, then a description of thermal refugia throughout the Project area can be mapped using aerial imagery calibrated with on-the-ground verification. The verification data used will be collected at the same time as the aerial imagery (or nearly the same time) using the established continuous temperature monitoring network and additional grab sample temperature readings where there may be gaps, such as in select sloughs. The elements described in the following sections are important considerations for data collection, specifications for data quality, and strategy for relating digital imagery and actual river surface water temperatures.

If the thermal imaging is not successful, the study component will be reevaluated. Future actions will depend on the causes of the failure. Potential causes for failure could include:

- Poor timing for the data acquisition flight.
- Insufficient differences in temperature between groundwater and surface water.
- Complex missing or dilution of the groundwater signal.

Potential solutions would include:

- Hand held FLIR meters that could be used during stream side studies, and a more focused thermal mapping task within focus areas using hand-held temperature meters and probes may prove useful.
- Use of documentation of open water leads as a substitute.
- Outfit the R44 helicopter to take advantage of regular field presence. Thermal imagery could be shot all summer long and brief intervals of ideal conditions could be used.
- The Focus Area results represent habitat identified as representative of the most important for fisheries use as described by the rational for site selection in Section 8.5.4.2 of the RSP. These results can be extrapolated to similar reaches, side channels, and sloughs in other areas of the Susitna drainage not directly monitored in this study to determine thermal refugia for fish.

5.5.4.10. Re-fly the thermal imaging under better conditions (a greater contrast in temperature between groundwater and surface water).**Radiant Temperature**

Remotely sensed thermal images allow for spatially distributed measurements of radiant temperatures in the river. Radiant temperature measurements are made only on the surface layer of the water (top 4 inches [10 centimeters]). Temperature readings can vary depending on the amount of suspended sediment in the water and the turbidity of the water. Collection of data will occur near the end of October when the freeze begins and the contrast between cold surface water and warmer groundwater influence is accentuated. The suspended sediment and turbidity will be diminished during this period of the year when the glacial flour content in the water column from glacial meltwater is reduced.

Spatial Resolution

The key to good data quality is determining the pixel size of the thermal infra-red (TIR) sensor and how that relates to the near-bank environment. Best practice is three pure-water pixels (ensures that the digital image represented by any three contiguous pixels discriminates water from land). Very fine resolution (0.7 to 3.3 feet [0.2 to 1 meter]) imagery is best used to determine groundwater springs and cold water seeps. Larger pixels can be useful for determining characteristic patterns of latitude and longitude thermal variation in riverine landscapes.

5.5.4.11. Calibrating Temperature

Water temperatures change during the day; therefore, measurements should occur near the same time each day and when water temperature is most stable (early afternoon). Data used from the continuous temperature probes throughout the middle reach will be the same time interval as thermal imaging collected at each location. Site selection for validation sampling will be determined by channel accessibility and where there is not known influences of tributaries or seeps in the area. Hand-held ground imaging radiometers can provide validation as long as the precision is at least as good as that expected from airborne TIR measurements. Availability of historical satellite imagery for thermal analysis will be investigated. Historical thermal imagery may enable exploration of potential trends in water temperature both spatially and temporally.

5.5.4.12. Groundwater Quality in Selected Habitats

The purpose of studying groundwater quality will be to characterize the water quality differences between a set of key productive aquatic habitat types (three to five sites) and a set of non-productive habitat types (three to five sites) that are related to the absence or presence of groundwater upwelling to improve the understanding of the water quality differences and related groundwater/surface water processes. Concern for sensitive fisheries habitat in floodplain shallow alluvial aquifers and changes to this habitat from Project operations is the focus for identifying environmental conditions that will affect food-chain elements (e.g., periphyton and benthic macroinvertebrates). The groundwater/surface water exchange (Section 7.5) is expected to influence the energy flow from primary producers (periphyton) to consumers at an intermediate level in the trophic food web (Section 9.8, River Productivity Study). An estimate of density and mass for each of these trophic food web components in target habitats will represent production of the food base and be compared against production necessary to support current fisheries populations. These sites will be co-located within the Focus Areas (Section 5.5.4.5) in order to measure groundwater input and influence on surface water chemistry.

Basic water chemistry information (temperature, dissolved oxygen [DO], conductivity, pH, turbidity, redox potential) that defines habitat conditions will be collected at selected instream flow, fish population, and riparian study sites. These data will be used to characterize groundwater and surface water interactions.

5.5.5. Consistency with Generally Accepted Scientific Practice

Studies, field investigations, laboratory testing, engineering analysis, etc. will be performed in accordance with general industry accepted scientific and engineering practices. The methods and work efforts outlined in this study plan are the same or consistent with analyses used by applicants and licensees and relied upon by FERC in other hydroelectric licensing proceedings.

The process for developing and implementing a water quality monitoring program ensures that high quality data is generated for use in regulatory decision-making and management of aquatic resources. Products like the: Quality Assurance Project Plan, use of NELAP Certified laboratory to analyze water samples, and sampling design for appropriate characterization of current water quality will ensure that complete documentation improves performance in implementing the Study Design.

5.5.6. Schedule

Baseline Water Quality Study elements will be completed in several stages and based on the timeline shown in Table 5.5-5. The thermal imaging data was acquired in October 2012, and will be processed and available for use in January 2013. Met stations were installed in August of 2012, and will collect data till the end of the project. The QAPP and SAP has been completed and is attached to this RSP. It will continue to be refined as the project goes forward. The temperature sensors were deployed in the river in August of 2012. They will continue recording data till the third quarter of 2014. It is anticipated that the sensors will have to be periodically replaced due to damage by ice, current, or battery replacement. Water quality monitoring will start in March 2013, and continue periodically throughout the remainder of the year. Sediment and fish tissue sampling will occur in July and August. Some fish tissue sampling has already been completed, in August of 2012. Data management will occur throughout the data acquisition phase of the project. The initial study repot will be completed by December 2014, with the final due in the first quarter of 2015.

5.5.7. Relationship with Other Studies

A flow chart describing interdependencies (Figure 5.5-3) outlines origin of existing data and related historical studies, specific output for each element of the Water Quality studies, and where the output information generated in the Water Quality studies will be directed. This chart provides detail describing flow of information related to the Water Quality studies, from historical data collection to current data collection. Data were examined in a Water Quality Data Gap Analysis (URS 2011), and this information was used, in part, to assist in making decisions about the current design for the Baseline Water Quality Monitoring Study and for ensuring that the current modeling effort would be able to compare the 1980s study results with results of planned modeling efforts.

Integral portions of this interdependency chart are results from the Ice Processes Study and from the Fish and Aquatic Instream Flow Study. The Ice Processes Study will support water quality model development (Section 5.6) with information about timing and conditions for ice formation and ice break-up. The Fish and Aquatic Instream Flow Study represents the effort to develop a hydraulic routing model that will be coupled with the EFDC water quality model. Water quality monitoring efforts for field parameters, general chemistry, and metals (including mercury) will be used as a calibration data set for developing the predictive EFDC model.

5.5.8. Level of Effort and Cost

The estimated cost for the Water Quality Baseline Monitoring Study in the Susitna basin in 2013 and 2014 is approximately $6,000,000, not including the cost of the thermal imaging.

5.5.9. Literature Cited

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5.5.10. Tables

Table 5.5-1. Proposed Susitna River Basin Temperature and Water Quality Monitoring Sites.

Susitna River Mile	Description	Susitna River Slough ID	Latitude (decimal degrees)	Longitude (decimal degrees)
15.1	Susitna above Alexander Creek	NA	61.4014	-150.519
25.8[3]	Susitna Station	NA	61.5454	-150.516
28.0	Yentna River	NA	61.589	-150.468
29.5	Susitna above Yentna	NA	61.5752	-150.248
40.6[3]	Deshka River	NA	61.7098	-150.324
55.0[1]	Susitna	NA	61.8589	-150.18
83.8[3]	Susitna at Parks Highway East	NA	62.175	-150.174
83.9[3]	Susitna at Parks Highway West	NA	62.1765	-150.177
97.0	LRX 1	NA	62.3223	-150.127
97.2	Talkeetna River	NA	62.3418	-150.106
98.5	Chulitna River	NA	62.5574	-150.236
103.0[2,3]	Talkeetna	NA	62.3943	-150.134
113.0[2]	LRX 18	NA	62.5243	-150.112
120.7[2,3]	Curry Fishwheel Camp	NA	62.6178	-150.012
126.0	--	8A	62.6707	-149.903
126.1[2]	LRX 29	NA	62.6718	-149.902
129.2[3]	--	9	62.7022	-149.843
130.8[2]	LRX 35	NA	62.714	-149.81
135.3	--	11	62.7555	-149.7111
136.5	Susitna near Gold Creek	NA	62.7672	-149.694
136.8[3]	Gold Creek	NA	62.7676	-149.691
138.0[1]	--	16B	62.7812	-149.674
138.6[3]	Indian River	NA	62.8009	-149.664
138.7[2]	Susitna above Indian River	NA	62.7857	-149.651
140.0	--	19	62.7929	-149.615
140.1[2]	LRX 53	NA	62.7948	-149.613
142.0	--	21	62.8163	-149.576
148.0	Susitna below Portage Creek	NA	62.8316	-149.406
148.8[2]	Susitna above Portage Creek	NA	62.8286	-149.379
148.8	Portage Creek	NA	62.8317	-149.379
148.8[3]	Susitna above Portage Creek	NA	62.8279	-149.377
165.0[1]	Susitna	NA	62.7899	-148.997
180.3[1]	Susitna below Tsusena Creek	NA	62.8157	-148.652
181.3[3]	Tsusena Creek	NA	62.8224	-148.613
184.5[1]	Susitna at Watana Dam site	NA	62.8226	-148.533
194.1	Watana Creek	NA	62.8296	-148.259

Susitna River Mile	Description	Susitna River Slough ID	Latitude (decimal degrees)	Longitude (decimal degrees)
206.8	Kosina Creek	NA	62.7822	-147.94
223.7[3]	Susitna near Cantwell	NA	62.7052	147.538
233.4	Oshetna Creek	NA	62.6402	-147.383

1 Site not sampled for water quality or temperature in the 1980s or location moved slightly from original location.
2 Proposed mainstem Susitna River temperature monitoring sites for purposes of 1980s SNTEMP model evaluation.
3 Locations with overlap of water quality temperature monitoring sites with other studies.
Locations in bold font represent that both temperature and water quality samples are collected from a site.

Table 5.5-2. Proposed Susitna-Watana Meteorological Stations.

Susitna River Mile	Description	Station Status (New / Existing)	Latitude (Decimal degrees)	Longitude (Decimal degrees)
44.3	Willow Creek	Existing (Talkeetna RWIS)	61.765	-150.0503
80.0	Susitna River near Sunshine Gage	Existing (Talkeetna RWIS)	62.1381	-150.1155
95.9	Susitna River at Talkeetna	Existing (Talkeetna Airport)	62.32	-150.095
136.8	Susitna River at Indian River	New	62.8009	-149.664
184.1	Susitna River at Watana Dam Camp (upland on bench)	New	62.8226	-148.5330
224.0	Susitna River above Cantwell	New	62.7052	-147.53799

Note: Our ability to upgrade existing met stations is currently being evaluated. If existing met stations cannot be upgraded, new met stations may be installed.

Table 5.5-3. Parameters for water quality monitoring and laboratory analysis (Baseline Water Quality Monitoring and Focus Area monitoring).

Parameter	Analysis Method	Sample Holding Times
In Situ Water Quality Parameters		
Dissolved Oxygen (DO)	Water Quality Meter	Not Applicable
pH	Water Quality Meter	Not Applicable
Water Temperature	Water Quality Meter	Not Applicable
Specific Conductance	Water Quality Meter	Not Applicable
Turbidity	Water Quality Meter	Not Applicable
Redox Potential	Water Quality Meter	Not Applicable
Color	Platinum-Cobalt Scale (SM)	Not Applicable
Residues	Defined in 18 ACC 70	Not Applicable
General Water Quality Parameters (grab samples for laboratory analysis)		
Hardness	EPA - 130.2	180 days
Nitrate/Nitrite	EPA - 353.2	48 hours

Parameter	Analysis Method	Sample Holding Times
Alkalinity	EPA - 2320	14 days
Ammonia as N	EPA - 350.1	28 days
Total Kjeldahl Nitrogen	EPA - 351.2	28 days
Total Phosphorus	EPA - 365.3	28 days
Ortho-phosphate	EPA - 365.3	48 hours
Chlorophyll-a	SM 10300	28 days
Total Dissolved Solids	EPA - 160.1	7 days
Total Suspended Solids	EPA - 160.2	7 days
Turbidity	EPA - 180.1	48 hours
TOC	EPA - 415.1	28 days
DOC	EPA – 415.1	28 days
Fecal Coliform	EPA 1604	30 hours
Petroleum Hydrocarbons	EPA 602/624 (TAqH) EPA 610/625 (TAH)	14 days
Radionuclides[1]	EPA 900.0, 901.1, 903.1, 904.0, 905.0, Alpha Spectroscopy	5 days
Metals – (Water) Dissolved and Total		
Aluminum	EPA – 6010B/6020A	48 hours
Arsenic	EPA – 6010B/6020A	48 hours
Barium	EPA – 6010B/6020A	48 hours
Beryllium	EPA – 6010B/6020A	48 hours
Cadmium	EPA – 6010B/6020A	48 hours
Chromium (III & IV)	EPA – 6010B/6020A	48 hours
Cobalt	EPA – 6010B/6020A	48 hours
Copper	EPA – 6010B/6020A	48 hours
Iron	EPA – 6010B/6020A	48 hours
Lead	EPA – 6010B/6020A	48 hours
Magnesium	EPA – 6010B/6020A	48 hours
Manganese	EPA – 6010B/6020A	48 hours
Mercury (Total and methylmercury)	EPA – 7470A	48 hours
Molybdenum	EPA – 6010B/6020A	48 hours
Nickel	EPA – 6010B/6020A	48 hours
Selenium	EPA – 6010B/6020A	48 hours

Parameter	Analysis Method	Sample Holding Times
Thallium	EPA – 6010B/6020A	48 hours
Vanadium	EPA – 6010B/6020A	48 hours
Zinc	EPA – 6010B/6020A	48 hours
Metals –Sediment (Total)		
Aluminum	EPA - 200.7	180 days
Arsenic	EPA - 200.7	180 days
Cadmium	EPA - 200.7	180 days
Copper	EPA - 200.7	180 days
Iron	EPA - 200.7	180 days
Lead	EPA - 200.7	180 days
Mercury	EPA – 245.5 / 7470A	28 days
Zinc	EPA - 200.7	180 days
Metals – Fish Tissue (Use EPA Sampling Method 1669) (Mercury Assessment Study Plan 5.7 only)		
Total Mercury	EPA – 1631	7 days
Methylmercury	EPA – 1631	7 days
Arsenic	EPA - 1632, Revision A	7 days
Cadmium	EPA - 1632	7 days
Selenium	EPA - 1632	7 days

Note: List of Radionuclides suggested for analysis includes the following: Americium-241; Cesium-137; Lead-210; Plutonium-238, 239, 240; Potassium-40; Radium-226; Radium-228; Strontium-90; Thorium-230, 232; Uranium-234, 235, 238; Tritium Gross Alpha, Gross Beta

Table 5.5-4. List of water quality parameters and frequency of collection.

Parameter	Task	Frequency of Collection
In Situ Water Quality Parameters		
Dissolved Oxygen (DO)	Baseline WQ and Sediment	Each Sampling Event
pH	Baseline WQ and Sediment	Each Sampling Event
Water Temperature	Baseline WQ and Sediment	Each Sampling Event
Specific Conductance	Baseline WQ and Sediment	Each Sampling Event
Turbidity	Baseline WQ and Sediment	Each Sampling Event
Redox Potential	Baseline WQ and Sediment	Each Sampling Event
Color	Baseline WQ (Visual)	Monthly
Residues	Baseline WQ (Visual)	One Survey-summer
General Water Quality Parameters (grab samples for laboratory analysis)		
Hardness	Baseline WQ	Monthly

Parameter	Task	Frequency of Collection
Alkalinity	Baseline WQ	Monthly
Nitrate/Nitrite	Baseline WQ	Monthly
Ammonia as N	Baseline WQ	Monthly
Total Kjeldahl Nitrogen	Baseline WQ	Monthly
Total Phosphorus	Baseline WQ	Monthly
Ortho-phosphate	Baseline WQ	Monthly
Chlorophyll-a	Baseline WQ	Monthly
Total Dissolved Solids	Baseline WQ	Monthly
Total Suspended Solids	Baseline WQ	Monthly
Turbidity	Baseline WQ	Monthly
TOC	Baseline WQ	One Survey-summer
DOC	Baseline WQ	Monthly
Fecal Coliform	Baseline WQ	One Survey-summer
Petroleum Hydrocarbons	Baseline WQ	One Survey-summer
Radioactivity	Baseline WQ	One Survey-summer
Metals – (Water) Dissolved and Total		
Aluminum	Baseline WQ (Total & Dissolved)	One Survey-summer
Arsenic	Baseline WQ (Total & Dissolved)	Monthly
Barium	Baseline WQ (Total & Dissolved)	Monthly
Beryllium	Baseline WQ (Total & Dissolved)	Monthly
Cadmium	Baseline WQ (Total & Dissolved)	Monthly
Chromium (III & IV)	Baseline WQ (Total & Dissolved)	One Survey-summer
Cobalt	Baseline WQ (Total & Dissolved)	Monthly
Copper	Baseline WQ (Total & Dissolved)	Monthly
Iron	Baseline WQ (Total & Dissolved)	Monthly
Lead	Baseline WQ (Total & Dissolved)	Monthly
Manganese	Baseline WQ (Total & Dissolved)	Monthly
Magnesium	Baseline WQ (Total & Dissolved)	Monthly
Mercury	Baseline WQ (Total & Dissolved)	Monthly
Molybdenum	Baseline WQ (Total & Dissolved)	Monthly
Nickel	Baseline WQ (Total & Dissolved)	Monthly
Selenium	Baseline WQ (Total & Dissolved)	One Survey-summer
Thallium	Baseline WQ (Total & Dissolved)	Monthly
Vanadium	Baseline WQ (Total & Dissolved)	Monthly

Parameter	Task	Frequency of Collection
Zinc	Baseline WQ (Total & Dissolved)	Monthly
Metals –Sediment (Total)		
Aluminum	Sediment Samples	One Survey-summer
Arsenic	Sediment Samples	One Survey-summer
Cadmium	Sediment Samples	One Survey-summer
Copper	Sediment Samples	One Survey-summer
Iron	Sediment Samples	One Survey-summer
Lead	Sediment Samples	One Survey-summer
Mercury	Sediment Samples	One Survey-summer
Zinc	Sediment Samples	One Survey-summer
Metals – Fish Tissue (Use EPA Sampling Method 1669)		
Total Mercury	Fish Tissue Screening	One Survey-late summer
Methylmercury	Fish Tissue Screening	One Survey-late summer
Arsenic	Fish Tissue Screening	One Survey-late summer
Cadmium	Fish Tissue Screening	One Survey-late summer
Selenium	Fish Tissue Screening	One Survey-late summer

Table 5.5-5. Schedule for Implementation of the Baseline Water Quality Study.

Activity	2012				2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Thermal Imaging (one survey)				—									
MET Station Installation and Data Collection			—	—	—	—	—	—	—	—	—	—	—
QAPP/SAP Preparation and Review			—	—									
Deployment of Temperature Monitoring Apparatus			—	—	—	—	—	—	—	—	—		
Water Quality Monitoring (monthly)						—	—	—					
Sediment Sampling							—						
Fish Tissue Sampling			—				—						
Data Analysis and Management				—	—	—	—	—	—	—	—		
Initial Study Report									Δ				
Updated Study Report													▲

Legend:

—— Planned Activity

Δ Initial Study Report

▲ Updated Study Report

5.5.11. Figures

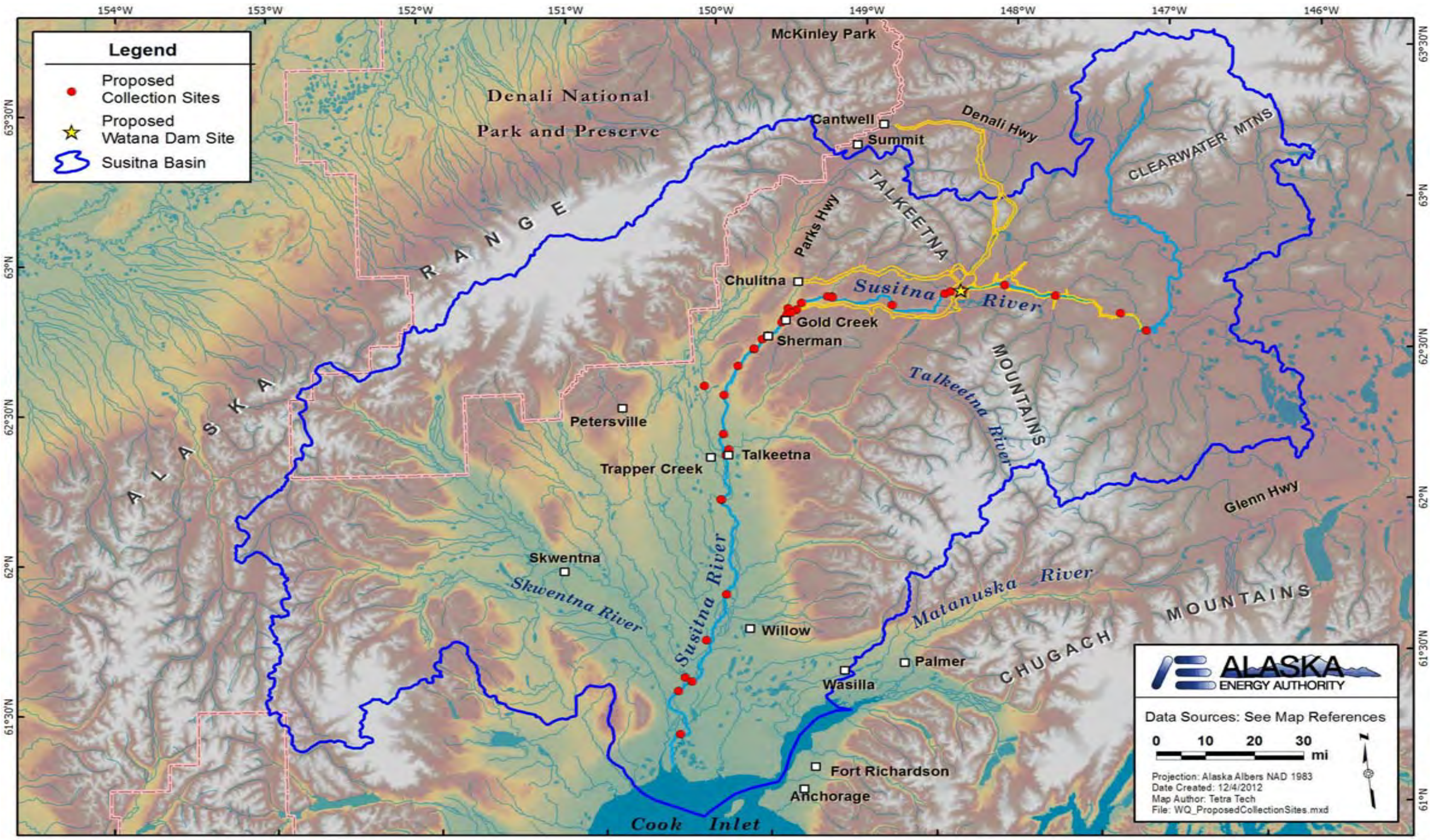

Figure 5.5-1. Proposed 2012 Stream Water Quality and Temperature Data Collection Sites for the Susitna-Watana Hydroelectric Project.

Figure 5.5-2. Example of a 10-foot (3-meter) tripod MET station installed above the proposed Watana Dam site.

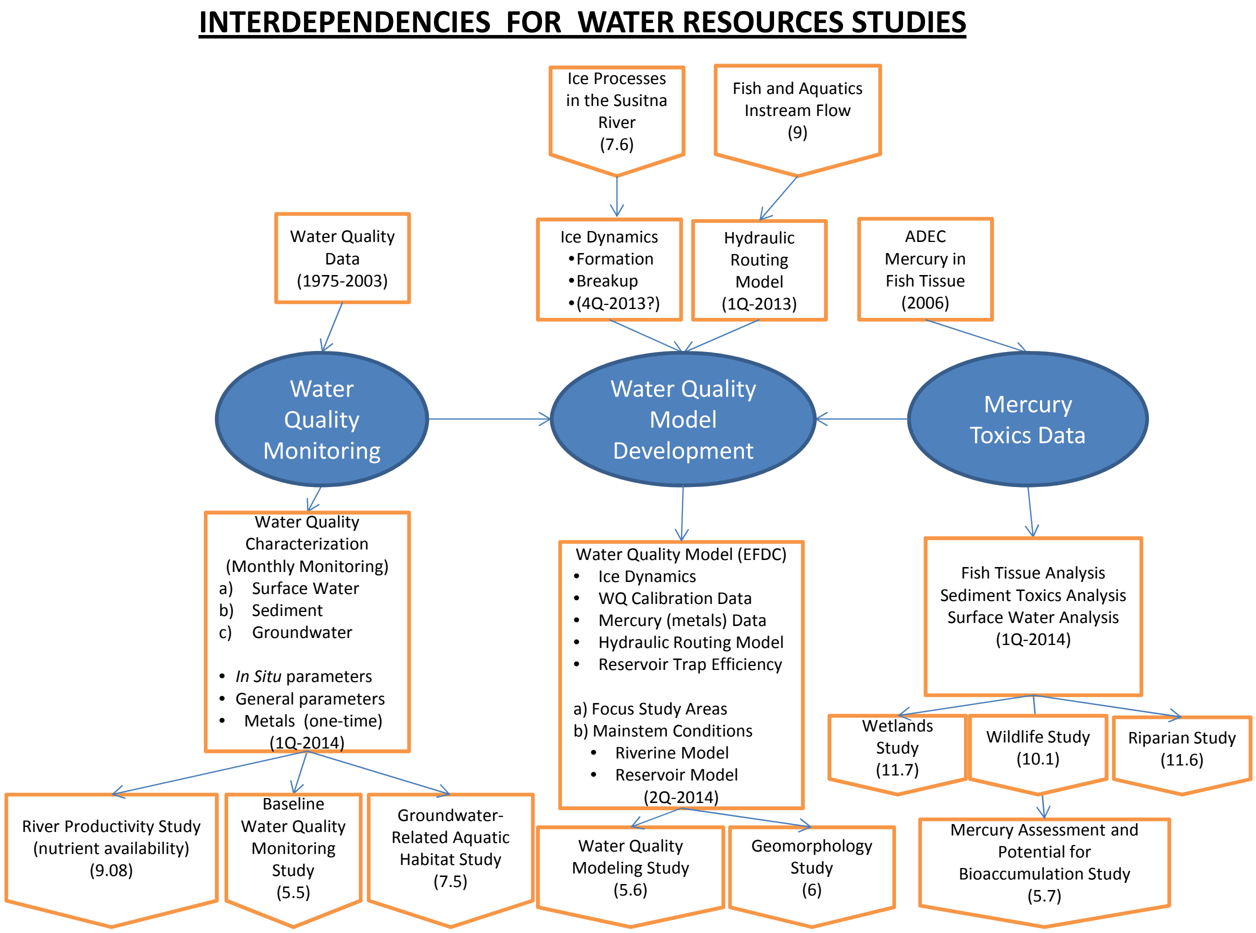

Figure 5.5-3. Interdependencies for water resources studies.

5.6. Water Quality Modeling Study

5.6.1. General Description of the Proposed Study

The collective goal of the water quality studies is to assess the impacts of the proposed Project operations on water quality in the Susitna River basin with particular reference to state water quality standards. Predicting the potential impacts of the dam and its proposed operations on water quality will require the development of a water quality model. The goal of the Water Quality Modeling Study will be to utilize the extensive information collected from the Baseline Water Quality Study to develop a model(s) to evaluate the potential impacts of the proposed Project and operations on various physical parameters within the Susitna River watershed.

A large number of water quality models are available for use on the Susitna-Watana Project. Selection of the appropriate model is based on a variety of factors, including cost, data inputs, model availability, time, licensing participant familiarity, ease of use, and available documentation. Under the current study, a multi-dimensional model capable of representing reservoir flow circulation, temperature stratification, and dam operations among other parameters is necessary. The proposed model must account for water quality conditions in the proposed Susitna-Watana Reservoir, including temperature, dissolved oxygen (DO), suspended sediment and turbidity, chlorophyll-a, nutrients, and metals, as well as water quality conditions in the Susitna River downstream of the proposed dam. The model must also simulate current Susitna River baseline conditions (in the absence of the dam) for comparison to conditions in the presence of the dam and reservoir.

The objectives of the Water Quality Modeling Study are as follows:

- With input from licensing participants, implement an appropriate reservoir and river water temperature model for use with past and current monitoring data.
- Using the data developed in Sections 5.5 (Baseline Water Quality Study) model water quality conditions in the proposed Susitna-Watana Reservoir, including (but not necessarily limited to), temperature, DO, suspended sediment and turbidity, chlorophyll-a, nutrients, ice, and metals.
- Model water quality conditions in the Susitna River from the proposed site of the Susitna-Watana Dam downstream, including (but not necessarily limited to) temperature, suspended sediment and turbidity, and ice processes (in coordination with the Ice Processes Study).

5.6.2. Existing Information and Need for Additional Information

In the 1980s, hydrologic and temperature modeling was conducted in the Susitna River basin to predict the effects of one or more dams on downstream temperatures and flows. The modeling suite used was called H2OBAL/SNTEMP/DYRESM. The modeling suite addressed temperature and had some limited hydrodynamic representation, but it lacked the ability to predict vertical stratification or local effects. In addition, the modeling suite lacked a water quality modeling component.

Review of existing water quality and sediment transport data revealed several gaps that present challenges for calibrating a water quality model (URS 2011). Analysis of existing data was used to identify future studies needed to develop the riverine and reservoir water quality models and to eventually predict pre-Project water quality conditions throughout the drainage. Some general observations based on existing data are as follows:

- Large amounts of data were collected during the 1980s. A comprehensive data set for the Susitna River and tributaries is not available.
- The influence of major tributaries (Chulitna and Talkeetna rivers) on Susitna River water quality conditions is unknown. There are no monitoring stations in receiving water at these mainstem locations.
- Continuous temperature data and seasonal water quality data are not available for the Susitna River mainstem and sloughs potentially used for spawning and rearing habitat.

Concentrations of water quality parameters including metals in sediment immediately below the proposed Project are unknown. Metals in these sediments may become mobile once the Project begins operation. Monitoring information in the immediate vicinity of the reservoir and riverine habitat will be important for developing two models (reservoir and riverine) and coupled for predicting expected water quality conditions below the proposed dam.

5.6.3. Study Area

Water quality samples will be collected at the same locations where temperature data loggers were installed (Table 5.6-1 and Figure 5.6-1) as part of the 2012 Baseline Water Quality Study. The study area begins at RM 15.1 and extends past the proposed dam site to RM 233.4. The lowermost boundary of the monitoring that will be used for developing and calibrating models is above the area protected for beluga whale activity. Twelve mainstem Susitna River monitoring sites are located below the proposed dam site and two mainstem sites above this location for calibration of the models. Six sloughs will be included in the models and represent important fish-rearing habitat. Tributaries to the Susitna River will be monitored and include those contributing large portions of the lower river flow like the Talkeetna, Chulitna, Deshka, and Yentna rivers. A partial list of the remaining tributaries that will be included in modeling and that represent important spawning and rearing habitat for anadromous and resident fisheries include Gold Creek, Portage Creek, Tsusena Creek, Watana Creek, and Oshetna Creek. These sites were selected based on the following rationale:

- Adequate representation of locations throughout the Susitna River and tributaries above and below the proposed dam site.
- Preliminary consultation with licensing participants including co-location with other study sites (e.g., instream flow, ice processes).
- Access and land ownership issues.

Eight of the sites are mainstem monitoring sites that were previously used for SNTEMP modeling in the 1980s. Thirty-one of the sites are Susitna River mainstem, tributary, or slough locations, most of which were also monitored in the 1980s.

5.6.4. Study Methods

This section provides the rationale for selection of the water quality model to be used for this Project. For the current Project, the model needs to be capable of simulating both river and reservoir environments. It also needs to be a multi-dimensional dynamic model that includes hydrodynamics, water temperature, water quality, and sediment transport modules and considers ice formation and break-up.

Ice dynamics evaluated in the Ice Processes Study will be used to inform the water quality model. Ice formation and break-up will have a profound impact on hydrodynamics and water quality conditions in the reservoir and riverine sections of the basin. Ice cover affects transfer of oxygen to and from the atmosphere and this directly affects the dissolved oxygen concentration at points along the water column. The output from the Ice Processes Study (Section 7.6) will provide boundary conditions for the water quality model.

The model will need to be configured for the reservoir and internally coupled with the downstream river model. This will form a holistic modeling framework that can accurately simulate changes in the hydrodynamic, temperature, and water quality regime within the reservoir and downstream. The model for use in this study should feature an advanced turbulence closure scheme to represent vertical mixing in reservoirs, and be able to predict future conditions. Thus, it will be capable of representing the temperature regime within the reservoir without resorting to arbitrary assumptions about vertical mixing coefficients.

The model will need to have the ability to simulate an entire suite of water quality parameters, and the capacity for internal coupling with the hydrodynamic and temperature modeling processes. The model will need to be configured to simulate the impact of the proposed Project on temperature as well as DO, nutrients, algae, turbidity, total suspended solids (TSS), and other key water quality features both within the reservoir and for the downstream river. This avoids the added complexity associated with transferring information among multiple models and increases the efficiency of model application.

Other important factors used for selecting the water quality model included the following:

- The model and code are easily accessible and are part of the public domain.
- The model is commonly used and accepted by EPA and other regulatory agencies.
- The water quality model will be available for current and future use and remain available for the life of the project and beyond (including upgraded versions).
- Model output can be compared to relevant ADEC water quality criteria (18 ACC 70.020(b)).

The following sections summarize the capabilities of models considered for use on this project and outline characteristics of those previously used with historical data from the Susitna River drainage and others commonly used for water quality modeling for regulatory decision-making.

5.6.4.1. H2OBAL/SNTEMP/DYRESM Model Review

The existing H2OBAL/SNTEMP/DYRESM model of the Susitna River basin is perhaps the most obvious candidate model to implement when assessing the effects of the originally proposed Project. The existing model was expressly configured to represent the unique conditions in the Susitna River basin. However, the modeling suite is limited to flow and temperature predictions. Hydrodynamics are simplified, and water quality is not addressed.

The Arctic Environmental Information and Data Center (AEIDC) previously completed a study that examined the temperature and discharge effects if the proposed Project was completed and compared the effects to the natural stream conditions, without a dam and reservoir system (AEIDC 1983a). The study also assessed the downstream point at which post-Project flows would be statistically the same as natural flows. Multiple models were used in the assessment: SNTEMP, a riverine temperature model; H2OBAL, a water balance program; and DYRESM, a reservoir hydrodynamic model.

The simulation period covered the years 1968 through 1982. Only the summer period was simulated, using historical meteorological and hydrological data to represent normal, maximum, and minimum stream temperature conditions, represented by the years 1980, 1977, and 1970, respectively (AEIDC 1983a). Post-project modifications were applied to these summer periods to compare natural conditions to post-Project stream temperatures. Due to a lack of data, a monthly time-step was used in these summer condition simulations.

Mainstem discharges from the Susitna-Watana Dam site were estimated from statistically-filled stream flow data and the H2OBAL program, which computes tributary inflow on a watershed area-weighted basis. Post-Project flows were predicted for both a one-dam scenario and a two-dam scenario using release discharge estimates from a reservoir operation schedule scenario in the FERC License Application. Flows derived from H2OBAL were input into SNTEMP.

SNTEMP is a riverine temperature simulation model that can predict temperature on a daily basis and for longer time periods. This allows for the analysis of both critical river reaches at a fine scale and the full river system over a longer averaging period (AEIDC 1983b). SNTEMP was selected because it contains a regression model that can fill in data gaps in temperature records. This is useful because data records in the Susitna River watershed are sparse. SNTEMP can also be calibrated to adjust for low-confidence input parameters. SNTEMP outputs include average daily water temperatures and daily maximum and minimum temperatures.

SNTEMP contains several sub-models, including a solar radiation model that predicts solar radiation based on stream latitude, time of year, topography, and meteorological conditions (AEIDC 1983b). SNTEMP was modified to include the extreme shading conditions that occur in the basin by developing a monthly topographic shading parameter. Modifications were also made to represent the winter air temperature inversions that occur in the basin. Sub-models are also included for heat flux, heat transport, and flow mixing.

SNTEMP validation indicated that upper tributary temperatures were under-predicted (AEIDC 1983b). Most of the data for the tributaries were assumed or estimated, leading to uncertainty. Five key poorly defined variables were identified as possible contributors to the under-prediction of temperatures: stream flow, initial stream temperature, stream length, stream width and distributed flow temperatures. Distributed flow temperatures were highlighted as the most important of the five variables. During calibration, groundwater temperature parameters were adjusted to modify distributed flow and improve tributary temperature prediction.

Water temperatures are derived from USGS gages, but when data were lacking, SNTEMP computed equilibrium temperatures and then estimated initial temperatures from a regression model. AEIDC noted that the reliability of the regression models "restricts the accuracy of the physical process temperature simulations" (1983a). The level of confidence in the regression model varies by the amount of gage data available. Continuous data yielded higher confidence, while years with only grab sample data notably decreased the confidence in the predicted temperatures.

The DYRESM model is a one-dimensional, hydrodynamic model designed specifically for medium size reservoirs (Patterson et al. 1977). The size limitation ensures that the assumptions of the model algorithm remain valid. DYRESM predicts daily temperature and salinity variations with depth and the temperature and salinity of off-take supply. The reservoir is modeled as horizontal layers with variable vertical location, volume, temperature and salinity. Mixing between layers is through amalgamation. Inflow and withdrawal are modeled by changes in the horizontal layer thickness and insertion or removal of layers, as appropriate. The model incorporates up to two submerged off-takes and one overflow outlet. Model output is on a daily time-step.

The DYRESM model was run to simulate the reservoir scenario for 1981 conditions (AEIDC 1983a). Other reservoir release temperature estimates were not available. The AEIDC report cautions that the results from 1981 may not be representative of other years due to annual variations in meteorology, hydrology, reservoir storage, and power requirements. The lack of reservoir release temperature data limited the simulation of downstream temperatures under operational conditions to one year. AEIDC noted that the "effort to delineate river reaches where post-project flows differ significantly from natural flows has been unsuccessful" (AEIDC 1983a). This was attributed in large part to the lack of estimates for the reservoir release temperatures. Additional data were needed to increase the predictive ability of SNTEMP.

Perhaps the biggest limitations of the existing H2OBAL/SNTEMP/DYRESM modeling suite are the lack of suitable data, simplified hydrology, and the lack of a water quality component. Modeling is limited to discharge and temperature. Other issues that limit the suitability of the modeling suite for the Water Quality Modeling Study are the chronic under-prediction of upper tributary temperatures, and the inability to predict vertical stratification within the reservoir.

5.6.4.2. Other Modeling Approaches

Two other modeling approaches may provide better results than the previously used H2OBAL/SNTEMP/DYRESM model. These are discussed below.

5.6.4.3. Two-Dimensional Approach (CE-Qual-W2)

The U.S. Army Corps of Engineers' CE-QUAL-W2 model is a two-dimensional, longitudinal/vertical (laterally averaged), hydrodynamic and water quality model (Cole et al. 2000). The model can be applied to streams, rivers, lakes, reservoirs, and estuaries with variable grid spacing, time-variable boundary conditions, and multiple inflows and outflows from point/nonpoint sources and precipitation.

The two major components of the model include hydrodynamics and water quality kinetics. Both of these components are coupled (i.e., the hydrodynamic output is used to drive the water quality output at every time-step). The hydrodynamic portion of the model predicts water surface elevations, velocities, and temperature. The water quality portion of the model can simulate 21 constituents including DO, suspended sediment, chlorophyll-a, nutrients, and metals. A dynamic shading algorithm is incorporated to represent topographic and vegetative cover effects on solar radiation.

5.6.4.4. Three-Dimensional Approach (EFDC)

The Environmental Fluid Dynamics Code (EFDC) model was originally developed at the Virginia Institute of Marine Science and is considered public domain software (Hamrick 1992).

This model is now being supported by EPA. EFDC is a dynamic, three-dimensional, coupled water quality and hydrodynamic model. In addition to hydrodynamic, salinity, and temperature transport simulation capabilities, EFDC is capable of simulating cohesive and non-cohesive sediment transport, near field and far field discharge dilution from multiple sources, eutrophication processes, the transport and fate of toxic contaminants in the water and sediment phases, and the transport and fate of various life stages of finfish and shellfish. The EFDC model has been extensively tested, documented, and applied to environmental studies world-wide by universities, governmental agencies, and environmental consulting firms.

The structure of the EFDC model includes four major modules: (1) a hydrodynamic model, (2) a water quality model, (3) a sediment transport model, and (4) a toxics model. The water quality portion of the model simulates the spatial and temporal distributions of 22 water quality parameters including DO, suspended algae (three groups), periphyton, various components of carbon, nitrogen, phosphorus and silica cycles, and fecal coliform bacteria. Salinity, water temperature, and total suspended solids are needed for computation of the 22 state variables, and they are provided by the hydrodynamic model. EFDC incorporates solar radiation using the algorithms from the CE-QUAL-W2 model.

5.6.4.5. Qualitative Comparison of Models

Table 5.6-2 presents an evaluation of the models' applicability to a range of important technical needs that support baseline water quality monitoring study objectives along with regulatory, and management considerations. Technical criteria refer to the ability to simulate the physical system in question, including physical characteristics/processes and constituents of interest. Regulatory criteria reflect the ability of a model to use and compare results to water quality standards or procedural protocol. Management criteria outline another set of selection elements for a water quality model and these comprise operational or economic constraints imposed by the end-user and include factors such as financial and technical resources. The relative importance of each group of criteria for model selection, as it pertains to the Project, are presented alongside the models' applicability ratings. Although the evaluation is qualitative, it is useful in selecting a model based on the factors that are most critical to this Project.

5.6.4.6. Technical Considerations

The following discussion highlights some of the key technical considerations for modeling associated with the Project and compares the ability of CE-QUAL- W2 and EFDC to address these considerations. For informational purposes, the H2OBAL/SYNTEMP/DYRESM modeling suite is also discussed in the technical considerations. Based on a review of the literature, some key factors that will likely be important in the modeling effort include the following:

1. Prediction of vertical stratification in the reservoir when the dam is present
2. Nutrient and algae representation
3. Sediment transport
4. Ability to represent metals concentrations
5. Integration between temperature and ice dynamics models
6. Capability of representing local effects (i.e., Focus Areas)

5.6.4.6.1. Predicting Vertical Stratification

Both EFDC and CE-QUAL-W2 are equipped with turbulence closure schemes that allow prediction of temporally/spatially variable vertical mixing strength based on time, weather condition, and reservoir operations. Therefore, both are capable of evaluating the impact of dam/reservoir operations/climate change on reservoir stratification. In contrast, the existing H2OBAL/SYNTEMP/DYRESM model does not have the necessary predictive capability because vertical stratification is represented based on parameterization through calibration. Therefore, it cannot represent the response of vertical mixing features to the changes in external forces.

5.6.4.6.2. Nutrient and Algae Representation

Both EFDC and CE-QUAL-W2 are capable of simulating dynamic interactions between nutrients and algae in reservoirs and interactions between nutrients and periphyton in riverine sections. This is very important for addressing the potential impact of the proposed Project on water quality and ecology in the river. EFDC has better nutrient predictive capabilities due to its sediment diagenesis module, which simulates interactions between external nutrient loading and bed-water fluxes. EFDC is thus capable of predicting long-term effects of the proposed Project. CE-QUAL-W2 does not have such a predictive capability. The existing H2OBAL/SNTEMP/DYRESM modeling suite is not capable of representing nutrient and algae interactions.

5.6.4.6.3. Sediment Transport

EFDC is fully capable of predicting sediment erosion, transport, and settling/deposition processes. CE-QUAL-W2 has limited sediment transport simulation capabilities. It handles water column transport and settling; however, it is not capable of fully predicting sediment bed re-suspension and deposition processes. H2OBAL/SNTEMP/DYRESM is not capable of simulating sediment transport. Reservoir trap efficiency will be simulated using EFDC and will use estimates for sediment inflow determined by the Geomorphology Study (Section 6.5).

5.6.4.6.4. Ability to Represent Metals Concentrations

EFDC is fully capable of simulating fate and transport of metals in association with sediments in both rivers and reservoirs. CE-QUAL-W2 does not have a module to simulate metals; however, a simplified representation can be implemented using the phosphorus slot in the model and simple partitioning (to couple with its basic sediment transport representation). The H2OBAL/SNTEMP/DYRESM is not capable of addressing metals issues.

5.6.4.6.5. Toxicity Modeling

The EFDC model will generate the water quality input for the Biotic Ligand Model (BLM). The BLM will be utilized to predict potential toxicity of copper, silver, cadmium, zinc, nickel, and lead to aquatic life. The BLM is focused on determining toxicity of individual metals to binding sites on tissue like gill filaments of freshwater fish while considering other factors that compete for the same binding sites.

The BLM will be restricted from use if the combination of water quality monitoring results for metals concentrations in sediments and surface water show little or no detectable concentrations and the water quality model shows that changes, if any, to water quality conditions that mobilize metals does not occur. This is part of the pathways analysis for individual metals toxics and is where decisions for use of secondary models (like BLM) in addition to the EFDC primary model will be made.

Borgmann et al. 2008 outline several assumptions under which toxicity of metals concentrations at sites of bioaccumulation interactions are additive. The use of the BLM to estimate a toxic effect from mixtures of metals must satisfy several unknowns and, as stated by the authors, should be used with caution and other strategies for these toxicity estimates considered.

5.6.4.6.6. Integration between Temperature and Ice Dynamics Models

The CE-QUAL-W2 model has a coupled temperature-ice simulation module, which is of moderate complexity and predictive capability. EFDC has a slightly simpler ice representation that was previously applied to a number of Canadian rivers (e.g., Lower Athabasca River and the North Saskatchewan River in Alberta, Canada). Both models, however, can be coupled to external ice models with a properly designed interface to communicate temperature results. Fully predictive simulation within either model would require code modification to handle the interaction between temperature simulation, ice formation and transport, hydrodynamics simulation, and water quality simulation.

5.6.4.6.7. Capability of Representing Local Effects

CE-QUAL-W2 is a longitudinal-vertical two-dimensional model; therefore, it is capable of resolving spatial variability in the longitudinal and vertical directions. It is not capable of representing high-resolution local effects such as lateral discharge, areas affected by secondary circulation, or certain habitat characteristic changes. EFDC is a three-dimensional model that can be configured at nearly any spatial resolution to represent local effects. H2OBAL/SNTEMP/DYRESM is a one-dimensional modeling suite and therefore has limited capability representing local effects.

5.6.4.7. Conclusion

Based on the evaluation of each model presented in Section 5.6.4.6, the EFDC model has been selected for further use in this study. A Water Quality Modeling Study, Sampling and Analysis, Quality Assurance Project Plan is included in Attachment 5-2.

5.6.4.8. Reservoir and River Downstream of Reservoir Modeling Approach

Reservoir modeling will focus on the length of the river from above the expected area of reservoir inundation to the proposed dam location. It will involve first running the without project scenario, or initial condition. This initial condition represents current baseline conditions in the absence of the dam. Subsequently, the model will represent the proposed reservoir condition when the dam is in place. The reservoir representation will be developed based on the local bathymetry and dimensions of the proposed dam. A three-dimensional model will be developed for the proposed reservoir to represent the spatial variability in hydrodynamics and water quality in longitudinal, vertical, and lateral directions. The model will be able to simulate flow circulation in the reservoir, turbulence mixing, temperature dynamics, nutrient fate and transport, interaction between nutrients and algae, sediment transport, and metals transport. The key feature that needs to be captured is water column stratification during the warm season and the de-stratification when air temperatures cool down. The capability of predictively representing the stratification/de-stratification period is of critical importance for evaluating the impact of the dam because this is the critical water quality process in the reservoir.

With the dam in place, the original river will be converted into a slow flowing reservoir; therefore, any sediment previously mobilized will likely settle in the reservoir, disrupting the natural sediment transport processes. Before the construction of the dam, primary production is likely driven by periphyton. After construction of the dam, periphyton will be largely driven out of existence due to deep water conditions typical of a reservoir environment. In lieu of periphyton, phytoplankton will likely be the dominant source of primary production of the ecological system with the dam in place. Nutrients from upstream will have longer retention in the reservoir, providing nutrient sources to fuel phytoplankton growth. All processes would need to be predictively simulated by both the reservoir model and the pre-reservoir river model for the same river segment.

Because the dam is not in place when the model is constructed, proper calibration of the model using actual reservoir data is not possible. To achieve reasonable predictions of water quality conditions in the proposed reservoir, a literature survey will be conducted to acquire parameterization schemes of the model. An uncertainty analysis approach will also be developed to account for the lack of data for calibration, therefore enhancing the reliability of reservoir model predictions.

Downstream of the proposed dam location, a river model will also be developed to evaluate the effects of the proposed Project. The same model platform used for the reservoir model will be implemented for the river model (at a minimum the two models will be tightly coupled). The river model will be capable of representing conditions in both the absence and presence of the dam. The downstream spatial extent of this model will be the lowermost monitoring site on the Susitna River mainstem (RM 15.1) extending downstream of the Susitna-Talkeetna-Chulitna confluence. Water quality modeling will extend into the lower river and will use channel topography and flow data at select locations in order to develop a model for predicting water quality conditions under various Project operational scenarios.

Flow, temperature, TSS, DO, nutrients, turbidity (continuous at USGS sites and bi-weekly at additional locations required for calibrating the model), and chlorophyll-a output from the reservoir model will be directly input into the downstream river model. This will enable downstream evaluation of potential impacts of the proposed Project on hydrodynamic, temperature, and water quality conditions.

The river model will be calibrated and validated using available data concurrently with the initial reservoir condition model (representing absence of the dam). Output from the models will be used directly in other studies (e.g., Ice Processes, Productivity, and Instream Flow studies).

The EFDC model will be calibrated in order to simulate water quality conditions for load-following analysis. Organic carbon content from inflow sources will be correlated with mercury concentrations determined from the Baseline Water Quality Study discussed in Section 5.5. Predicted water quality conditions established by Project operations and that promote methylation of mercury in the bioaccumulative form will be identified by location and intensity in both riverine and reservoir habitats. Water temperature modeling and routing of fluctuating flows immediately prior to and during ice cover development may be conducted with a separate thermodynamics-based ice process model River 1-D ice-processes model; the Susitna Hydraulic and Thermal Processes Model (Section 7.6.3.2).

Modeling of mercury concentrations in dissolved and in methylated form will be done by updating the EFDC model to simulate three sorptive toxic variables representing mercury (Hg) states. Algorithms have been successfully used with EFDC in other studies and will be modified to account for potential sources of Hg as the reservoir is filled (e.g., soils, vegetation, air deposition). Other metals parameters will be modeled if significant concentrations are identified from surface water and sediment. However, cumulative impacts of multiple metals on aquatic life are difficult to predict using the proposed modeling strategy because there are associated uncertainties. Measuring additivity or synergism of toxics effects is possible using laboratory bioassays, but may not be adequately predicted by a model. The level of uncertainty in extrapolating results from laboratory to field conditions is large and potentially unreliable. A suggested approach for estimating toxicity mixtures would be to develop a weight of evidence (WOE) algorithm that produces a weighting factor for re-calculating the potential chronic and acute toxic effects of a mixture (Mumtaz et al. 1998).

5.6.4.8.1 Focus Areas

The EFDC model will be used to predict water quality conditions at a finer scale of resolution for Focus Areas. The increased intensity of sampling at transects 100 m apart and at three locations across each transect will improve resolution for predictions at approximately 100 m longitudinally and a smaller distance laterally. This model will be embedded within the larger-scale EFDC model used for the entire riverine component of the Project area. An embedded model can also be used for predicting conditions in sloughs and selected braided areas of the mainstem Susitna River.

Some of the water quality parameters listed in Section 5.5.4.4 will be used to predict conditions within the Focus Areas to determine if suitability of habitat for life stages of select fish species is maintained or changes under each of the operational scenarios. The EFDC model calibrated for each of the Focus Areas will have a time-step component so that conditions and areal extent are described for each of the water quality parameters and are associated with load-following.

5.6.4.8.2 Scales for Modeling and Resolution of the Output

The large-scale EFDC model calibrated using the mainstem water quality monitoring data will have a longitudinal predictive resolution between 250 m and 1 kilometer (km) depending on lateral variability of conditions and the run-time selected. Single channel areas of the mainstem Susitna River and sloughs may not require higher resolution predictions if water quality conditions are uniform. The uniformity of conditions will be evaluated by measuring across transects at a few locations in the drainage to determine if lateral variability is low.

Grid size in the model determines spatial resolution of predicted water quality conditions. The riverine (and reservoir) areas of the Project are divided into equal-sized grids and the center of each represents the predicted water quality condition. The grid size is dependent on a number of characteristics of the Project area. These characteristics include elevation changes throughout the length of the drainage, length of the water body that will be modeled, surrounding terrain, and length of time the model is run for predicting temporal changes. Each of the factors ultimately determines the resolution of the predictive capability of the EFDC model.

5.6.5. Consistency with Generally Accepted Scientific Practice

Models will be the primary method used for predicting potential impacts to water quality conditions in both the proposed reservoir and the riverine portion of the Susitna basin. The models will be developed for each of the reservoir and riverine sections of the Susitna River and will be used to predict conditions resulting from Project operations under several operational scenarios. In the absence of a dam and data describing actual water quality conditions in the proposed reservoir, models are the only way to predict potential changes that may occur in the Susitna River from the presence of a dam. The 401 Water Quality Certification process includes the use of baseline assessment information and the use of models. The use of models is a scientifically accepted practice for predicting impacts to water quality and generating operational scenario outputs to inform the Project certification. The model selection process evaluated model features required for use in a river setting with braided channels, glacial water source, and ability to predict conditions in more than two-dimensions. The evaluation and proposed documentation describing performance and use of the model are accepted scientific practice for generating defensible and high quality data. The output from model calibration and predictions are consistent with recommended steps in generating high quality data as guided by a Credible Data Policy.

5.6.6. Schedule

The planned schedule for the study plan is presented in Table 5.6-3. Close coordination will be maintained with the water quality studies to make sure the data generated is sufficient and appropriate for the modeling effort. The model selection was made in July 2012, and the selection process is provided here. The water quality model will begin to be calibrated starting in the middle of 2013, as the data becomes available from the field. We anticipate producing an initial study report in the first quarter of 2014. After that will be a period of re-calibrations, verification runs, and generating operating scenarios for the proposed reservoir. The final modeling report will be complete in the first quarter of 2015.

5.6.7. Relationship with Other Studies

Figure 5.6-2 shows the interdependencies between existing data and related historical studies, specific output for each element of the Water Quality studies, and where the output information generated in the Water Quality studies will be directed. This chart provides details describing the flow of information related to the Water Quality studies, from historical data collection to current data collection. Data were examined in a Water Quality Data Gap Analysis (URS 2011) and this information was used, in part, to assist in making decisions about the current design for the Baseline Water Quality Modeling Study and for ensuring that current modeling efforts would be able to compare the 1980s study results with current modeling results.

Integral portions of this interdependency chart are results from the Ice Processes Study and from the Fish and Aquatic Instream Flow Study. The Ice Processes Study will support water quality model development (Section 5.6) with information about timing and conditions for ice formation and ice break-up. The Fish and Aquatic Instream Flow Study represents the effort to develop a hydraulic routing model that will be coupled with the EFDC water quality model. Water quality monitoring efforts for field parameters, general chemistry, and metals (including mercury) will be used as a calibration data set for developing the predictive EFDC model.

5.6.8. Level of Effort and Cost

The estimated cost for the proposed water quality modeling effort in 2013 and 2014, including planning, model calibration and development, modeling various operational scenarios, and reporting is approximately $1,750,000.

5.6.9. Literature Cited

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5.6.10. Tables

Table 5.6-1. Proposed Susitna River Basin Water Quality and Temperature Monitoring Sites.

Susitna River Mile	Description	Susitna River Slough ID	Latitude (decimal degrees)	Longitude (decimal degrees)
15.1	Susitna above Alexander Creek	NA	61.4014	-150.519
25.8[3]	Susitna Station	NA	61.5454	-150.516
28.0	Yentna River	NA	61.589	-150.468
29.5	Susitna above Yentna	NA	61.5752	-150.248
40.6[3]	Deshka River	NA	61.7098	-150.324
55.0[1]	Susitna	NA	61.8589	-150.18
83.8[3]	Susitna at Parks Highway East	NA	62.175	-150.174
83.9[3]	Susitna at Parks Highway West	NA	62.1765	-150.177
97.0	LRX 1	NA	62.3223	-150.127
97.2	Talkeetna River	NA	62.3418	-150.106
98.5	Chulitna River	NA	62.5574	-150.236
103.0[2,3]	Talkeetna	NA	62.3943	-150.134
113.0[2]	LRX 18	NA	62.5243	-150.112
120.7[2,3]	Curry Fishwheel Camp	NA	62.6178	-150.012
126.0	--	8A	62.6707	-149.903
126.1[2]	LRX 29	NA	62.6718	-149.902
129.2[3]	--	9	62.7022	-149.843
130.8[2]	LRX 35	NA	62.714	-149.81
135.3	--	11	62.7555	-149.7111
136.5	Susitna near Gold Creek	NA	62.7672	-149.694
136.8[3]	Gold Creek	NA	62.7676	-149.691
138.0[1]	--	16B	62.7812	-149.674
138.6[3]	Indian River	NA	62.8009	-149.664
138.7[2]	Susitna above Indian River	NA	62.7857	-149.651
140.0	--	19	62.7929	-149.615
140.1[2]	LRX 53	NA	62.7948	-149.613
142.0	--	21	62.8163	-149.576
148.0	Susitna below Portage Creek	NA	62.8316	-149.406
148.8[2]	Susitna above Portage Creek	NA	62.8286	-149.379
148.8	Portage Creek	NA	62.8317	-149.379
148.8[3]	Susitna above Portage Creek	NA	62.8279	-149.377
165.0[1]	Susitna	NA	62.7899	-148.997
180.3[1]	Susitna below Tsusena Creek	NA	62.8157	-148.652
181.3[3]	Tsusena Creek	NA	62.8224	-148.613
184.5[1]	Susitna at Watana Dam site	NA	62.8226	-148.533
194.1	Watana Creek	NA	62.8296	-148.259
206.8	Kosina Creek	NA	62.7822	-147.94

Susitna River Mile	Description	Susitna River Slough ID	Latitude (decimal degrees)	Longitude (decimal degrees)
223.7[3]	**Susitna near Cantwell**	NA	62.7052	147.538
233.4	Oshetna Creek	NA	62.6402	-147.383

1 Site not sampled for water quality or temperature in the 1980s or location moved slightly from original location.
2 Proposed mainstem Susitna River temperature monitoring sites for purposes of 1980s SNTEMP model evaluation.
3 Locations with overlap of water quality temperature monitoring sites with other studies.

Locations in bold font represent that both temperature and water quality samples are collected from a site.

Table 5.6-2. Evaluation of models based on technical, regulatory, and management criteria.

● High Suitability ◐ Medium Suitability ○ Low Suitability

Considerations	*Relative Importance*	*H2OBAL/SNTEMP/DYRESM*	*CE QUAL W2*	*EFDC*
Technical Criteria				
Physical Processes:				
• advection, dispersion	High	◐	●	●
• momentum	High	○	●	●
• compatible with external ice simulation models	High	○	●	●
• reservoir operations	High	◐	●	●
• predictive temperature simulation (high latitude shading)	High	◐	●	●
Water Quality:				
• total nutrient concentrations	High	○	●	●
• dissolved/particulate partitioning	Medium	○	●	●
• predictive sediment diagenesis	Medium	○	○	●
• sediment transport	High	○	◐	●
• algae	High	○	●	●
• dissolved oxygen	High	○	●	●
• metals	High	○	◐	●
Temporal Scale and Representation:				
• long term trends and averages	Medium	◐	◐	●
• continuous – ability to predict small time-step variability	High	○	●	●
Spatial Scale and Representation:				
• multi-dimensional representation	High	○	◐	●
• grid complexity - allows predictions at numerous locations throughout model domain	High	○	◐	●

●*High Suitability* ◐ *Medium Suitability* ○ *Low Suitability*				
Considerations	*Relative Importance*	*H2OBAL/SNTEMP/DYRESM*	*CE QUAL W2*	*EFDC*
• suitability for local scale analyses, including local discharge evaluation	Medium	○	◐	●
Regulatory Criteria				
Enables comparison to AK criteria	High	○	●	●
Flexibility for analysis of scenarios, including climate change	High	◐	●	●
Technically defensible (previous use/validation, thoroughly tested, results in peer-reviewed literature, TMDL studies)	High	◐	●	●
Management Criteria				
Existing model availability	High	●	●	●
Data needs	High	●	●	●
Public domain (non-proprietary)	High	●	●	●
Cost	Medium	●	◐	◐
Time needed for application	Medium	N/A	◐	◐
Licensing participant community familiarity	Low	●	◐	◐
Level of expertise required	Low	●	●	●
User interface	Low	◐	◐	◐
Model documentation	Medium	◐	●	●

Table 5.6-3. Schedule for Implementation of the Modeling Study.

Activity	2012				2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Coordination with water quality data collection and analysis				—	—	—	—	—	—				
Model Evaluation/Selection			—										
Model Calibration (Water Quality)							—	—					
Initial Study Report									Δ				
Re-calibration adjustments										—	—		
Verification runs											—		
Generate Results for Operational Scenarios										—	—	—	
Updated Study Report													▲

<u>Legend:</u>

—— Planned Activity
Δ Initial Study Report
▲ Updated Study Report

5.6.11. Figures

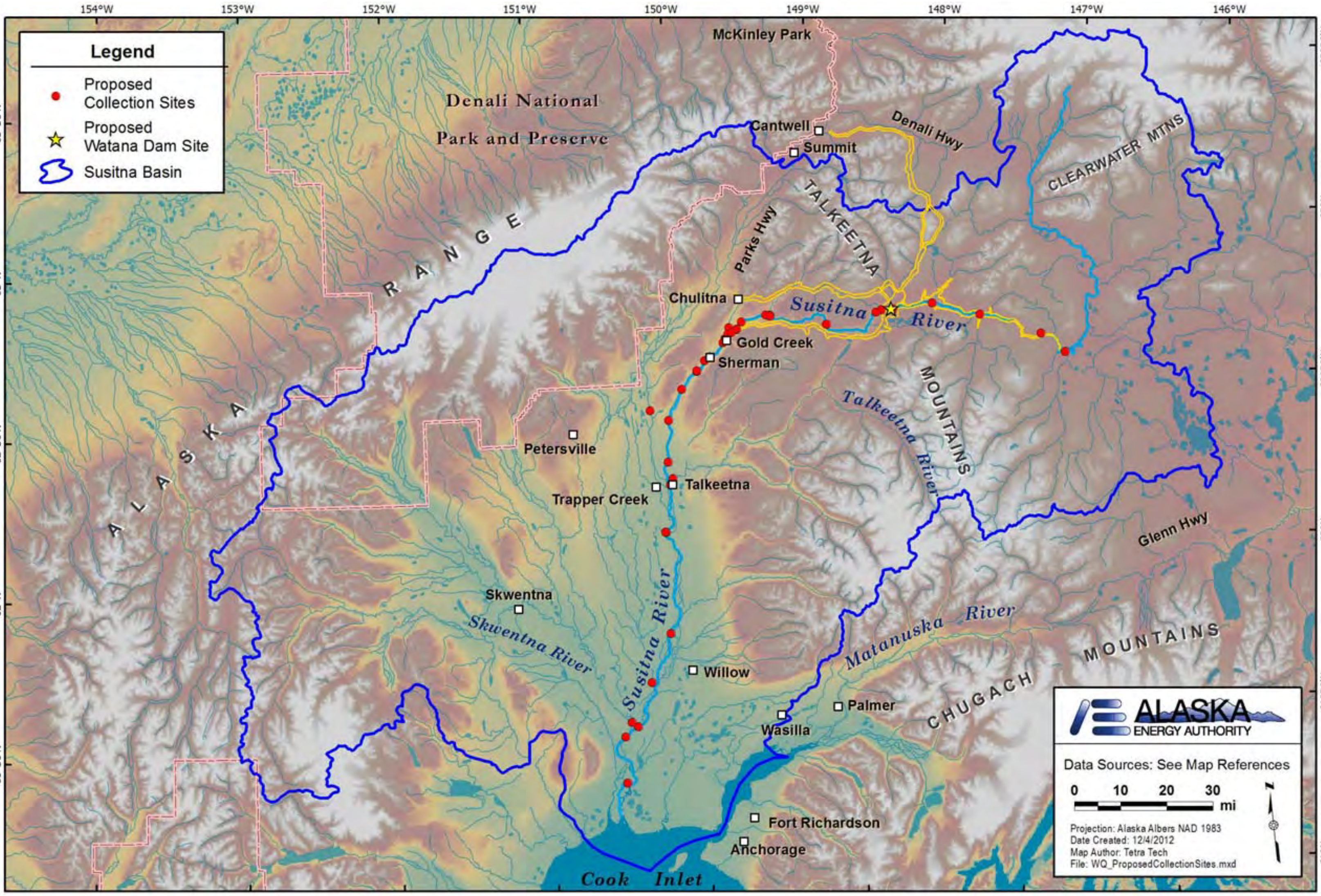

Figure 5.6-1. Proposed 2012 Stream Water Quality and Temperature Data Collection Sites for the Susitna-Watana Hydroelectric Project.

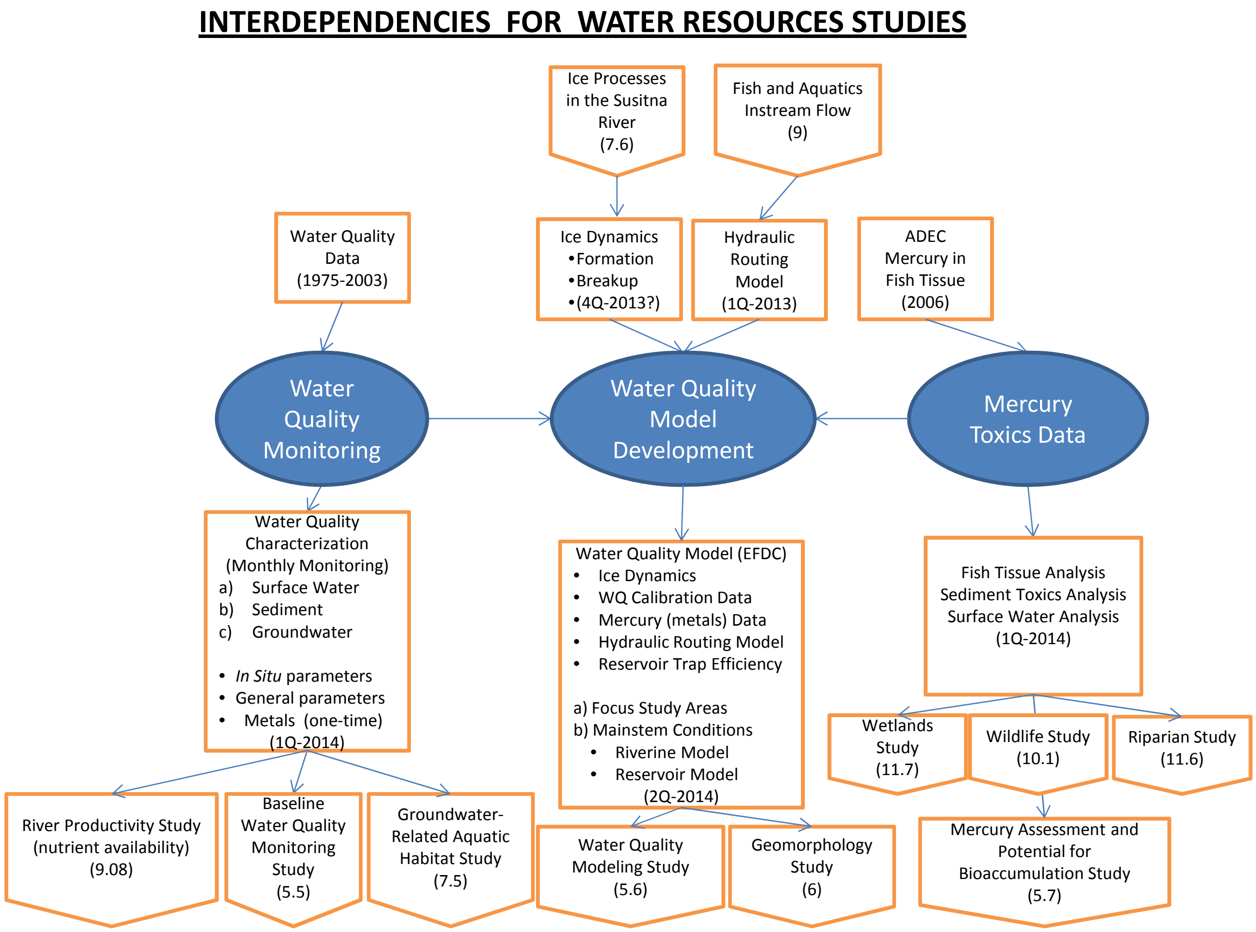

Figure 5.6-2. Interdependencies for water resources studies.

5.7. Mercury Assessment and Potential for Bioaccumulation Study

5.7.1. General Description of the Proposed Study

Many studies have documented increased mercury concentrations in fish and wildlife following the flooding of terrestrial areas to create hydroelectric reservoirs. The purpose of this study is to assess the potential for such an occurrence in the proposed Project area.

Based on several studies, the mercury that is found in newly formed reservoirs originates predominantly from inundation of organic soils. Receptors are and will be present in the inundation area (macroinvertebrates, fish, birds, etc.). Mercury methylation in reservoirs is a fairly well understood process, and numerous models exist to predict the occurrence and magnitude of the phenomena.

Given these known factors, key questions that need to be answered by this study include the following:

1) Whether conditions within the reservoir will cause mercury methylation from this source.
2) The concentrations of methylmercury that might occur.
3) Whether a mechanism exists (fish and small invertebrates living in the methylation zone) to transfer that methylmercury to wildlife, resulting in detrimental impacts.

Based on these questions, specific objectives of this study are as follows:

- Summarize available and historic water quality information for the Susitna River basin, including data collection from the 1980s Alaska Power Authority (APA) Susitna Hydroelectric Project.
- Characterize the baseline mercury concentrations of the Susitna River and tributaries. This will include collection and analyses of vegetation, soil, water, sediment pore water, sediment, piscivorous birds and mammals, and fish tissue samples for mercury.
- Utilize available geologic information to determine if a mineralogical source of mercury exists within the inundation area.
- Map mercury concentrations of soils and vegetation within the proposed inundation area. This information will be used to develop maps of where mercury methylation may occur.
- Use the water quality model to predict where in the reservoir conditions (pH, dissolved oxygen, turnover) are likely to be conducive to methylmercury formation.
- Use modeling to estimate methylmercury concentrations in fish.
- Assess potential pathways for methylmercury to migrate to the surrounding environment.

- Coordinate study results with other study areas, including fish, instream flow, and other piscivorous bird and mammal studies.

5.7.2. Existing Information and Need for Additional Information

The process by which mercury enters ecosystems is fairly well understood. Inorganic mercury from the atmosphere is deposited in lakes and rivers. Where conditions are right (anoxic, available sulfur), inorganic mercury can be converted by bacteria to methylmercury. Transfer of elemental mercury occurs from atmospheric deposition to surface water, and surface water to sediments. Production of methylmercury, mediated by bacterial activity is promoted or suppressed by one or combination of several factors in the aquatic environment.

Factors known to enhance methylation of mercury either in surface water or sediment are the following:

- Presence of aquatic vegetation and low oxygen concentrations
- Increased nutrients, temperature, microbial respiration, and dissolved organic carbon
- Neutral to low pH

Factors known to suppress methylation of mercury either in surface water or sediment are as follows:

- High oxygen concentrations
- Presence of sulfides and acid-volatile sulfides
- Presence of Selenium in sediments

Transfer of bioaccumulated mercury outside of the aquatic environment occurs between top of food chain animals with consumption of aquatic organisms by terrestrial animals.

At each level in a food chain, from bacteria to plankton, small fish, larger fish, and ultimately piscivorous terrestrial wildlife and humans, organisms take in more mercury than they excrete thereby accumulating the excess. This results in elevated concentrations of methylmercury at higher trophic levels. Fish-eating birds and mammals can suffer a wide range of impacts from accumulated methylmercury, including behavioral, neurochemical, hormonal, and reproductive effects.

While this process occurs all over the world in natural wetlands, it can be especially acute in newly formed reservoirs. This is because organic-rich soils can absorb mercury from the atmosphere over decades, and their degradation at the bottom of the reservoir will generate a spike in methylmercury production (Stokes and Wren 1987; Bodaly et al, 1984; Bodaly el al. 2007; Rudd, 1995; Hydro-Quebec 2003).

Many studies have documented increased mercury levels in fish following the flooding of terrestrial areas to create hydroelectric reservoirs (Bodaly et al. 1984; Bodaly et al 1997; Bodaly et al 2004; Bodaly et al. 2007; Rylander et al. 2006; Lockhart et al 2005; Johnston et al. 1991; Kelly et al. 1997; Morrison 1991b). Increased mercury concentrations have also been noted at other trophic levels within aquatic food chains of reservoirs, such as aquatic invertebrates (Hall et al. 1998). These problems have been particularly acute in hydropower projects from northern climates including Canada and Finland (Rosenberg et al. 1997). When boreal forests with large surface-area-to-volume ratios are flooded, substantial quantities of organic carbon and mercury stored in vegetation biomass and soils become inputs to the newly formed reservoir (Bodaly et al. 1984; Grigal 2003; Kelly et al. 1997). This flooding accelerates microbial decomposition, causing high rates of microbial methylation of mercury. Studies have shown this increase is temporary, lasting between 10 and 35 years (Hydro-Quebec 2003; Bodaly et al. 2007), whereupon methylmercury concentrations return to background levels. It should be noted that background methylmercury concentrations are rarely zero, and many natural water bodies have shown elevated concentrations of methylmercury.

Inorganic mercury deposition from the atmosphere is not a significant source of mercury concentrations that are elevated above background; however, it can be a source of background mercury concentrations. For example, Rudd (1995) has shown that just 0.3 and 3% of the mercury in a reservoir is derived from precipitation, the remainder from inundated fine organic soil particles. As explained in Section 5.7.1, the goal of this study is to quantify mercury resulting from filling the reservoir, not necessarily background mercury.

Background mercury concentrations are better predicted from studying mercury levels in nearby natural lakes, not quantifying atmospheric deposition. Background lake studies are included as part of the fish tissue sampling (see Section 5.7.4.2.6).

Mercury in organic soils is common. Background concentrations in organic soils of the Kuskokwim area of Alaska were found to be 0.10 to 1.2 parts per million (ppm) (Bailey and Gray 1997; Gray et al 2000); however, this area is well known to have large ore bodies of cinnabar, a mercury ore. Soils in Norway and Sweden were found to have mercury concentrations only as high as 0.24 ppm (Lindqvist 1991). In the United States, the mean concentrations reported from organic soils and loamy soils are 0.28 ppm and 0.13 ppm, respectively (Kabata-Pendias and Pendias 1992). Background concentrations for organic soils in Canada as high as 0.40 ppm have been reported (Kabata-Pendias and Pendias 1992). Shacklette and Boerngen (1984) report an average value of 0.058 ppm in all soil types in the contiguous United States.

In organic soils, mercury is mainly present in its inorganic form; the methylated form usually represents less than 1 percent of the total. Mercury does not appear to be mobile in soils, where it is firmly bound to the humus (Hydro-Quebec 2003).

Methylmercury can be detected in nearly every fish analyzed, from nearly any water body in the world. This is because the primary source of mercury to most aquatic ecosystems is deposition from the atmosphere. Mercury deposition worldwide has been steadily increasing due to the widespread burning of coal. In 2007, an international panel of experts concluded, “remote sites in both the Northern and Southern hemispheres demonstrate about a threefold increase in Hg deposition since preindustrial times” (Lindberg et al. 2007). Lakes at Glacier Bay, Alaska, have shown that current rates of atmospheric mercury deposition are about double what was observed in pre-industrial times (Engstrom and Swain 1997).

Mercury of non-atmospheric origin has been occasionally found in water bodies. The source can be industrial processes, mercury mining, or simply the presence of sulfate-rich mercury ores, which occur in very limited areas. In the study area, no mining has occurred, and there are no industrial sources. Point sources have been documented on the Kuskokwim River in Alaska, but are relatively rare, and are associated with known sulfate-rich ore bodies (Saiki and Martin 2010; Gray et al 2000). Based on the available geologic information, the inundation area consists largely of diorite and granodiorite, which are not typically associated with massive sulfide mineral deposits. For this reason, such a point source appears to be unlikely in the inundation area for the dam.

In areas that lack the necessary mercury mineralization, the mercury concentration in parent geologic materials is typically very low, and cannot explain the mercury concentrations observed in sediment in aquatic ecosystems (Fitzgerald et al. 1998; Swain et al. 1992; Wiener et al. 2006).

Historical mercury data from the study area are limited. Some samples were collected during previous studies of the APA Susitna Hydroelectric Project in the 1980s (AEA, 2011). This consisted of the collection of water samples at Gold Creek (RM 136) in 1982. Total mercury was found to be 0.12 micrograms per liter (µg/L) in turbid, summer water, and 0.04 µg/L in the clear, winter water (AEA, 2011). The same results were found downriver at Susitna Station (RM 26).

Frenzel (2000) collected sediment samples from the Deshka River and Talkeetna River, as well as from Colorado Creek and Costello Creek, which are tributaries to the Chulitna River (Table 5.7-1). Based on these results, mercury concentrations in the drainage appear to be elevated over the national median, and appear to vary significantly by drainage. The report indicated that both Colorado and Costello Creeks appear to drain a portion of Denali National Park and Preserve that is highly mineralized, which likely causes the higher than background mercury concentrations. Previous studies (St. Louis et al. 1994) have shown that methylmercury occurrence is positively correlated with wetland density, and the Deshka River has significantly more wetlands in the drainage than other tributaries to the Susitna River.

Additional samples were collected by Frenzel (2000) of slimy sculpin from the Deshka River, Talkeetna River, and Costello Creek (Table 5.7-2). Whole fish samples tend to underestimate the presence of methylmercury, given that this compound concentrates in muscle tissue.

Samples of fish tissue and sediment from the Deshka River and Costello Creek were speciated for metallic mercury and methylmercury (Table 5.7-3). As anticipated, the ratio of methylmercury to inorganic mercury in the Deshka River is relatively high due to extensive wetlands in the drainage area. Costello Creek was found to have a higher inorganic mercury component due to possible mineralogical sources of mercury in the drainage area.

Overall mercury concentrations in water were also found to be positively correlated with the turbidity of the water. Very little mercury was found in filtered water samples (Frenzel 2000). This is consistent with methylmercury being strongly bound to organic particles.

These results are in agreement with the results from Krabbenhoft et al. (1999). In nationwide mercury sampling, in a wide array of hydrological basins and environmental settings, wetland density was found to be the most important factor controlling methylmercury production. It was also found that methylmercury production appears proportional to total mercury concentrations only at low total mercury levels. Once total mercury concentrations exceed 1,000 nanograms per gram (ng/g), little additional methylmercury was observed to be produced. Atmospheric deposition was found to be the predominant source for most mercury. Subbasins characterized as mixed agriculture and forested had the highest methylation efficiency, whereas areas affected by mining were found to be the lowest.

A more recent study has been done by the Alaska Department of Environmental Conservation's Department of Environmental Health (ADEC 2012). ADEC is currently analyzing salmon (all five species) as well as other freshwater species for total mercury in the Susitna River drainages (Table 5.7-4). These results appear to be consistent with those in other areas of the state.

5.7.3. Study Area

Water quality and sediment samples will be collected at the sites identified in Table 5.7-5. The study area begins at RM 15.1 and extends past the proposed dam site to RM 233.4. Tributaries to the Susitna River will be sampled and include those contributing large portions of the lower river flow such as the Talkeetna, Chulitna, Deshka, and Yentna rivers. Also included are smaller tributaries such as Gold, Portage, Tsusena, and Watana creeks, and the Oshetna River. These sites were selected based on the following rationale:

- Adequate representation of locations throughout the Susitna River and tributaries above and below the proposed dam site for the purpose of a baseline mercury characterization.
- Location on tributaries where proposed access road crossing impacts might occur during and after construction (upstream/downstream sampling points on each crossing).
- Consultation with licensing participants including co-location with other study sites (e.g., instream flow, ice processes).
- Sites that are in the Susitna River mainstem, tributary, or slough locations, most of which were monitored in the 1980s.

The proposed study will describe impacts from road crossings on mercury concentrations. Several access road corridors have been identified, one of which will be utilized to access the proposed dam site. Road crossings are expected to impact streams at each of the crossings and these locations will be surveyed for toxics concentrations above background in sediment and surface water.

Soil and vegetation samples will be collected from the proposed inundation area. Piscivorous birds and mammals, and fish samples, will be collected from a variety of drainages in the study area; however, the focus will be on the proposed inundation area for the dam to establish background concentrations of methylmercury in fish prior to site development.

5.7.4. Study Methods

This study responds to comments from NMFS and USFWS, among other licensing participants. Originally the study components described here were spread into several other sections of the overall study plan. They have been consolidated here to provide an overview of the proposed mercury assessment and bioaccumulation plans.

This study consists of six study components:

- Summarize available information for the Susitna River basin, including data collection from the 1980s APA Susitna Hydroelectric Project, and existing geologic information to determine if a mineralogical source of mercury exists within the inundation area.
- Collect and analyze background vegetation, soil, water, sediment, sediment pore water, piscivorous birds and mammals, and fish tissue samples for mercury. This will include

mapping vegetation types and the lateral extent, thickness, and mercury concentrations of soils within the proposed inundation area. These data will be used to provide background concentrations for mercury, but will also help evaluate potential mitigation methods (soil and vegetation removal) should that become necessary.

- Use the water quality model to predict where in the reservoir conditions (pH, dissolved oxygen, turnover) are likely to be conducive to methylmercury formation (see Section 5.6).
- Utilize specialty models to predict potential fish methylmercury concentrations.
- Assess potential pathways for mercury movement from different areas of methylmercury formation to the surrounding environment.
- Prepare a technical report on analytical results, modeling, and mercury pathway assessment.

5.7.4.1. Summary of Available Information

Existing literature will be reviewed to summarize the current understanding of the occurrence of mercury in the environment. Much of that work has already been performed as part of this work plan and during previous studies (URS 2011) for this project. This review will include the following:

- A summary of 1980s APA Susitna Hydroelectric Project water quality studies, including data.
- Data collected in Alaska by both USGS and ADEC.
- A summary of the findings during development of other cold region hydroelectric projects.

5.7.4.2. Collection and Analyses of Soil, Vegetation, Water, Sediment, Sediment Pore Water, Piscivorous Birds and Mammals, and Fish Tissue Samples for Mercury

Data will be collected from soil, vegetation, surface water, sediment pore water, sediment, piscivorous birds and mammals, and fish tissue. Each of these media has been carefully selected on the following basis:

1. Applicability. Does measurement of background mercury contributions in the specified media contribute to understanding and predicting methylmercury concentrations after impoundment?
2. Measurability. Can we collect accurate data? Is the data representative of what is occurring in the environment? Will we be able to collect the same data post-impoundment?
3. Impact. Is the media likely to be impacted by the impoundment? Will the sampling damage the resource?

At this time there are media not being sampled as part of this study plan because it violates one of more of these decision points. The following is a summary of the most important media we are not sampling, and the reasoning for their exclusion from the sampling program:

Macroinvertebrates. Current mercury concentrations in macroinvertebrates are poor indicators post impoundment methylmercury concentrations in fish and wildlife, and most methylmercury models do not utilize this data for that reason (Harris and Hutchison, 2008; Hydro Quebec, 2003, etc.).

There appears to be no predictive model that can utilize current macroinvertebrate methylmercury concentration to predict future macroinvertebrate concentrations. Rennie et al (2011) has developed a predictive model for benthic macroinvertebrates, but not for other macroinvertebrates. Modeling of methylmercury in benthic invertebrates is of limited value, given these organisms are primarily predated by fish, which are already being modeled elsewhere in the study.

Methylmercury concentrations in macroinvertebrates can vary significantly by species, location, life stage, feeding behavior, and fish predation (Henderson et al, 2011). Sample mass can also be an issue. Even with the relatively low mass required for analyses, macroinvertebrates often require mixing of several individuals specimens, or even species, sometimes from collection locations far apart, into a single sample analytical result.

We are aware of only one study (Gerrard and St Louis, 2001) where terrestrial wildlife has been directly impacted by methylmercury in macroinvertebrates post-impoundment, bypassing migration via fish. However, while that study showed an approximate doubling of methylmercury concentrations in the swallows, they found no overt toxicological affects. In fact increased dipteran productivity (the primary food source of tree swallows) after reservoir creation resulted in earlier nest initiation, larger eggs, and faster growth rates of wing and bill length in nestlings.

Sampling of macroinvertebrates would need to be conducted based on pathway analysis to define methylmercury generation and potential bioexposure routes. Current macroinvertebrates communities may have little bearing on post impoundment communities.

Methylmercury in fish tissues is generally an order of magnitude higher than that of their food sources (Rennie et al, 2011). Therefore methylmercury is typically not damaging to macroinvertebrates, and may not be damaging to their predators due to the position at a lower trophic level than piscivorous fish, birds, and mammals. Well-developed predictive models for fish and piscivorous wildlife should be generally protective of wildlife that feed directly on macroinvertebrates. Sampling for fish, piscivorous birds, and aquatic wildlife is planned in this study.

In summary, macroinvertebrate sampling at this time would appear to have limited applicability, in that it does not contribute significantly to predicting future methylmercury concentrations or impacts. There are concerns regarding whether that data can be collected and interpreted accurately, and other studies are focused on more sensitive and easily measured methylmercury impacts.

Atmosphere. As illustrated in Figure 5.7-1, mercury cycles between the water soil, and atmosphere. Net accumulation rates are low. Also, the rate and amount of atmospheric deposition doesn't depend on whether the water body is a natural lake or reservoir.

Previous studies have found that increases in methylmercury concentrations in a reservoir after filling are not related to atmospheric deposition. As previously stated, Rudd (1995) has shown that just 0.3 and 3% of the mercury in a reservoir is derived from precipitation, the remainder from inundated fine organic soil particles. While inorganic mercury deposition from the atmosphere is not a significant source of mercury concentrations that are elevated above background, it can be a source of background mercury concentrations. The goal of this study is to quantify mercury resulting from filling the reservoir, not necessarily background mercury.

Background mercury concentrations are better predicted from studying mercury levels in nearby natural lakes, not quantifying atmospheric deposition. Background lake studies are included as part of the fish tissue sampling.

Mercury in reservoirs typically isn’t source limited, but is related to methylation rates in the reservoir. The water quality model will predict methylation rates in the reservoir (Section 5.6.4.8).

In summary, mercury deposition from the atmosphere represents an impact not related to creation of the reservoir. Measurements of atmospheric deposition are unlikely to advance our understanding and prediction of methylmercury concentrations after impoundment. The media (air) is unlikely to be impacted by filling of the reservoir.

Large Terrestrial Wildlife. Large terrestrial wildlife such as bears and foxes can consume fish and even piscivorous birds, however it is not their primary food source in the area, therefore net accumulation of methylmercury should be relatively low. Population density is anticipated to be low, and food sources may include areas well outside the drainage. The proposed study includes sampling of lower trophic levels (fish and birds), which should be protective of these apex predators.

Salmon. Limited numbers of salmon (estimated at 30 to 50) are currently in the inundation zone. Sampling a sufficient number of these fish to generate statistically usable data would be harmful to the fish run. As a small run, it currently serves as a very limited food source to the area. Salmon typically have higher mercury concentrations than resident fish, however, this mercury is predominately oceanic in origin.

The following sections describe these planned study components. A Quality Assurance Project Plan/Sampling and Analysis Plan (QAPP/SAP) has been developed for the Mercury Assessment and Potential for Bioaccumulation Study (Attachment 5-3). This QAPP/SAP includes specific detail describing study design, sampling procedures, and determining quality of data collected that satisfy objectives. This document is a required document when generating environmental data intended for use in making regulatory decisions. The QAPP/SAP ensures that defensible and high quality data is generated in this study by establishing performance goals and a process for evaluation of each of the study elements.

5.7.4.2.1. Vegetation

The principal concern for the vegetation portion of this study is to determine the mass of organics and mercury concentrations in the reservoir area. Plant species differ in their ability to take up mercury. At the Red Devil and Cinnabar Creek mines, alders and willows concentrate mercury at levels as much as 20 times higher than those in the other species collected in this study (Baily and Gray 1997). The mechanism of mercury uptake and reason for variation in mercury uptake by species is unclear. Siegal et al. (1985, 1987) have suggested that some species are mercury accumulators, whereas other plant species release their absorbed mercury as mercury vapor and thus lower their total concentration of mercury. Overall, leaves and needles have been found to hold the greatest accumulations of mercury in Alaska plants (Baily and Gray 1997).

The degradation rate for organic materials in water seems to be a primary source of the spike in methylmercury concentrations after filling of a reservoir (Hydro-Quebec 2003). Only the green part of the vegetation (leaves of trees and shrubs as well as forest ground cover) and the top centimeters of humus decompose quickly. Tree branches, trunks and roots, as well as deeper humus, remain almost intact decades after flooding (Morrison and Thérien 1991). Previous studies by Hydro-Quebec have shown that woody debris, even if it contains mercury, is not a problem for mercury methylation because the decay rate is slow in cold water (Hydro-Quebec 2003).

Based on these studies, up to 50 samples will be collected from various plants within the proposed inundation area. Studies are currently being completed on the distribution of types of species in the inundation zone, thus this information is currently unavailable. The sampling will be biased toward total vegetative mass, that is to say species that are present in the inundation area at low frequency and size may not be sampled, because even if these plants contain mercury, their contributions to mercury methylation will be low. Multiple samples (five to seven) will be collected at different locations for each species in the inundation area. Based on the available preliminary data, it is anticipated that a majority of the samples will consist of alder *(Alnus crispa),* willow *(Salix* sp.), white spruce *(Picea glauca),* cottonwood *(Populus balsamifera),* black spruce *(Picea mariana),* paper birch *(Betula papyrifera), and* dwarf birch *(Betula nana).* Leaves and needles will be collected.

Additional details of the sampling methods are provided in a combined Sampling and Analysis Plan (SAP) and the Quality Assurance Project Plan (QAPP) for this study.

5.7.4.2.2. Soil

Studies have found that the primary source of mercury to new reservoirs was the inundated soils (Meister et al. 1979), especially the upper organic soil horizon, which often has higher mercury levels than the lower inorganic soil layers (Bodaly et al. 1984). Measuring the thickness and mercury content of these soils prior to inundation may allow predictions of possible mercury methylation, and assist with evaluating potential mitigation methods, if necessary.

To the extent possible, soil samples are coincident with vegetative samples. The primary concern is to document the thickness and extent of organic rich soils, because these soils will have the highest concentrations of mercury and will provide most of the organic material resulting in the generation of methylmercury.

Additional details of the sampling methods are provided in a combined SAP and the QAPP for this study.

5.7.4.2.3. Water

The purpose of the water sampling is to collect baseline water quality information to support an assessment of the effects of the proposed Project operations on water quality in the Susitna River basin.

Mercury in water will be tested monthly during the summer along with two sampling events during the winter. Mercury has been shown to vary in concentrations throughout the year (Frenzel 2000).

Water samples will be collected at the locations shown on Table 5.7-5. The proposed spacing of the sample locations follows accepted practice when segmenting large river systems for development of Total Maximum Daily Load (TMDL) water quality models. Water sampling during winter months will be focused on locations where flow data are currently collected, or were historically collected by USGS. Water samples will be analyzed for the parameters reported in Table 5.7-6.

Grab samples will be collected along a transect of the stream channel/water body, using methods consistent with ADEC and EPA protocols and regulatory requirements for sampling ambient water and trace metal water quality criteria. Mainstem areas of the river not immediately influenced by a tributary will be characterized with a single transect. Areas of the mainstem with an upstream tributary that may influence the nearshore zone or that are well-mixed with the mainstem will be characterized by collecting samples at two transect locations: in the tributary and in the mainstem upstream of the tributary confluence. Samples will be collected at 3 equi-distant locations along each transect (i.e. 25% from left bank, 50% from left bank, and 75% from left bank). Samples will be collected from a depth of 0.5 meters below the surface as well as 0.5 meters above the bottom. This will ensure that variations in concentrations, especially metals, are captured and adequately characterized throughout the study area.

These samples will be collected on approximately a monthly basis (four samples from June to September). The period for collecting surface water samples will begin at ice break-up and extend to beginning of ice formation on the river. Limited winter sampling (once in December, and again in March) will be conducted where existing or historic USGS sites are located.

Review of existing data (URS 2011) indicates that few exceedances occur with metals concentrations during the winter months. If the 2013 data sets suggest that mercury concentrations exceed criteria or thresholds, then an expanded 2014 water quality monitoring program will be conducted to characterize conditions on a monthly basis throughout the winter months.

Variation of water quality in a river cross-section is often significant and is most likely to occur because of incomplete mixing of upstream tributary inflows, point-source discharges, or variations in velocity and channel geometry. Water quality profiles at each location on each transect will be conducted for field water quality parameters (e.g., temperature, pH, dissolved oxygen, and conductivity) to determine the extent of vertical and lateral mixing. Additional details of the sampling methods are provided in a combined SAP and the QAPP for this study.

5.7.4.2.4. Sediment and Sediment Pore Water

In general, all sediment samples will be taken from sheltered backwater areas, downstream of islands, and in similar riverine locations in which water currents are slowed, favoring accumulation of finer sediment along the channel bottom. Samples will be analyzed for mercury (Table 5.7-6). In addition, sediment size and total organic carbon (TOC) will be included to evaluate whether these parameters are predictors for elevated mercury concentrations. Samples will be collected just below and above the proposed dam site. Additional samples will be collected near the mouth of tributaries near the proposed dam site, including Fog, Deadman, Watana, Tsusena, Kosina, Jay, and Goose creeks, and the Oshetna River. The purpose of this sampling will be to determine where metals, if found in the water or sediment, originate in the drainage.

Mercury occurrence is typically associated with fine sediments, rather than with coarse-grained sandy sediment or rocky substrates. Therefore, the goal of the sampling will be to obtain sediments with at least 5 percent fines (i.e., particle size <63 µm, or passing through a #230 sieve).

Surficial sediment sampling will be conducted with a Van Veen sampler lowered from a boat by a power winch. This sampling device collects high-quality sediment samples from the top four to six inches of sediment. Three sediment samples will be collected at each of the sites sampled. These three samples will be collected and analyzed separately to characterize the presence of mercury and generate statistical summaries for site characterization. A photographic record of each sediment sample will be assembled from images of newly collected material.

Care will be taken to ensure the following:

- The sampler will not be overfilled with sediment.
- The overlying water is present when the sampler is retrieved.
- At least two inches of sediment depth is collected.
- There is no evidence of incomplete closure of the sampling device.

If a sediment sample does not meet all of the criteria listed above, it will be discarded and another sample will be collected.

Sediment interstitial water, or pore water, is defined as the water occupying the space between sediment particles. Interstitial waters will be collected from sites listed above and separated from sediments in the field house laboratory using a pump apparatus to draw pore water from each of the replicate samples. Filtering of samples will utilize a 0.45-µm pore size filter in both the lab apparatus and field apparatus. In some cases, pore water may be drawn from sediment samples in the field by using 100-milliliter (mL) syringes immersed in the dredge sample once a sediment sample is collected in a sample jar. These would be cases where sediment samples have slightly coarser particle sizes and pore water extraction in the field is possible. In other instances, where sediment samples have finer particle sizes requiring more time to draw samples for laboratory analysis, these samples will be transferred to the field laboratory for pore water extraction.

Additional details of the sampling methods are provided in a combined SAP and QAPP for this study.

5.7.4.2.5. Piscivorous Birds and Mammals

The potential impacts of methylmercury on upper trophic level species can by influenced by a variety of factors including animal behavior and physiology (e.g., foraging behavior, diet composition) and physical/chemical properties of the receiving environment (e.g., organic carbon content, anaerobic conditions, sulfides, etc.). Fish, in particular, absorb methylmercury efficiently from dietary sources and store this material in organs and tissues (U.S. EPA, 1997). Because fish are the primary source of methylmercury migration into the terrestrial ecosystem, this evaluation focuses on the impact of methylmercury generated in the proposed reservoir on fish-eating (piscivorous) upper trophic species.

5.7.4.3. Bird Species

Waterbirds such as loons, grebes, terns, and kingfishers consume varying amounts of small fish. Small fish tend to have lower mercury concentrations than larger fish. Previous studies have shown that mercury levels in waterbirds are highly variable (Braune et al. 1999; Langis et al. 1999). This variability results from the propensity of waterbirds to migrate between drainages, and the variability of mercury concentrations between drainages and food sources. Because of dietary preferences, the belted kingfisher and loon are likely to be a more conservative indicator species than grebe and other aquatic bird species that could be exposed to mercury.

For raptors, ospreys typically consume a diet exclusively of fish, whereas bald eagles feed on fish, birds and other animals including carrion (Watson and Pierce 1998). These birds have a long life span (15 to 30 years in the wild), so they are likely to have the opportunity to accumulate significant amounts of mercury throughout their lifespans. A study in northern Quebec found that ospreys nesting near reservoirs had high burdens of methylmercury in their muscle tissues (DesGranges et al. 1998). However, the ospreys there did not appear to suffer reproductive problems that are typical of high methylmercury exposure, and it has been suggested that the tolerance of fish-eating raptors to this compound may be higher than other species (DesGranges et al. 1998).

Predicting site-specific mercury exposure in raptors from feather or tissue residue concentrations is difficult because that they tend to feed over wide ranges (osprey are migratory), and that while both species feed on salmon, eagles tend to favor this type of fish. Salmon mercury concentrations are generally higher than other species of fish, but are typically only available seasonally in freshwater environments. This means that mercury concentrations in raptors may vary seasonally as well. In addition, salmon are not anticipated to be in the area after completion of the reservoir.

5.7.4.4. Aquatic Mammal Species

Aquatic furbearers that eat fish are at the highest risk of accumulating mercury. River otter and mink, both of which occur in the study area at low numbers, can accumulate the highest concentrations of mercury in their body tissues (Yates et al, 2005). As with birds, predicting how methylmercury in the aquatic food chain will affect mammal populations is difficult. The concentration of methylmercury in mammal tissue depends on diet, range, and longevity of the animal. Studies have documented mercury levels in river otter ranging from 0.89 to 36.0 µg/g wet weight in muscle tissue, and from 0.02 to 96.0 µg/g wet weight in liver tissue (Wren et al. 1980). Mink have similar mercury levels, ranging from 0.71 to 15.2 µg/g wet weight in muscle tissue and from 0.04 to 58.2 µg/g wet weight in liver tissue. Because mink and otter represent an aquatic and terrestrial species, both species will be considered as part of this study.

5.7.4.5. Sampling Program

There are two significant challenges to the proposed sampling program. The first is that the populations of most piscivorous birds and aquatic mammals are relatively small in the proposed study area. For that reason, sampling efforts are likely to collect few samples, or may be entirely unsuccessful for some species. From a statistical standpoint, low sample returns (< 5 samples), coupled with high variability in methylmercury concentrations, and may reduce the accuracy of results and conclusions for this study. In addition, damaging relatively small populations of these species as part of this study is undesirable, and therefore non-destructive sampling methods are preferred.

The second challenge is that some species may be feeding in areas outside the area of project effects. Species that feed in more than one area may be exposed to widely varying methylmercury dietary loads that are not specific to the inundation zone.

To compensate for these problems, the proposed study will:

1) Utilize data obtained in other studies on background concentrations of methylmercury in natural northern environments.
2) Utilize samples in the muscle and liver of various fish species and from feathers and fur, where it does not degrade quickly (Thompson, 1996; Strom 2008). These types of samples can be collected without harvesting or even harassing the species being sampled.

Feathers will be collected from nests of raptors (principally bald eagles, given that ospreys are rare in the study area), loons, grebes, arctic terns, and kingfishers found during the wildlife surveys planned for 2013 and 2014. Feathers from raptors and waterbirds will only be collected after the nests have been vacated for the season. Kingfisher feathers will be collected from borrows during the planned survey of colonially nesting swallows.

Fur samples from river otters and mink will be sought from animals harvested by trappers in the study area; river otter furs must be presented to ADF&G for sealing, at which time fur samples can be obtained from animals known to have been harvested in or near the study area. In view of the low level of trapping expected to occur in the area, however, it is possible that this approach will yield few samples. If this approach does not yield fur samples in 2013, fur will be collected by placing hair-snag “traps” at or near the mouths of tributaries near the proposed dam site, including Fog, Deadman, Watana, Tsusena, Kosina, Jay, and Goose creeks, and the Oshetna River.

Studies have shown that a vast majority of the mercury found in fur and feathers will consist of methylmercury, therefor the analyses will be for total mercury only (Evers et al 2005). Samples will be analyzed using Environmental Protection Agency (EPA) Method 7473. Additional details on the sampling are included as part of the SAP/QAPP (Attachment 5-1).

5.7.4.6. Predictive Risk Analyses

A predictive risk analysis is likely to be a better indicator of potential mercury impacts on the terrestrial environment than measured concentrations of mercury at the project site, since the number of samples that may be collected will be low, and methylmercury concentrations in fur and feathers can change seasonally (U.S. EPA, 1997). In addition, mercury sequestration in feathers may not be a good indicator of current or relevant exposure levels. For example, a study measuring feather mercury concentrations in seabirds during various growth and development stages of the birds suggest that in seabirds molting may be an efficient means of eliminating mercury (Becker et al., 1994; Burger et al., 1994).

The potential impacts of the Project on mercury levels on piscivorous birds and aquatic furbearers will be assessed using a risk characterization approach. This approach uses exposure and toxicity assessments to link a chemical of potential concern, in this case methylmercury, with adverse ecological effects (known as the toxicity reference value or TRV). The hazard quotient (HQ) is the ratio of average anticipated concentration of mercury being ingested to the known concentration where adverse effects may occur. It will be calculated for all species for which significant samples are available.

The global assumptions and limitations of the mercury models are as follows:

- The reservoir is flooded and mercury baseline is measured as Day 1 of operation.
- Herbivores and omnivores accumulate less total mercury in tissue than piscivores, therefore this type of assessment is protective of other terrestrial species.
- Mercury concentrations in fish are expected to peak in 3 to 7 years after filling of the reservoir.
- Fish concentrations will be predicted using other modeling methods outlined in Section 5.7.4.2.6.
- Because total mercury levels in piscivores are highly correlated with the ingestion rates of fish, total mercury bioaccumulation will approximate the rate of increase and decline in fish.

In order for the predicted exposure to be compared against the TRV, the daily intake (D) will be calculated. D is defined as the amount of chemical an organism is exposed to on a mg/kg body weight/day basis and is normalized for body mass. Because the sediment and water intake of mercury is likely to be minimal as compared to the food ingestion pathway, only dietary intake will be quantified. The formula for calculating D is as follows:

$$D = \frac{F_{site} \times [(IF \times EPC \times PF)]}{BW}$$

Where:

- IF is the Intake Factor (kg fish/kg body weight per day)
- EPC is the Exposure Point Concentration (mg methylmercury/kg fish)
- PF is portion of total food containing a particular chemical of concern.
- BW = body weight (kg)
- F_{site} is the fraction of total ingestion from the site.

The IF is calculated using the ingestion rate (IR) of fish (kg/day) on a dry weight basis. The model can be adjusted to account for the consumption of piscivorous and non-piscivorous fish species.

TRV values for mercury incorporated a chronic lowest-observed adverse effects level threshold for adverse effects to reproduction, growth, and/ or survival. As previously stated, the HQ =D/TRV. Typically, a HQ >1 indicates that the exposure concentration has surpassed the threshold and adverse effects are possible. A HQ < 1 means the exposure concentration has not surpassed the threshold and consequently adverse effects are unlikely to occur. These values will be derived from the extant literature. For example, USEPA (1997) set reference doses for methylmercury in avian and mammalian wildlife at 21 and 18 µg/kg body weight per day, respectively. It also suggested the wildlife criterion as measured in water for several key species as follows:

Species	Methylmercury in water (pg/L)
Kingfisher (*Ceryle alcyon*)	27
Mink (*Mustela vison*)	57
Loon (*Gavia immer)*	67
Osprey (*Pandion haliaetus*)	67
River otter (*Lutra canadensis*)	42
Bald eagle (*Haliaeetus leucocephalus*)	82

pg/L= picograms per liter

5.7.4.6.1. Fish Tissue

Methylmercury is ubiquitous in the environment, and can be found in fish throughout Alaska. The primary concern of this study is not to catalogue this source of mercury in the environment; rather, it is to evaluate the potential for increasing mercury concentrations above background due to filling of the reservoir.

Methylmercury bioaccumulates, and the highest concentrations are typically in the muscle tissue of adult predatory fish. Targeting adult fish is a good way of monitoring methylmercury migration to the larger environment. While it may be possible for methylmercury generated by the reservoir to affect other species, there does not appear to be any pathway by which this could happen without also affecting fish. Avian species have the potential to bypass fish by feeding on small fish species and macroinvertebrates; however, bird species can move between drainages and sources of mercury, and it is difficult to determine what contributions may be from the reservoir or from outside sources.

Target fish species in the vicinity of the Susitna-Watana Reservoir will be Dolly Varden, arctic grayling, stickleback, long nose sucker, whitefish species, lake trout, burbot, and resident rainbow trout. If possible, filets will be sampled from seven adult individuals from each species. The larger number of samples from existing fish species will allow for some statistical control over the results.

For comparison purposes, Hydro-Quebec, in their extensive study of methylmercury impacts from existing reservoirs, collected 131 lake trout from 7 lakes over a period of 22 years (Hydro Quebec, 2003). This comes to less than 1 fish per water body per year. AEA is proposing collecting many more fish over a shorter period of time.

Methylmercury concentrations in fish vary predominately by species, age, water body size, and location. For example, ADEC has reported statewide concentrations of methylmercury in pike to be 420 ppb (n =532), while in arctic grayling it is 84 ppb (n=44) (ADEC 2012), a 400%

difference. Increases in methylmercury above background post impoundment are typically measured in units of 100% (Harris and Hutchison, 2008).

There is a well-known positive correlation between fish size (length and weight) and mercury concentration in muscle tissue (Bodaly et al. 1984; Somers and Jackson 1993). Larger, older fish tend to have higher mercury concentrations. These fish will be the targets for sampling. Body size targeted for collection will represent the adult phase of each species life cycle. For stickleback, whole fish samples will need to be used.

Collection times for fish samples will occur in August and early September. Intensive studies of methylmercury concentrations in the zooplankton of boreal lakes (Garcia et al. 2007) has shown that average methylmercury concentrations increased by 48% between spring and mid-summer, and decreased by just 12% between mid and late summer. This is very consistent with Bodaly et al (1993) which showed that methylmercury concentrations in fish, when controlled for age and reservoir size, were strongly related to shallow water temperatures. As water temperatures are reduced, methylmercury concentrations in fish tissue also tend to decrease. Therefore the proposed sampling period should represent the highest concentrations of methylmercury in fish tissue, and also the most likely time when the fish may be harvested by terrestrial wildlife.

Samples will be analyzed for methyl and total mercury (Tables 5.7-6). It is anticipated that most of the mercury found in the fish with be methylmercury. Liver samples will also be collected from burbot and analyzed for mercury and methylmercury. Salmon will not be sampled. Preliminary data suggests that approximately 30 Chinook (king) salmon spawn in the Watana area. Collecting a sufficient number of samples from this resource would seriously deplete it. Instead, sampling data from ADEC will be used to evaluate mercury concentrations in this resource (ADEC 2012). It should be noted that most of the mercury in salmon is oceanic in origin.

Field procedures will be consistent with those outlined in applicable ADEC and/or EPA sampling protocols (USEPA 2000). Clean nylon nets and polyethylene gloves will be used during fish tissue collection. Species identification, measurement of total length (mm), and weight (g) will be recorded, along with sex and sexual maturity. If possible, efforts will be made to determine the age of the fish, including an examination of otoliths and scales.

It is possible that adult fish of all species may not be present or available in the drainage. In this case, younger fish may be sampled. To eliminate the bias associated with differences in fish size, appropriate statistical procedures will be used to determine the mean mercury concentration for a specific fish size (Hydro Quebec 2003).

Additional details of the sampling methods are provided in a combined SAP and the QAPP for this study.

5.7.4.7. Modeling

Reservoir impoundments have been documented to cause significant increases in fish mercury levels by factors that generally ranged from 3 to 7 (Hydro-Quebec 2003). The phenomenon is temporary, and mercury concentrations generally returned to baseline values after 7 to 30 years.

Reservoir construction involves raising the water level and flooding a large quantity of terrestrial organic matter (vegetation and the surface layers of soils). During the early years of a reservoir's existence, this organic matter is subject to accelerated bacterial decomposition, which increases methylation of the mercury accumulated in the soil from the atmosphere. The production of methylmercury is governed by the amount and type of flooded organic matter and by biological and physical factors such as bacterial activity, water temperature, oxygen content of the water, etc.

Part of the methylmercury produced is released into the water column where it may be transferred to fish via zooplankton. Insect larvae feeding in the top centimeters of flooded soils can assimilate the methylmercury available and transfer it to fish (Figure 5.7-2).

There is evidence that mercury concentrations in fish correlate closely with environmental parameters such as pH (Qian et al. 2001; Ikingura and Akagi 2003), organic carbon (Cope et al. 1990; Suns and Hitchin 1990; Driscoll et al. 1995), and wetland area (Greenfield et al. 2001). However, because fish assimilate the vast majority of their mercury burden from their diet, such correlations are indirect (Westcott and Kalff 1996; Lawson and Mason 1998). It is, however, possible to predict the potential for mercury methylation based on the pH, dissolved oxygen content, organic carbon, and wetland area of an individual drainage.

There are several ways to predict the occurrence of methylmercury in a newly formed reservoir. One way is to model the physical conditions that create methylation of mercury. If the conditions for methylation are present (low DO, low pH, organic content, etc.), then it is presumed that methylation will occur, and the methylmercury will be transferred outside the reservoir. This type of modeling will be done as part of the model for the reservoir (see Section 5.6 Water Quality Modeling Study). This type of modeling does not predict specific impacts to the ecosystem, but merely suggests that such impacts could occur, and where in the reservoir methylmercury may be forming. Such an approach has considerable value in evaluating potential mitigation measures.

The other way of predicting the occurrence of methylmercury is to model concentrations in fish tissue after filling of the reservoir. Schetagne et al. (2003) found a strong correlation between the ratio of flooded area, the mean annual flow through of the reservoir, and maximum mercury concentrations in fish tissue. This approach was further refined by Harris and Hutchinson (2008) to provide a predictive tool for methylmercury concentrations in fish. Regression calculations using historical data from multiple reservoirs have determined the coefficients that control these equations. The drawback to these models is that they only predict peak methylmercury concentrations, not when these concentrations will occur or subside.

Phosphorous release modeling is a semi-empirical way to derive the same result, but has the added benefit of being able to predict when peak methylmercury concentrations will occur, and when they are likely to subside (Hydro-Quebec 2003). Unfortunately, they require considerably more input parameters, which can create additional uncertainty in the results.

5.7.4.7.1. Harris and Hutchison Model

The model assumes that the primary source of methylmercury in a new reservoir is the flooded terrain, while the primary methylmercury removal mechanism is outflow/dilution. The highest methylmercury concentrations in fish are therefore associated with reservoirs that flood large areas, but have low flow-through.

The formula is as follows:

Peak Increase factor = 1 + K_1 x <u>Area Flooded</u>

$$Q + K_2 \times (\text{Area Total})$$

Where

Peak increase factor = peak increase factor in fish methylmercury over background

Area flooded = flooded area (km^2)

Q = mean annual flow (km^3/yr.)

K_1 = regression coefficients (km/yr.)

K_2 = regression coefficients (1/yr.)

Area total = Total reservoir area (km^2)

The values of K1 and K2 are adjusted for piscivorous and non-piscivorous species of fish. The use of area in the denominator reflects an assumption that methylmercury removal mechanisms other than outflow are primarily related to area (e.g., photodegradation, burial and sediment demethylation) rather than volume. This approach has been calibrated and tested in the field, with good results (Harris and Hutchinson 2008). This method will be used to estimate methylmercury concentrations in fish at the proposed reservoir.

5.7.4.8. Phosphorous Release Model

The more complex method of estimating methylmercury impacts was pioneered by Messier et al. (1985) based on the phosphorus release model of Grimard and Jones (1982), whole-ecosystem reservoir experiments at the Experimental Lakes Area (ELA) in Ontario, Canada (Bodaly et al. 2005), and confirmed by decades-long studies of reservoirs by Hydro-Quebec (2003). It predicts peak fish mercury levels and the timing of the response to flooding. The model pays special attention to flood zone characteristics, because decomposition after flooding is a key driver for increases in methylmercury levels in new reservoirs.

Studies have shown that a simple model cannot explain all the differences observed between reservoirs with regard to maximum fish mercury levels (Hydro-Quebec 2003). The filling time is another important factor in determining the maximum levels in fish; several authors have demonstrated that mercury is released into the water column very rapidly when organic matter from soils and vegetation is flooded (Morrison and Thérien 1991; Kelly et al. 1997). Chartrand et al. (1994) showed that the changes in reservoir water quality correspond to bacterial decomposition of organic matter (as does mercury release) and peak two or three years after impoundment in reservoirs filled in one year or less, but after six to ten years in impoundments that took 35 months to fill. Thus, a longer filling time leads to lower peak values, but prolongs the period of elevated mercury levels.

The percentage of flooded land area located in the drawdown zone is another important factor because it is an indicator of the active transfer of methylmercury to fish by periphyton and benthic organisms. In fact, this transfer can occur for over 14 years in shallow areas that are rich in flooded organic matter and protected from wave action (Tremblay and Lucotte 1997). Where forest soil cover is thin, wave action along the exposed banks of the drawdown zone quickly erodes the mercury-rich organic matter and deposits it in deeper, colder areas that are less conducive to methylation. This erosion considerably reduces the area of flooded soil that still has organic matter colonized by the benthic organisms responsible for much of the transfer of methylmercury to fish. Therefore, the larger the percentage of flooded land area in a reservoir drawdown zone, the smaller and shorter in duration the increase in fish mercury levels is likely to be. Colder water and the vegetation and soil cover that contained less decomposable organic matter (Association Poulin Thériault-Gauthier & Guillemette Consultants Inc. 1993) may also help mitigate the increase in fish mercury levels.

The Hydro-Quebec model is semi-empirical, not mechanistic: decaying organic material releases phosphorous at a set rate (the phosphorus release curve), which controls decomposition of the organic material in the inundation zone. This turns out to be a fairly accurate measure of the bioavailability of mercury for fish, and can be used to predict mercury concentrations in muscle tissues.

The basic equation used by Hydro-Quebec is as follows:

$$V\,(P_r)_t = \frac{P_i}{Ø} \times (1-e^{-Øt}) + \frac{rB}{\alpha - r} \times \left(\frac{e^{-rt}-e^{-Øt}}{Ø-r} + \frac{e^{-Øt}-e^{-\alpha t}}{Ø-r}\right) + V\,(P_r)_0 e^{-Øt}$$

Where:

V	=	Reservoir volume (m^3)
P_r	=	Concentration of total phosphorous in the reservoir at time t (mg/m^3)
t	=	time in years after reservoir filling
Pi	=	Total phosphorous from inflows (mg/yr.)
Ø	=	The sum of the sedimentation coefficient and the flushing coefficient (r)
r	=	The reservoir flushing coefficient (per year)
α	=	The phosphorous release coefficient = ½(365/X)
X	=	The half-life of the organic matter in days
B	=	$\alpha(I_t)S_{max}$
S_{max}	=	Maximum surface area flooded (m^3)
T	=	Time (year)

When solved for Pr, this allows for the calculation of the amount of decomposable organic matter (mgC/m2) at a specific time (It), calculated by:

$$I_t = (P_r)_0 + 4((Pr)_t - (P_r)_0)$$

Where It is the decomposition factor at the time t. This result can then be used to calculate mercury concentrations in non-piscivorous (NP) species and piscivorous (P) species of fish:

$$(Hg_{np})_t = (Hg_{np})_{t-1} \times \frac{(1)}{(2^{365/u})} + dI_t$$

Where:

Hg_{np} = mercury concentration in non-piscivorous muscle tissue (mg/kg)
u = half-life of mercury in fish (days). This is typically set at 700 days in northern climates, but can be adjusted.
d = a transfer factor

For the predatory species, the decomposition factor was replaced by a factor (f) for mercury transfer from the prey to the predator:

$$(Hg_p)_t = (Hg_p)_{t-1} \times \frac{(1)}{(2^{365/u})} + f(Hg_{np})_t$$

Where Hgp = mercury concentration in piscivorous muscle tissue.

These formulas have been tested, and found to be very effective in predicting mercury concentrations in fish tissue (Figure 5.7-2). Note that the predictions generally tend to overestimate the changes actually recorded. This situation reflects a conscious choice on the part of the developers of the formula to be conservative with their predictions.

The phosphorous release model will be used if the previous methods (the water quality model or the Harris and Hutchison model) suggest there may be significant methylmercury production in the reservoir.

5.7.4.9. Pathway Assessment

Assessment of the potential pathways for mercury in the environment will be based on readily available literature (Hydro-Quebec 1993; Johnston et al. 1991; Therriault and Schneider 1998), and additional mercury studies, to ensure the most applicable methods are used to meet Project needs. The goal of the pathway assessment will be to evaluate the potential pathways for methylmercury to move into the ecosystem, both from the reservoir and downstream of the reservoir.

The pathway assessment will incorporate both existing conditions, and conditions with the reservoir and dam in place. The reservoir representation will be developed based on the local bathymetry and dimensions of the proposed dam. The Water Quality Modeling Study (Section 5.6) provides for a three-dimensional model to be developed for the proposed reservoir to represent the spatial variability in hydrodynamics and water quality in longitudinal, vertical, and lateral directions. The model will be able to simulate flow circulation in the reservoir, turbulence mixing, temperature dynamics, nutrient fate and transport, interaction between nutrient and algae, and potentially sediment and metal transport.

5.7.4.10. Technical Report on Analytical Results and Mercury Assessment

The technical report will include a description of the study goals and objectives, assumptions made, sample methods, analytical results, models used, and other background information. Field data, laboratory report, and quality assurance information will be attached. Mercury will be modeled using two methods:

1. Water quality modeling of the reservoir will predict whether the conditions for the formation of methylmercury will be present, and where in the reservoir this may occur.
2. The linear model of Harris and Hutchinson (2008) to provide an initial prediction of peak mercury concentrations in fish.

The phosphorous release model may be used if there is a need to evaluate when peak methylmercury production may occur.

The report will include a conceptual model showing mercury inputs to the reservoir, mercury methylation, mercury circulation among different media (fish, air, water, sediment, etc.), and bioabsorption and transfer. Strategies to manage mercury methylation, bioaccumulation, and biomagnification will be reviewed (Mailman et al. 2006).

Sediment, water, and tissue results from toxics analysis will use the federal NOAA Screening Quick Reference Tables (SQuiRTs). These are thresholds used as screening values for evaluation of toxics and potential effect to aquatic life in several media and will be implemented where ADEC water quality, sediment, or tissue criteria are not available.

An example for SQuiRT values can be found at the following website:

http://mapping2.orr.noaa.gov/portal/sanfranciscobay/sfb_html/pdfs/otherreports/squirt.pdf

Specific thresholds and criteria for toxics in each of the media are included in a QAPP.

Coordination will occur with the instream flow, ice processes, productivity, and fish studies to obtain information needed to reflect the results of this study in the context of the various Project scenarios.

5.7.5. Consistency with Generally Accepted Scientific Practice

Field sampling practices proposed in this study are consistent with ADEC (2003, 2005); USGS (Ward and Harr 1990); Edwards and Glysson 1988); and EPA (USEPA 2000). Results will be compared to established NOAA cleanup levels (NOAA 2012). Studies, field investigations, laboratory testing, engineering analysis, etc. will be performed in accordance with general industry-accepted scientific and engineering practices. The methods and work efforts outlined in this study plan are the same or consistent with analyses used by applicants and licensees and relied upon by FERC in other hydroelectric licensing proceedings.

The Clean Water Act Section 401 Water Quality Certification process includes a baseline assessment of mercury conditions and will determine if existing conditions will result in a potential for bioaccumulation. The monitoring strategy used in this study follows scientifically accepted practice for identifying impacts to water quality and will be used for Project certification. ADEC and USGS are currently pursing similar sampling programs for fish tissue in the state (ADEC 2012; Frenzel 2000; and Krabbenhoft et al. 1999).

FERC has a long history of performing similar studies during hydroelectric permitting, including most recently at the Middle Fork American River Project (FERC Project No. 2079) in 2011; and Yuba County Water Agency Yuba River Development Project (FERC Project No. 2246).

5.7.6. Schedule

The study elements will be completed in several stages and based on the timeline shown in Table 5.7-7. Water quality monitoring will start in March 2013, and continue periodically throughout the remainder of the year. Sediment and fish tissue sampling will occur in July and August. Bird and aquatic furbearer samples will be collected in the third quarter of 2013. Some fish tissue samples have already been collected in 2012, the remainder will be collected in the third quarter of 2013. The initial study report will be completed by December 2014, with the final due in the first quarter of 2015. Additional follow-up studies will be performed between these two dates, as necessary.

5.7.7. Relationship with Other Studies

A flow chart (Figure 5.7-3) describing interdependencies outlines origin of existing data and related historical studies, specific output for each element of the Water Quality studies, and where the output information generated in the Water Quality studies will be directed. This chart provides details describing the flow of information related to the Water Quality studies, from historical data collection to current data collection. Data were examined in a Water Quality Data Gap Analysis (URS 2011) and this information was used, in part, to assist in making decisions about the current design for the Water Quality Monitoring studies and for ensuring that the current modeling effort would be able to compare the 1980s study results with current modeling results.

Integral portions of this interdependency chart are results from the Ice Processes Study and from the Fish and Aquatic Instream Flow Study. The Ice Processes Study will support water quality model development (Study Plan 5.6) with information about timing and conditions for ice formation and ice break-up. The Fish and Aquatic Instream Flow Study represents the effort to develop a hydraulic routing model that will be coupled with the EFDC water quality model. Water quality monitoring efforts for field parameters, general chemistry, and metals (including mercury) will be used as a calibration data set for developing the predictive EFDC model.

5.7.8. Level of Effort and Cost

The estimated cost for the proposed work in 2013 and 2014, including planning and reporting is approximately $500,000. This presumes that the costs for sampling and analyses all non-biological media are covered within the water quality costs.

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5.7.10. Tables

Table 5.7-1. Sediment Results from the Susitna River Drainage

Location	Mercury (µg/g dry weight)
Talkeetna River	0.04
Deshka River	0.46
Colorado Creek	0.18
Costello Creek	0.23
National median value	0.06

From Frenzel (2000)

Table 5.7-2. Whole Body Slimy Sculpin Results from the Susitna River Drainage

Location	Mercury (µg/g dry weight)
Talkeetna River	0.08
Deshka River	0.11
Costello Creek	0.08

From Frenzel (2000)

Table 5.7-3. Speciated Mercury Results from Susitna River Drainage (µg/g dry weight)

Location	Sediment		Fish	Water	
	Inorganic mercury	Methylmercury	Inorganic mercury	Inorganic mercury	Methylmercury
Deshka River	0.021	0.00510	0.246 (SS)	Not sampled	Not sampled
Costello Creek	0.169	0.00004	0.101 (DV)	0.00497	0.00002

SS = whole slimy skulpin
DV = Dolly Varden fillet
From Frenzel (2000)

Table 5.7-4. Summary of ADEC Data for Mercury in Fish Tissue, Susitna River Drainage

Species	Number of Samples	Mean	Std. Deviation
Arctic Char	3	0.21000	0.052915
Burbot	1	0.09400	0
Grayling	18	0.10239	0.033477
Northern Pike	98	0.21071	0.206272
Salmon – Pink	16	0.25813	0.051279
Salmon – Red	14	0.02907	0.017398
Salmon – Silver	5	0.09520	0.053905
Stickleback – Nine Spine*	1	0.07600	0
Stickleback – Three Spine*	2	0.07350	0
Lake Trout	3	0.38000	0.319531
Rainbow Trout	27	0.11187	0.086007
Whitefish - Round	7	0.10929	0.048623

Concentrations in mg/kg. * indicates sample analyzed as whole body composite sample. All other fish samples analyzed as skinless fillets. Samples that were below detection limits were listed as 1/2 of detection limit. NOTE: If Std. Dev. is listed as 0, all the samples were below detection limits (ADEC, 2012).

Table 5.7-5. Proposed Susitna River Basin Mercury Monitoring Sites

Susitna River Mile	Description	Susitna River Slough ID	Latitude (decimal degrees)	Longitude (decimal degrees)
25.8	Susitna Station	NA	61.5454	-150.516
28.0	Yentna River	NA	61.589	-150.468
29.5	Susitna above Yentna	NA	61.5752	-150.248
40.6	Deshka River	NA	61.7098	-150.324
55.0	Susitna	NA	61.8589	-150.18
83.8	Susitna at Parks Highway East	NA	62.175	-150.174
97.2	Talkeetna River	NA	62.3418	-150.106
98.5	Chulitna River	NA	62.5574	-150.236
103.0	Talkeetna	NA	62.3943	-150.134
120.7	Curry Fishwheel Camp	NA	62.6178	-150.012
136.8	Gold Creek	NA	62.7676	-149.691
138.6	Indian River	NA	62.8009	-149.664
138.7	Susitna above Indian River	NA	62.7857	-149.651
148.8	Susitna above Portage Creek	NA	62.8286	-149.379
148.8	Portage Creek	NA	62.8317	-149.379
184.5	Susitna at Watana Dam site	NA	62.8226	-148.533
223.7	Susitna near Cantwell	NA	62.7052	147.538

Table 5.7-6. List of parameters and frequency of collection.

Media	Analyses	Frequency of Collection	Holding Time
Surface Water, sediment pore water	Total and methylmercury (EPA-7470A)	Monthly	48 hours
Soil, Sediment	Total mercury (EPA 245.2/7470A)	One Survey-summer	28 days
Avian, Terrestrial Furbearers, and Fish Tissue	Total and methylmercury (EPA-1631)	One Survey-late summer	7 days

Table 5.7-7. Schedule for Implementation of the Mercury Assessment and Potential for Bioaccumulation Study.

Activity	2012				2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Water Quality Monitoring (monthly)							▬	▬					
Soil and Vegetation Sampling							▬						
Sediment Sampling							▬						
Bird and Aquatic Furbearer Sampling							▬						
Fish Tissue Sampling			▬				▬						
Data Analysis and Management								▬	▬				
Initial Study Report									Δ				
Follow-up studies (as needed)										▪▪▪	▪▪▪	▪▪▪	
Updated Study Report													▲

<u>Legend:</u>

▬ Planned Activity
▪▪▪ Optional Activity

Δ Initial Study Report
▲ Updated Study Report

5.7.11. Figures

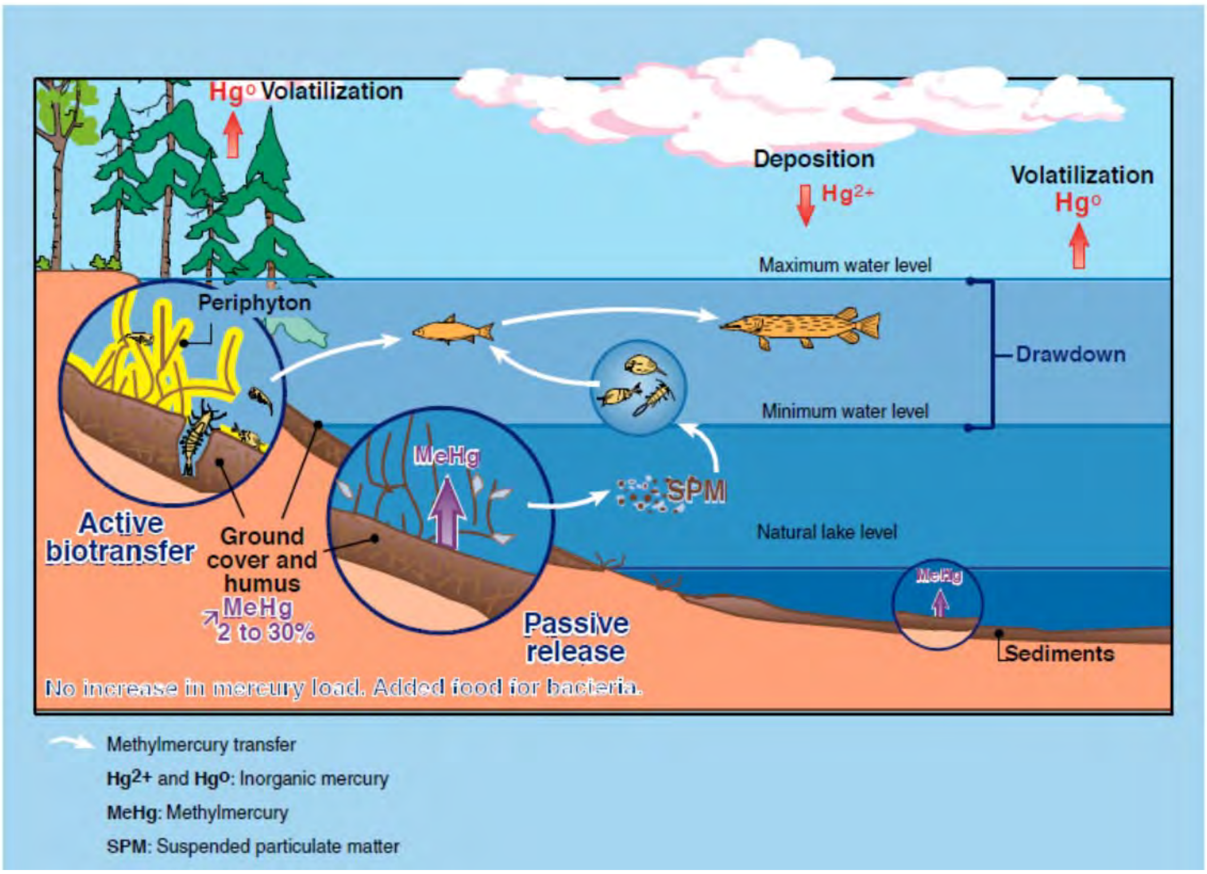

Figure 5.7-1. Transfer of Methylmercury to Fish Shortly after Impoundment from Hydro-Quebec (2003).

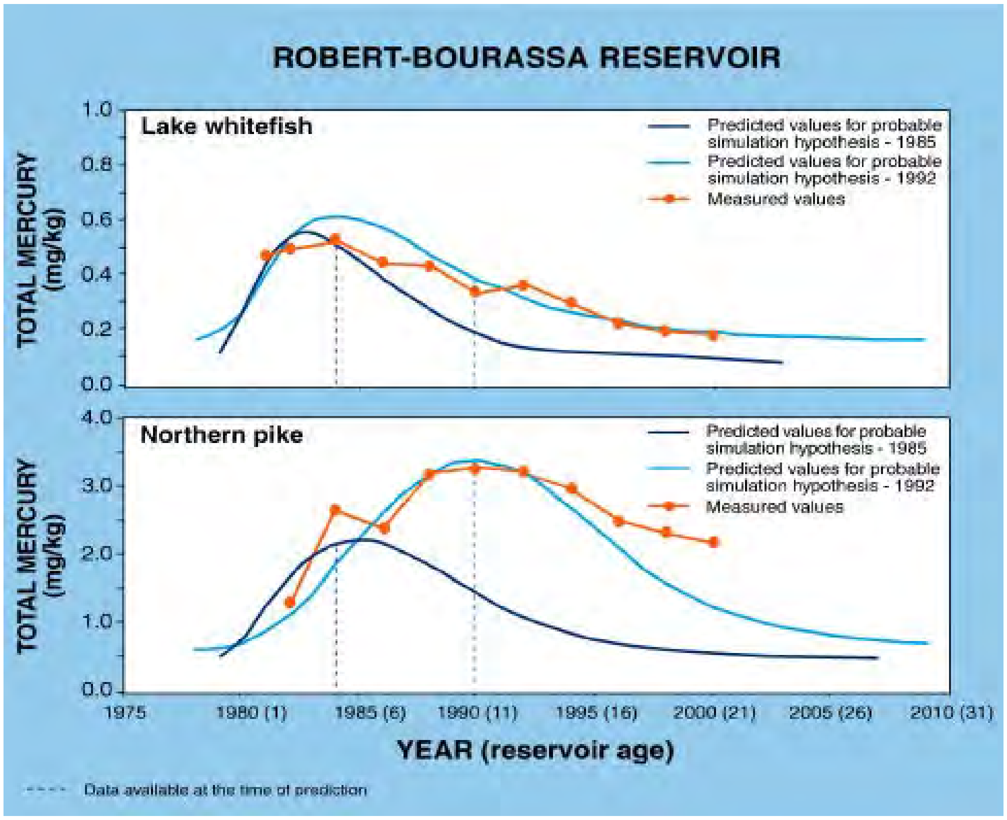

Figure 5.7-2 Example of Predicted and Actual Mercury Concentrations in Fish (from Hydro-Quebec 2003).

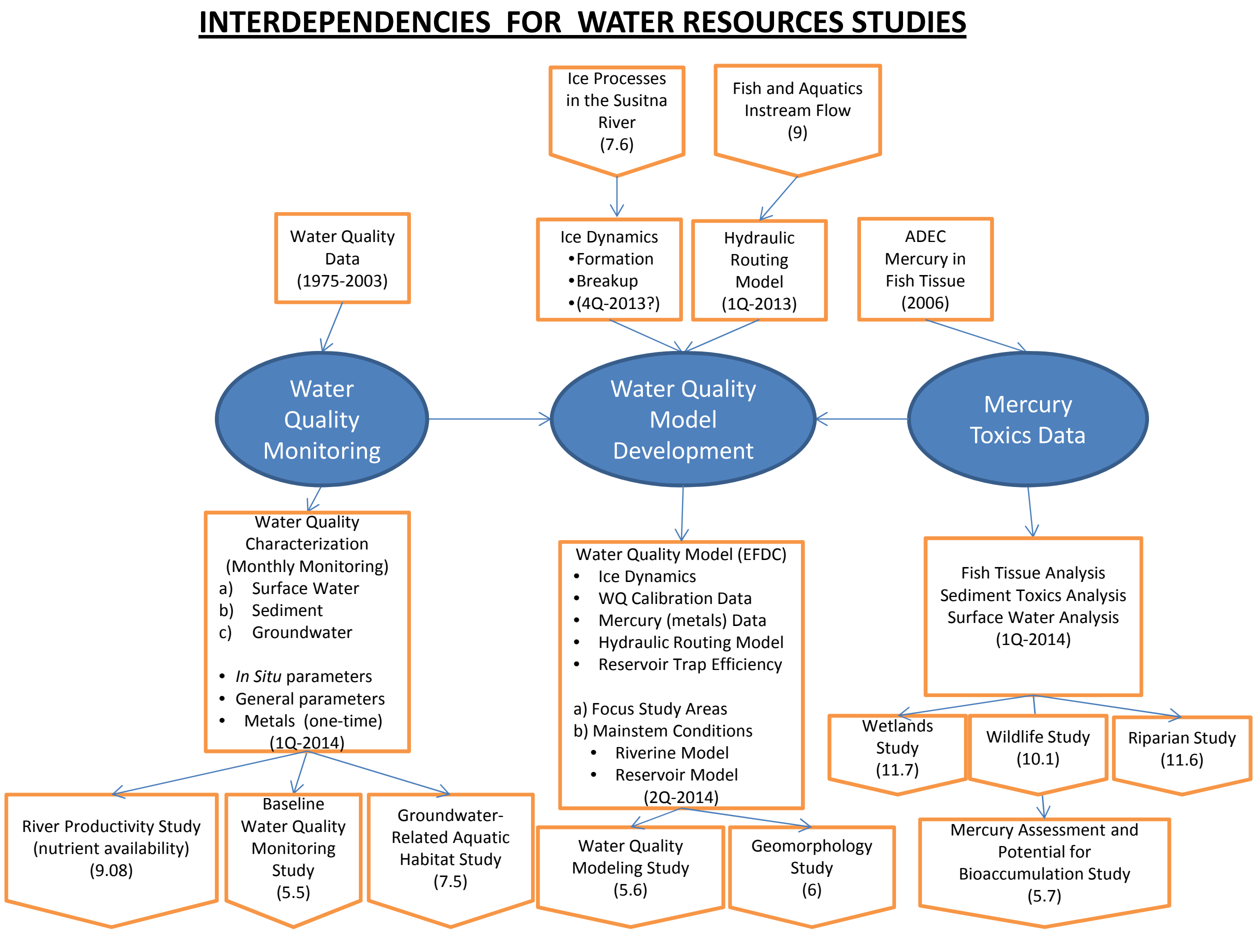

Figure 5.7-3. Interdependencies for water resources studies.

5.8. Attachments

ATTACHMENT 5-1. BASELINE WATER QUALITY MONITORING - SAMPLING AND ANALYSIS PLAN (SAP)/QUALITY ASSURANCE PROJECT PLAN (QAPP).

ATTACHMENT 5-2. WATER QUALITY MODELING STUDY - SAMPLING AND ANALYSIS PLAN (SAP)/QUALITY ASSURANCE PROJECT PLAN (QAPP).

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BASELINE WATER QUALITY MONITORING
SAMPLING AND ANALYSIS PLAN (SAP) / QUALITY ASSURANCE PROJECT PLAN (QAPP)

Sampling and Analysis Plan/Quality Assurance Project Plan

for the

Susitna – Watana Hydroelectric Project

Water Quality Study
Susitna River, Southcentral Alaska

FERC Project No. 14241

Alaska Energy Authority
Contract No. AEA-11-025

Prepared for:

Alaska Energy Authority
813 West Northern Lights
Anchorage, AK 99503

Prepared by:

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November 7, 2012

QAPP xxx, Revision 0

This quality assurance project plan (QAPP) has been prepared according to guidance provided in Alaska Department of Environmental Conservation and *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5, EPA/240/B-01/003, U.S. Environmental Protection Agency (EPA), Quality Assurance Division, Washington, DC, March 2001 [Reissued May 2006]) to ensure that environmental and related data collected, compiled, and/or generated for this project are complete, accurate, and of the type, quantity, and quality required for their intended use. Tetra Tech will conduct work in conformance with the quality assurance program described in the quality management plan for Tetra Tech's Fairfax Group and with the procedures detailed in this QAPP.

Approvals:

Betsy McGregor Assistant Director Alaska Energy Authority	Date	Paul Dworian Principal Manager URS Corporation	Date
Robert Plotnikoff Technical Lead Tetra Tech, Inc.	Date	Mark Vania Field Team Lead URS Corporation	Date
Harry Gibbons Project Manager Tetra Tech, Inc.	Date	Shannon Brattebo Field Team Lead Tetra Tech, Inc.	Date
Gene Welch QA Officer Tetra Tech, Inc.	Date	William Loskutoff QA Officer URS Corporation	Date

Contents

ACRONYMS AND ABBREVIATIONS

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
AEA	Alaska Energy Authority
°C	degrees Celsius
cm	centimeters
DO	Dissolved oxygen
DQI	Data quality indicators
DQO	Data Quality Objectives
EPA	U. S. Environmental Protection Agency
g	grams
m	meter(s)
µS/cm	microSiemens per centimeter
mg/L	milligrams per liter
NPS	Nonpoint source
PDF	Portable Document Format
PM	Project Manager
QA	Quality assurance
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QAPP	Quality assurance project plan
QC	Quality control
QCO	Quality Control Officer
RPD	Relative percent difference
RSD	Relative standard deviation
SNTEMP	Stream Network Temperature
SOP	Standard Operating Procedure
TIR	Thermal infrared
TMDL	Total Maximum Daily Load
TL	Technical Lead
Tt	Tetra Tech, Inc.
TWG	Technical Workgroup

DISTRIBUTION

This document will be distributed to the following, Alaska Energy Authority, URS, and Tetra Tech staff members who are involved in this project, as well as to all responsible project participants.

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A. PROJECT MANAGEMENT ELEMENTS

A 1.0 PROJECT/TASK ORGANIZATION

The Alaska Energy Authority (AEA) is preparing a License Application that will be submitted to the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project (Project). The Project is located on the Susitna River, an approximately 300 mile long river in the South-central region of Alaska. The Project's dam site will be located at River Mile (RM) 184. The results of this study and of other proposed studies will provide information needed to support the FERC's National Environmental Policy Act (NEPA) analysis for the Project license.

Construction and operation of the Project as described in the Pre-Application Document (PAD, AEA 2011) is expected to change some of the water quality characteristics of the resulting riverine portion of the drainage downstream of the dam site as well as the inundated area that will become the reservoir. This study plan outlines the objectives and methods for developing a monitoring program that will adequately characterize surface water quality, stream temperatures and meteorological data in the Susitna River within and downstream of the proposed Project area.

This Sampling and Analysis Plan (SAP)/Quality Assurance Project Plan (QAPP) is being prepared to document the quality assurance (QA) and quality control (QC) measures that will be observed to ensure the following objectives are met: data are consistent, correct, and complete, with no errors or omissions; QC sample results have been reviewed and are included; established criteria for QC results are met; measurement quality objectives have been met, or data qualifiers are properly assigned where necessary; and data specified in the sampling process design are obtained. Data collection methods will follow established state and federal (e.g., Alaska Department of Environmental Conservation; ADEC, U.S. Environmental Protection Agency; EPA) guidelines.

The purpose of this document is to present the quality assurance project plan (QAPP) for conducting a baseline water quality study of the Susitna River.

This QAPP provides general descriptions of the work to be performed to collect in-river data, the objectives to be met, and the procedures that will be used to ensure that the data are scientifically valid and defensible and that uncertainty has been reduced to a known and practical minimum. The QAPP describes procedures used to prepare for the field effort, conduct field sampling using standard protocols, and post-process field data.

The organizational aspects of a program provide the framework for conducting tasks. The organizational structure can also facilitate project performance and adherence to quality control (QC) procedures and quality assurance (QA) requirements. Key project roles are filled by those persons responsible for ensuring the collection of valid data and the routine assessment of the data for precision and accuracy, as well as the data users and the person(s) responsible for approving and accepting final products and deliverables. The key personnel involved in the Baseline Water Quality Study of the Susitna River are listed in Table A1-1.

Table A1-1. Project/Task Organization and Responsibility Summary

Personnel	Responsibility	Address/E-Mail	Phone Number
Betsy McGregor,	Responsible for project coordination with local, county, state, and federal government officials; and for reviewing drafts of the study plan, QAPP and summary data reports	Alaska Energy Authority 411 W. 4th Ave, Suite 1 Anchorage, AK 99501 bmcgregor@aidea.org	907-771-3957
Paul Dworian	Responsible for directing daily project activities and tracking product delivery. Communicates with AEA Environmental Manager on project schedule and timing for product delivery.	URS Corporation 700 G Street, Suite 500 Anchorage, AK 99501 paul.dworian@urs.com	907-261-6735
Mark Vania	Responsible for field sampling assistance, quality assurance and quality control of field protocols.	URS Corporation 700 G Street, Suite 500 Anchorage, AK 99501 mark.vania@urs.com	907-261-9755
Robert Plotnikoff	Responsible for preparing the project QAPP, coordinating and completing sampling activities, analyzing project data, and preparing the draft and final data reports. Serves as the principal project team contact for field staff for the duration of the study	Tetra Tech, Inc. 1420 5th Ave. Suite 550 Seattle, WA 98101 robert.plotnikoff@tetratech.com	206-728-9655
Harry Gibbons	Responsible for managing the project, overseeing preparation of the project QAPP, reviewing analysis of project data, and review of the draft and final data reports. Serves as the principal project team contact for the technical aspects of the study	Tetra Tech, Inc. 1420 5th Ave. Suite 550 Seattle, WA 98101 harry.gibbons@tetratech.com	206-728-9655
Shannon Brattebo	Responsible for water quality and toxics field sampling, quality assurance and quality control of field protocols.	Tetra Tech, Inc. 316 W. Boone Ave. Suite #363 Spokane, WA 99203 shannon.brattebo@tetratech.com	509-232-4312
Gene Welch	Reviews QAPP and all Ecology quality assurance programs. Provides technical assistance on QA/QC issues during the implementation and assessment of the project.	Tetra Tech, Inc. 1420 5th Ave. Suite 550 Seattle, WA 98101 gene.welch@tetratech.com	206-728-9655

Additional technical staff will be responsible for conducting specific tasks during the project (e.g., performing field sampling and collecting surface water quality data) at the direction and discretion of the Project Manager (PM). The Project Manager will supervise the technical staff participating in the project, including implementing the QC program, completing assigned work on schedule with strict adherence to procedures established in the approved QAPP, and completing required documentation. The PM will direct the work of the field sampling team including collection, preparation, and shipment of samples and completion of field-sampling records. To perform the required work effectively and efficiently, the field-sampling team will include scientific staff with specialization and technical competence in field-sampling activities, as required to ensure the highest quality data are collected without incident, and experience qualifications set forth by ADEC. They must perform all work in adherence with the project work plan and QAPP, including maintenance of field sample documentation. Where applicable, custody procedures are required to ensure the integrity of the samples with respect to preventing contamination and maintaining proper sample identification during handling. Where field samples are collected the sampling team is responsible for the following:

- Receiving, inspecting, and inventorying the sample containers
- Receiving, inspecting, calibrating, and maintaining field instrumentation
- Completing, reviewing, and signing appropriate field records
- Assigning tracking numbers to each sample (sample identification numbers)
- Controlling and monitoring access to samples while in their custody
- Verifying the completeness and accuracy of chain-of-custody documentation
- Initiating shipment and verifying receipt of samples at their appropriate destinations
- Verifying the results of sample measurements collected for compliance with the requirements of the reference methods, data quality objectives (DQOs) and this QAPP

Additional oversight will be provided by the QC Officers (QCO), who are responsible for performing evaluations to ensure that QC is maintained throughout the sampling process, that the data collected will be of optimal validity and usability, and that limitations of the data set are minimized as much as is possible given the challenges of the routine field investigation. The QCO is any senior technical staff assigned the responsibility of providing a second-level review of all documentation and records developed during the sample and data collection process. The QC evaluations will include double-checking work as it is completed and providing written documentation of these reviews (minimally initialing and dating documents as they are reviewed) to ensure that the standards set forth in the QAPP are met or exceeded. QCOs may be assigned at the task or subtask level allowing teams to efficiently divide work processes or tasks required and exchanging project documentation for review prior to departure from a sampling station. In this regard, QCOs ensure that all required data and information are recorded for each sampling station prior to physically leaving the collection site. Other QA/QC staff, such as technical reviewers and technical editors selected as needed, will provide peer review oversight on the content of work products and ensure that work products comply with the client's specifications.

Technical staff involved with the program will be responsible for reading and understanding this QAPP and complying with and adhering to its requirements in executing their assigned tasks relative to this project.

Water quality samples will be collected and temperature data loggers installed at 39 sites as defined by the 2012 Baseline Water Quality Study. The study area begins at RM 15.1 and extends past the proposed dam site to RM 233.4. The lowermost boundary of the monitoring is above the area protected for Beluga whale activity. Twelve mainstem Susitna River monitoring sites are located below the proposed dam site and two mainstem sites above this location for calibration of the models. Six sloughs will be included in the monitoring and represent important fish-rearing habitat. Tributaries to the Susitna River will be monitored and include those contributing large portions of the lower river flow like the: Talkeetna, Chulitna, Deshka, and Yentna rivers. A partial list of the remaining tributaries that will be included in monitoring and represents important spawning and rearing habitat for anadromous and resident fisheries include: Gold Creek, Portage Creek, Tsusena Creek, Watana Creek, and Oshetna Creek. These sites were selected based on the following rationale:

- Adequate representation of locations throughout the Susitna River and tributaries above and below the proposed dam site;
- Preliminary consultation with AEA and licensing participants including co-location with other study sites (e.g., instream flow, ice processes);
- Access and land ownership issues; and

Eight of the sites are mainstem monitoring sites that were previously used for Stream Network Temperature Modeling (SNTEMP) in the 1980s (refer to Table B1-2). Thirty-one of the sites are Susitna River mainstem, tributary, or slough locations, most of which were also monitored in the 1980s by the Alaska Energy Authority.

A 2.0 PROBLEM DEFINITION/BACKGROUND

Construction and operation of the Project as described in the Pre-Application Document (PAD, AEA 2011) is expected to change some of the water quality characteristics of the resulting riverine portion of the drainage downstream of the dam site as well as the inundated area that will become the reservoir.

The study area includes the Susitna River within the proposed Watana Reservoir and downstream of the proposed Watana Dam. Water quality studies will be conducted from river mile 15.1 (Susitna River above Alexander Creek) to river mile 233.4 (at Oshetna Creek, just above the upper extent of the proposed reservoir area) and within select tributaries. The proposed dam would be located at river mile 184.5. The dam would create a reservoir 42.5 miles long and 1 to 2 miles wide, with a normal reservoir surface area of approximately 23,546 acres and a normal maximum pool elevation of 2,050 feet. The lowermost boundary of the monitoring activity is above the area protected for Beluga whale activity.

The collective goal of the water quality studies is to assess the impacts of the proposed Project operations on water quality in the Susitna River basin with particular reference to state water quality standards set forth in ADEC regulations Title 18-Health, Safety, and Housing; Chapters: 70-Water Quality Standards [surface water]; 75-Oil and Other Hazardous Substances Pollution Control [groundwater], and 80-Drinking Water Standards; of the Alaska Administrative Code (AAC); 18 AAC 70, 18 AAC 75, and 18 AAC 80, respectively (ADEC 2012a; ADEC 2012b; and ADEC 2012c). Predicting the potential impacts of the dam and its proposed operations on water quality will require the development of water quality models. The goal of the Water Quality Modeling Study will be to utilize the extensive information collected from the Baseline Water Quality Study to develop a model(s) in which to evaluate the potential impacts of the proposed Project and operations on various physical parameters within the Susitna River watershed.

The specific objectives of the Baseline Water Quality Study are to:

- Document historical water quality data and combine with data generated from this study. The combined data set will be used in the water quality modeling study to predict Project impacts under various operations.

- Add three years of current stream temperature and meteorological data to the existing data. Stream temperatures and meteorological data was collected in 2012 (Tetra Tech 2012) and will continue to be collected in 2013-2014.

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

- Measure baseline inorganic metals concentrations in sediment and fish tissue for comparison to federal and state criteria.

- Perform a pilot thermal imaging assessment of a portion of the Susitna River.

A large-scale assessment of water quality conditions throughout the Susitna drainage has not been completed. Historical water quality data available for the study area includes water temperature data, some general water quality data, and limited metals data primarily collected during the 1980s. Additional data has been recently collected at limited mainstem Susitna sites describing flow, in-situ, general, and metals parameters by the United States Geological Study (USGS). In 2012, water temperature data loggers and meteorological stations were installed throughout the Project area. A data gap analysis was conducted for water quality and sediment transport in 2011 (URS 2011) summarizing mainstem and tributary data available. Some general observations based on existing data are as follows:

- Large amounts of data were collected during the 1980s. A comprehensive data set for the Susitna River and tributaries is not available.

- The influence of major tributaries (Chulitna and Talkeetna rivers) on Susitna River water quality conditions is unknown. There are no monitoring stations in receiving water at these mainstem locations.

- Continuous temperature data and seasonal water quality data are not available for the Susitna River mainstem and sloughs potentially used for spawning and rearing habitat.

Concentrations of water quality parameters including metals in sediment immediately below the proposed Project are unknown. Metals in these sediments may become mobile once the Project begins operation. Monitoring information in the immediate vicinity of the reservoir and riverine habitat will be important for developing two models (reservoir and riverine) and coupled for predicting expected water quality conditions below the proposed dam.

An expanded network of continuous temperature monitoring data and water quality data (including sediment, surface water, potentially pore water) collection is required for this Study because:

- More information is needed to define existing thermal refugia throughout the Susitna drainage.
- Limited information is available on natural, background conditions for water quality.
- It is unknown if seasonal patterns exist for select water quality parameters.
- Additional information is required for calibrating the water quality model to be used in the water quality modeling study. More recent water quality data will be used for predicting reservoir conditions and predicting riverine conditions downstream of the proposed dam.

An expanded network of water quality and temperature monitoring sites is proposed from approximately RM 15.1 to RM 234. Monitoring sites are located at the same sites characterized during the 1980s studies, as well as additional sites. Monitoring of areas of the mainstem Susitna River or tributaries with high metals concentrations or temperature measurements (based on the Data Gap Analysis for Water Quality, URS 2011) will confirm previous observations and will describe the persistence of any water quality exceedances that might exist.

A 3.0 PROJECT/TASK DESCRIPTION

This section provides an overview of the staffing organization and schedule. The key personnel involved in the Water Quality Monitoring Study of the Susitna River are listed in Table A3-1.

Table A3-1. Project/Task Organization and Responsibility Summary

Personnel	Responsibility	Address/E-Mail	Phone Number
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Paul Dworian, URS	Responsible for directing daily project activities and tracking product delivery. Communicates with AEA Environmental Manager on project schedule and timing for product delivery.	URS Corporation 700 G Street, Suite 500 Anchorage, AK 99501 paul.dworian@urs.com	907-261-6735
Mark Vania, URS	Responsible for field sampling assistance, quality assurance and quality control of field protocols.	URS Corporation 700 G Street, Suite 500 Anchorage, AK 99501 mark.vania@urs.com	907-261-9755
Robert Plotnikoff, Tetra Tech, Inc.	Responsible for preparing the project SAP/QAPP, coordinating and completing sampling activities, analyzing project data, and preparing the draft and final data reports. Serves as the principal project team contact for field staff for the duration of the study	Tetra Tech, Inc. 1420 5th Ave. Suite 550 Seattle, WA 98101 robert.plotnikoff@tetratech.com	206-728-9655
Harry Gibbons Tetra Tech, Inc.	Responsible for managing the project, overseeing preparation of the project QAPP, reviewing analysis of project data, and review of the draft and final data reports. Serves as the principal project team contact for the technical	Tetra Tech, Inc. 1420 5th Ave. Suite 550 Seattle, WA 98101 harry.gibbons@tetratech.com	206-728-9655

Personnel	Responsibility	Address/E-Mail	Phone Number
	aspects of the study		
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The Water Quality Monitoring Study for the Susitna River will begin October 2012 and continue through March 2014. The exact scheduling of the monthly and seasonal sampling will be coordinated between AEA and Tetra Tech staff. Table A3-2 gives the projected schedule of activities and deliverables.

Table A3-2. Schedule for the Baseline Water Quality Study Elements and Production of Associated Deliverables

Monitoring Activity	Timeline
Thermal Imaging (one survey)	October 2012
MET Station Installation and Data Collection (as part of the 2012 Water Temperature Monitoring and MET Station Installation Study)	July 2012
QAPP/SAP Preparation and Review	January 2013-March 2013
Deployment of Temperature Monitoring Apparatus (if removed before winter ice-up)	June 2013 (retrieve in October 2014)
Water Quality Monitoring (monthly)	June 2013-October 2013 (one sampling event in each of December 2013 and March 2014)
Sediment Sampling (one survey)	August-September 2013
Fish Tissue Sampling (one survey)	August-September 2012/2013
Thermal Imaging (one survey)	October 2013
Data Analysis and Management	June 2013-November 2013
Initial Study Report	December 2013
Updated Study Report	December 2014

A 4.0 DATA QUALITY OBJECTIVES AND CRITERIA

Measurement quality objectives (MQOs) are the performance or acceptance criteria for individual data quality indicators, including precision, bias, and sensitivity (Ecology, 2004). The MQOs[1] for this project are presented in Table A4-1. Industry standard field methods will be used throughout this project to minimize measurement bias (systematic error) and to improve precision (to reduce random error). MQOs are listed for each of the parameters measured in water and from meteorological sites established in the upper river region of the Project area.

Table A4-1. Measurement Quality Objectives

Parameter	Check Standard (LCS)	Duplicate Measurements	Expected Range of Measurements	Lowest Measurement of Interest
	% Calibration Checks/Recovery Limits	RPD		Units of Measurement
Baseline WQ – In-situ				
Temperature	± 0.1 ºC	± 10 %	0-25 ºC	0.1 ºC
pH	± 0.2 pH units	± 0.1 pH units	6.0 – 9.0 pH units	0.1 pH units
Dissolved oxygen	± 0.2 mg/L	± 10 %	1.0 – 12 mg/L	0.2 mg/L
Specific Conductance	± 10 µS/cm	± 10 %	50 – 500 µS/cm	25 µS/cm
Redox Potential	N/A	± 10 %	-400 - +400 mv	25-50 mv
Turbidity	5 NTU	± 10 %	5 – 1000 NTU	5 NTU
Color	N/A	N/A	N/A	N/A
Residues	N/A	N/A	N/A	N/A
Baseline WQ – General WQ Parameters				
Hardness	± 3.0 mg/L as $CaCO_3$	±20%	3.0 – 200 mg/L as $CaCO_3$	3.0 mg/L as $CaCO_3$
Nitrate/Nitrite	± 0.10 mg/L	±20%	0.1 – 30 mg/L	0.1 mg/L
Alkalinity	± 10 mg/L as $CaCO_3$	±20%	20 – 200 mg/L as $CaCO_3$	10 mg/L as $CaCO_3$
Ammonia-N	± 0.10 mg/L	±20%	0.1 – 30 mg/L	0.1 mg/L
Total Kjeldahl Nitrogen	± 0.10 mg/L	±20%	0.1 – 30 mg/L	0.1 mg/L
Total Phosphorus	± 0.01 mg/L	±20%	0.01 – 10 mg/L	0.01 mg/L
Ortho-Phosphorus	± 0.01 mg/L	±20%	0.01 – 5 mg/L	0.01 mg/L
Chlorophyll a	± 0.1 µg/L	±20%	0.1 – 200 µg/L	0.1 µg/L
Total Dissolved Solids	± 10 mg/L	±20%	1 – 10,000 mg/L	N/A
Total Suspended Solids	± 10 mg/L	±20%	1 – 10,000 mg/L	N/A

Parameter	**Check Standard (LCS)**	**Duplicate Measurements**	**Expected Range of Measurements**	**Lowest Measurement of Interest**
	% Calibration Checks/Recovery Limits	**RPD**		**Units of Measurement**
Turbidity	5 NTU	± 20 %	5 – 1000 NTU	5 NTU
TOC	± 0.5 mg/L	± 20%	0.5 – 20 mg/L	0.5 mg/L
DOC	± 0.5 mg/L	± 20%	0.5 – 20 mg/L	0.5 mg/L
Fecal Coliform	± 11 mg/L	± 20%	Not Known	Not Known
Petroleum Hydrocarbons	60 %	± 20%	Not Known	Not Known
Radionuclides	Not Known	± 20%	Not Known	Not Known
Baseline WQ – Metals (Water) Dissolved and Total				
Aluminum	85 %	± 20%	Not Known	50 µg/L
Arsenic	85 %	± 35%	Not Known	100 µg/L
Barium	85 %	± 20%	Not Known	Not Known
Beryllium	85 %	± 20%	Not Known	Not Known
Cadmium	85 %	± 5%	Not Known	5 µg/L
Cobalt	85 %	± 20%	Not Known	10 µg/L
Copper	85 %	± 20%	Not Known	10 µg/L
Iron	85 %	± 20%	Not Known	20 µg/L
Lead	85 %	± 25%	Not Known	50 µg/L
Magnesium	85 %	± 20%	Not Known	20 µg/L
Manganese	85 %	± 20%	Not Known	5 µg/L
Mercury	85 %	± 15%	Not Known	0.2 µg/L
Molybdenum	85 %	± 20%	Not Known	10 µg/L
Nickel	85 %	± 20%	Not Known	20 µg/L
Selenium	85 %	± 20%	Not Known	100 µg/L

Parameter	Check Standard (LCS)	Duplicate Measurements	Expected Range of Measurements	Lowest Measurement of Interest
	% Calibration Checks/Recovery Limits	RPD		Units of Measurement
Thallium	85 %	± 20%	Not Known	Not Known
Vanadium	85 %	± 20%	Not Known	10 µg/L
Zinc	85 %	± 20%	Not Known	10 µg/L
Baseline WQ – Metals (Sediment) Total				
Aluminum	NA	± 20%	Not Known	Not Known
Arsenic	NA	± 35%	Not Known	3.0 mg/kg
Cadmium	NA	± 20%	Not Known	1.0 mg/kg
Copper	NA	± 20%	Not Known	Not Known
Iron	NA	± 20%	Not Known	Not Known
Lead	NA	± 25%	Not Known	1.5 mg/kg
Mercury	NA	± 30%	Not Known	0.1 mg/kg
Zinc	NA	± 20%	Not Known	3.5 mg/kg
Baseline WQ – Metals, Fish Tissue				
Total Mercury	±10	±10 %	Not Known	5 ng/L
Methyl-mercury	±10	±10 %	Not Known	5 ng/L
Arsenic	±10	±10 %	Not Known	10 ng/L
Cadmium	±10	±10 %	Not Known	10 ng/L
Selenium	±10	±10 %	Not Known	10 ng/L

(a) Field temperatures will be verified by comparing pre-deployed instrument readings and *in-situ* temperature readings collected on a monthly schedule when data downloads are completed.

Precision - Precision is defined as the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to subsequent (repeated) measurements. Precision is usually expressed as standard deviation, variance, or range, in either absolute or relative terms. Field sample replicates for assessment of precision will be analyzed at no less than a 5 percent frequency of the total number of samples. Laboratory replicates for assessment of precision will be analyzed at no less than a 5 percent frequency of the total number of samples submitted to the laboratory.

For sample results that exceed the reporting detection limit (RDL), the relative percent difference (RPD) will be less than or equal to 20 percent. No criteria are presented for duplicates that are below the RDL, as these data are provided for informational purposes only. When one or more of the results is below the RDL, professional judgment will be used in determining the compliance of the data to project requirements.

Representativeness - Sample representativeness is the degree to which data accurately and precisely represent a characteristic of a population. Representativeness will be addressed at two distinct points in the data collection process. During sample collection, the use of generally accepted sampling procedures applied in a consistent manner throughout the project will help ensure that samples are representative of conditions at the point where the sample was taken. During subsampling (sample aliquot removal) in the laboratory, samples will be inverted several times to ensure that the analytical subsample is well mixed and therefore representative of the sample container's contents.

Completeness - Completeness is a measure of the amount of valid data needed to meet the project's objectives. Completeness will be judged by the amount of valid data compared to the data expected. Valid data are those data in compliance with the data quality criteria as presented in this section, and in compliance within expected range of conditions and daily fluctuation patterns. While the goal for the criteria described above is 100 percent completeness, a level of 95 percent completeness will be considered acceptable. However, any time data are incomplete, decisions regarding re-sampling and/or re-analysis will be made. These decisions will take into account the project data quality objectives as presented above.

Comparability - Comparability is a measure of the confidence with which one dataset can be compared to another. This is a qualitative assessment and is addressed primarily by sampling design through use of comparable sampling procedures or, for monitoring programs, through consistent sampling of stations over time. In the laboratory, comparability is assured through the use of comparable analytical procedures and ensuring that project staff are trained in the proper application of the procedures. Within-study comparability will be assessed through analytical performance (quality control samples).

A 5.0 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

This QAPP and supporting materials will be distributed to all participants. The local Project Manager, Paul Dworian and/or Mark Vania, will conduct a procedural review before the field team is mobilized for sampling. The procedural review will include the requirements of the QAPP and referenced SOPs, as well as instrument manufacturers' operation and maintenance instructions. It will be performed concurrently with a check that all equipment and sampling gear are fully functional and ready for deployment. In addition, there will be discussions and demonstrations of sampling method(s) to be used and discussions regarding specific health and safety concerns. Each sampling team will consist of, at a minimum, one sample collector and a scientist familiar with QC requirements, which will ensure strict adherence to the project protocols, check all documentation for completeness and correctness, and verify that no transcription errors or omissions have been made in preparing sample custody records and other project documentation.

A 6.0 DOCUMENTATION AND RECORDS

Thorough documentation of all field sample collection is necessary for proper processing of data and, ultimately, for interpreting study results. Field sample collection will be documented in writing, on forms as well as on the following forms and labels:

- A field log notebook for general observations and notes
- A Field Data Record Form that contains information about observations and measurements made and samples collected at the site
- Checklists for each sampling event, sampling point, and sampling time.

The Technical Leads, and the appropriate PMs within subcontractor organizations will maintain files, as appropriate, as repositories for information and data used in preparing any reports and documents during the project and will supervise the use of materials in the project files. The following information will be included:

- Any reports and documents prepared
- Contract and Task Order information
- Project QAPP
- Results of technical reviews, data quality assessments, and audits
- Communications (memoranda; internal notes; telephone conversation records; letters; meeting minutes; and all written correspondence among the project team personnel, subcontractors, suppliers, or others)
- Maps, photographs, and drawings
- Studies, reports, documents, and newspaper articles pertaining to the project
- Special data compilations
- Spreadsheet data files: physical measurements, analytical chemistry data (hard copy and disk)

Copies of the field log books and physical characterization/water quality data sheets and sampling checklists will be supplied to the Field PMs at the close of each sampling event. These data will be used in conjunction with inspection checklists to compile the sampling event reports. Formal reports that are generated from the data will be subject to technical and editorial review before submission to Alaska Energy Authority and will be maintained at Tt's Seattle, Washington office in the central file (disk and hard copy). The data reports will include a summary of the types of data collected, sampling dates, and any problems or anomalies observed during sample collection.

If any change(s) in this QAPP are required during the study, a memo will be sent to each person on the distribution list describing the change(s), following approval by the appropriate persons. The memos will be attached to the QAPP. All written records relevant to the sampling and processing of samples will be maintained at Tt's Seattle, Washington office in the central file. Unless other arrangements are made, records will be maintained for a minimum of 5 years following expiration of the contract.

B. MEASUREMENT AND DATA ACQUISITION

B 1.0 SAMPLING DESIGN

This SAP and QAPP is prepared as part of the implementation of the 2013-2014 Baseline Water Quality Study Plan. The SAP and QAPP is standard documentation prepared before any water model development begins. These documents follow guidelines for the State of Alaska and U.S. Environmental

Protection Agency Region 10 Credible Data Policy (ADEC 2005). The following sections document how water quality data will be collected such that existing and post-Project water quality conditions within the Susitna River basin can be characterized. Data collected as part of this study will be used in the Water Quality Model to predict how operational scenarios will impact water quality conditions in both the reservoir and riverine portions of the basin.

Water quality data will be collected from multiple aquatic media including surface water, sediment, and fish tissue. The fish tissue collection will be conducted as part of Study Plan 7.5/7.6 (Study of Fish Distribution and Abundance in the Upper Susitna River and the Middle/Lower Susitna River, respectively). Tissue or whole fish samples will be collected in the mainstem Susitna River under Study Plan 7.5 and Study Plan 7.6 for use in analysis of potential for bioaccumulation. Continuous temperature monitoring will inform the predictive model on how the mainstem river and tributaries will respond to alternative Project operational scenarios and if changes in water quality conditions could affect aquatic life use and survival in the Project area. In addition, several other requirements of the 401 Water Quality Certification Process will be addressed with collection and description of additional data including the following:

- conducting a water quality baseline assessment;
- description of how existing and designated uses are met;
- use of appropriate field methods and models;
- use of acceptable data quality assurance methods;
- scheduling of technical work to meet deadlines; and
- derivation of load calculations of potential pollutants (pre-Project conditions).

Two types of water quality monitoring activities will be implemented: 1) routine monitoring for characterizing water quality baseline conditions, and 2) a single, comprehensive survey for a larger array of parameters. Frequency of sampling water quality parameters varies by category and potential for mobilization and bioavailability. Most of the general water quality parameters and select metals will be sampled on a monthly basis since each parameter has been demonstrated to be present in one or both of surface water and sediment (URS 2011). An initial screening survey has been proposed for several other toxics that might be detected in sediment and tissue samples (Table 6-1). The single surveys for toxics in sediment, tissue, or water will trigger additional study for extent of contamination and potential timing of exposure if results exceed criteria or thresholds (e.g., LAETs, LC50s, etc.). The general list of water quality parameters and metals will be used in calibrating the water quality model in both a riverine and reservoir environment.

The operation of temperature monitoring sites (Tetra Tech 2012) will continue as part of water quality monitoring activities in 2013/2014. Table 3-1 lists the temperature monitoring sites. These sites were selected based on the following rationale:

- Adequate representation of locations throughout the Susitna River and tributaries above and below the proposed dam site for the purpose of a baseline water quality characterization;
- Location on tributaries where proposed access road-crossing impacts might occur during and after construction (upstream/downstream sampling points on each crossing);
- Preliminary consultation with AEA and licensing participants including co-location with other study sites (e.g., instream flow, ice processes);
- Access and land ownership issues; and
- Eight of the sites are mainstem monitoring sites that were previously used for SNTEMP modeling in the 1980s. Thirty-one of the sites are Susitna River mainstem, tributary, or slough locations, most of which were monitored in the 1980s.

Water Quality Data Collection: Longitudinal Profile of the Susitna River

Twelve mainstem Susitna River monitoring sites are located below the proposed dam site and two mainstem sites above this location. Five sloughs will be monitored that represent a combination of physical settings in the drainage and that are known to support important fish-rearing habitat. Tributaries to the Susitna River will be monitored and include those contributing large portions of the lower river flow like the Talkeetna, Chulitna, Deshka, and Yentna rivers. A partial list of the remaining tributaries that will be monitored represent important spawning and rearing habitat for anadromous and resident fisheries and include: Gold Creek, Portage Creek, Tsusena Creek, Watana Creek, and Oshetna Creek.

Monitoring sites are spaced at approximately 5 mile intervals so that the various factors that influence water quality conditions are captured and support the development (and calibration) of the water quality model. Frequency of sites along the length of the river is important for capturing localized effects from tributaries and from past and current human activity.

These sites were selected based on the following rationale:

- Adequate representation of locations throughout the Susitna River and tributaries above and below the proposed dam site for the purpose of a baseline water quality characterization.
- Location on tributaries where proposed access road-crossing impacts might occur during and after construction (upstream/downstream sampling points on each crossing).
- Preliminary consultation with licensing participants including co-location with other study sites (e.g., instream flow, ice processes).
- Access and land ownership issues.
- Eight of the sites are mainstem monitoring sites that were previously used for SNTEMP modeling (see Section 5.6) in the 1980s. Thirty-one of the sites are Susitna River mainstem, tributary, or slough locations, most of which were monitored in the 1980s.

Water quality data collection will be at the locations in bold in Table B1-2. The initial sampling will be expanded if general water quality, metals in surface water, or metals in fish tissue exceed criteria or thresholds. Additional contiguous sample sites will be visited on this list beginning the following sampling month wherever criteria or thresholds have been exceeded by individual parameters. This proposed spacing follows accepted practice when segmenting large river systems for development of Total Maximum Daily Load (TMDL) water quality models. Sampling during winter months will be focused on locations where flow data is currently collected (or was historically collected by the USGS) and will be used for water quality modeling.

Water quality collection can be broken into two components: in-situ water quality sampling and general water quality sampling. In-situ water quality sampling consists of on-site monthly measurements of physical parameters at fixed locations using field equipment. General water quality sampling will consist of monthly grab samples that will be sent to an off-site laboratory for analysis. The laboratory will have at a minimum, National Environmental Laboratory Accreditation Program (NELAP) Certification in order to generate credible data for use by state, federal, and tribal regulatory programs for evaluating current and future water quality conditions. In general, these samples represent water quality components that cannot be easily measured in-situ, such as metals concentrations, nitrates, etc.

Water quality samples will be analyzed for several parameters reported in Table B1-3. Metals monitoring for total and dissolved fractions in surface water include the full set of parameters used by ADEC in fish health consumption screening. The creation of a reservoir and potential alteration of surface water downstream of the proposed dam site may change characteristics of groundwater in the upper and middle Susitna basin. The water quality parameters identified in Table B1-3 will address the influence surface water may have on adjoining groundwater supplies in the vicinity of each sampling site. Changes to groundwater quality may have an effect on drinking water supplies so several parameters included on the inorganic chemical contaminants list have been included as part of this sampling program (ADEC 2003).

The criteria that will be used for comparison with sampling results are the drinking water primary maximum contaminant levels.

Additional parameters will be measured from all sites in a single survey that occurs during low water conditions (e.g., August/September) in the Susitna basin. The following is a list of pollutants for which Alaska Water Quality Standards has established water quality criteria (18 ACC 70.020(b)) for protecting designated uses in freshwater:

- Continuous temperature monitoring program
  - Temperature, already included as part of the continuous temperature monitoring program.

- In-situ monitoring program
  - pH, included as part of the monthly water quality sampling routine.
  - Color, categorical observation.
  - Residues, categorical assessment (floating solids, debris, sludge, deposits, foam, or scum).

- General water quality program
  - Dissolved gas, included in the monitoring program (Dissolved Oxygen).
  - Dissolved inorganic substances (Total Dissolved Solids), included in monthly monitoring.
  - Turbidity, already included as part of the monthly water quality sampling routine.
  - Toxic and other deleterious organic and inorganic, already included in monitoring for inorganic metals and mercury/methyl-mercury (organometals).

- One time survey
  - Fecal coliform bacteria, included in monthly monitoring.
  - Sediment, already included in assessing mercury and other metals from sediments.
  - Petroleum Hydrocarbons, oil, and grease, included in a one-time survey.
  - Radioactivity; radionuclide concentrations to be generated from surface water samples.
  - Toxic and other deleterious organic and inorganic, already included in monitoring for inorganic metals and mercury/methyl-mercury (organometals).

Water quality parameters listed above that do not exceed Alaska Water Quality Standards will not be collected in succeeding months; the exception are those parameters in Table A4-1 associated with monthly sample collection from surface water.

Water Quality Data Collection: Focus Areas on the Susitna River

A total of ten Focus Areas were presented and discussed with the TWG and are proposed for detailed study within the Middle Segment of the river. The Focus Areas are intended to serve as specific geographic areas of the river that will be the subject of intensive investigation by multiple resource disciplines including water quality. The proposed Focus Areas were selected during an interdisciplinary resource meeting that involved a systematic review of aerial imagery within each of the Geomorphic Reaches (MR1 through MR8) for the entire Middle Segment of the river. Focus Areas were selected within MR1, MR2, MR5, MR6, MR7, and MR8. Focus Areas were not selected for MR3 or MR4 due to safety considerations related to Devils Canyon.

The areas selected were those deemed representative of the major features in the Geomorphic Reach and included mainstem habitat types of known biological significance (i.e., where fish have been observed based on previous and/or contemporary studies), as well as some locations (e.g, Slough 17) where previous sampling revealed few/ no fish. The areas included representative side channels, side sloughs, upland sloughs, and tributary mouths.

The Focus Area selections considered:

- All major habitat types (main channel, side channel, side slough, upland slough, tributary delta).
- At least one Focus Area per geomorphic reach (excepting reaches associated with Devils Canyon) will be included that are representative of other areas.
- A replicate sampling strategy will be used for measure habitat types within each Focus Area which many include random selection process.
- Areas that are known (based on existing and contemporary data) to be biologically important for salmon spawning/ rearing in mainstem and lateral habitats will be sampled (i.e., critical habitats) and
- Areas for which little or no fish use has been documented or for which information on fish use is lacking, will also be sampled.

Maps of each FA with River Mile numbers included are shown below in Figure B1-1 through B1-10.

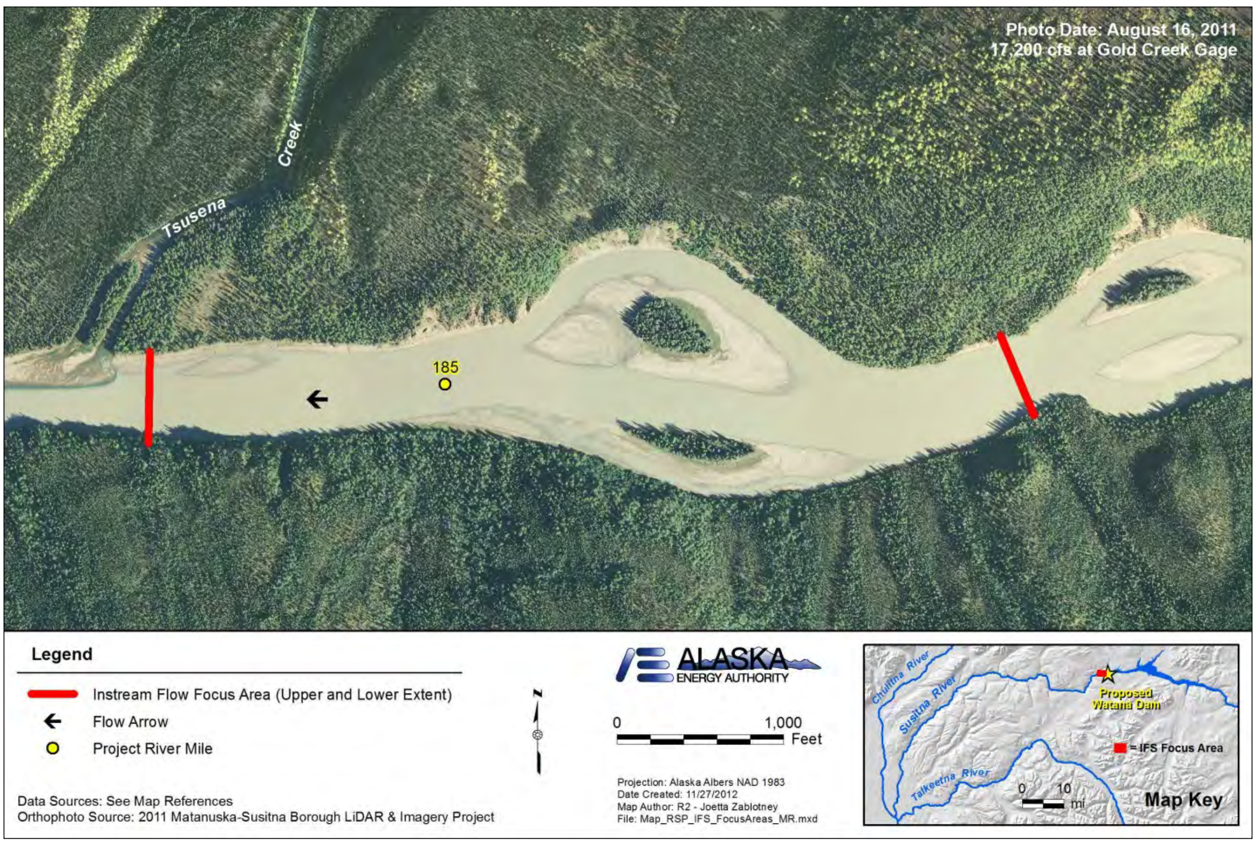

Figure B1-1. Map of Focus Area 1

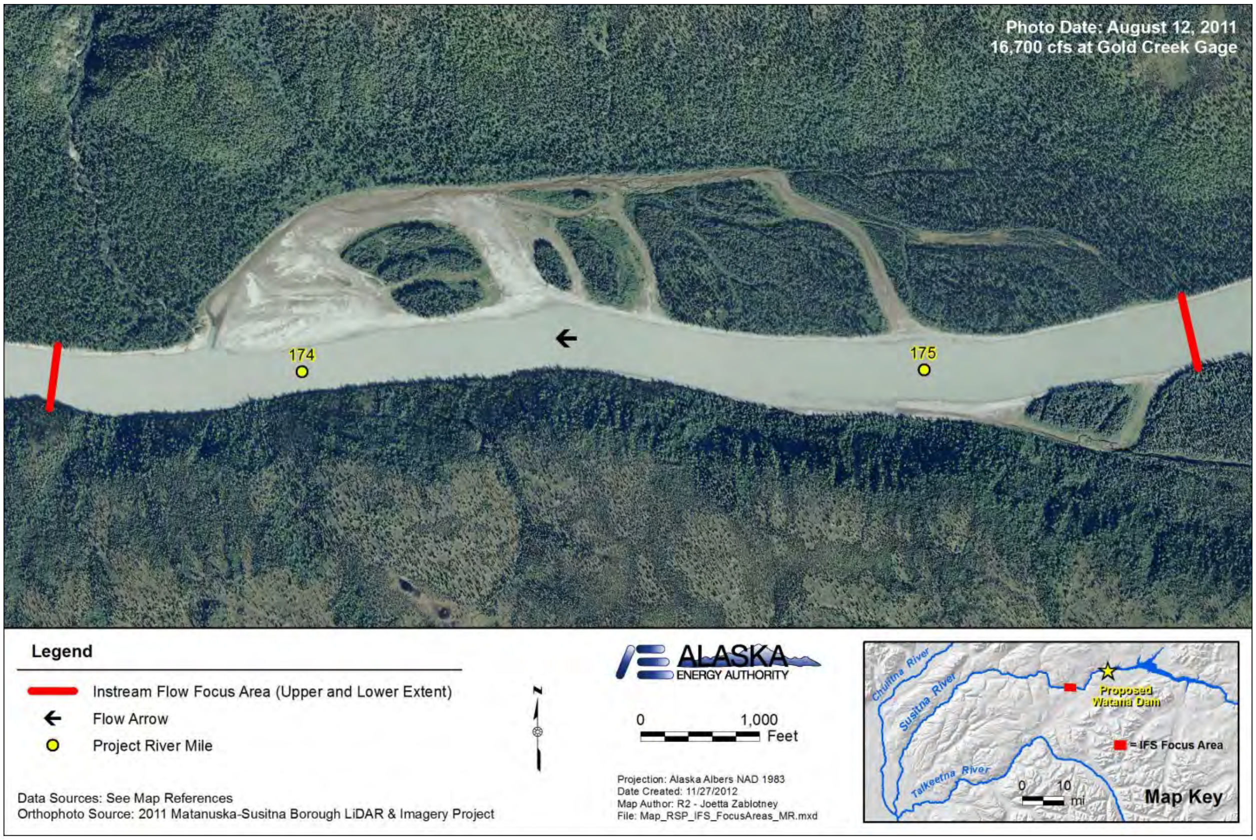

Figure B1-2. Map of Focus Area 2

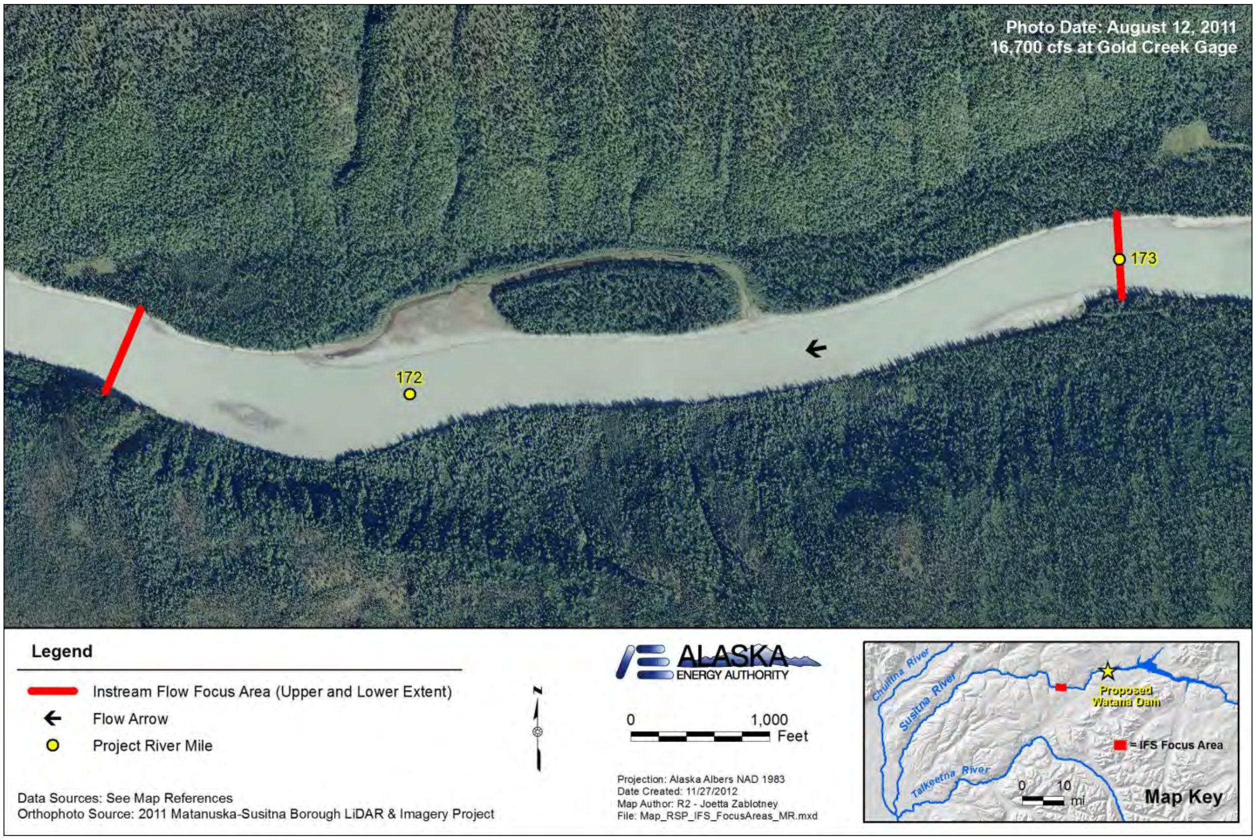

Figure B1-3. Map of Focus Area 3

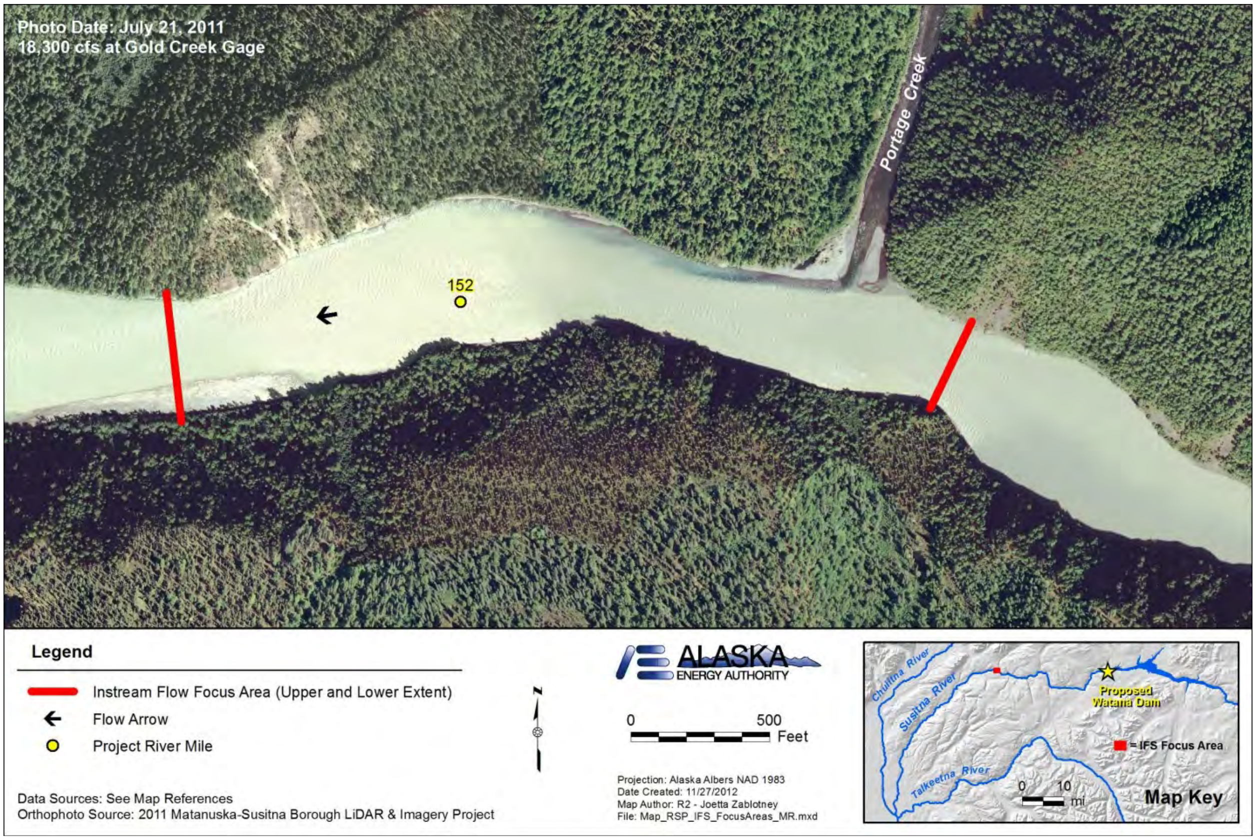

Figure B1-4. Map of Focus Area 4

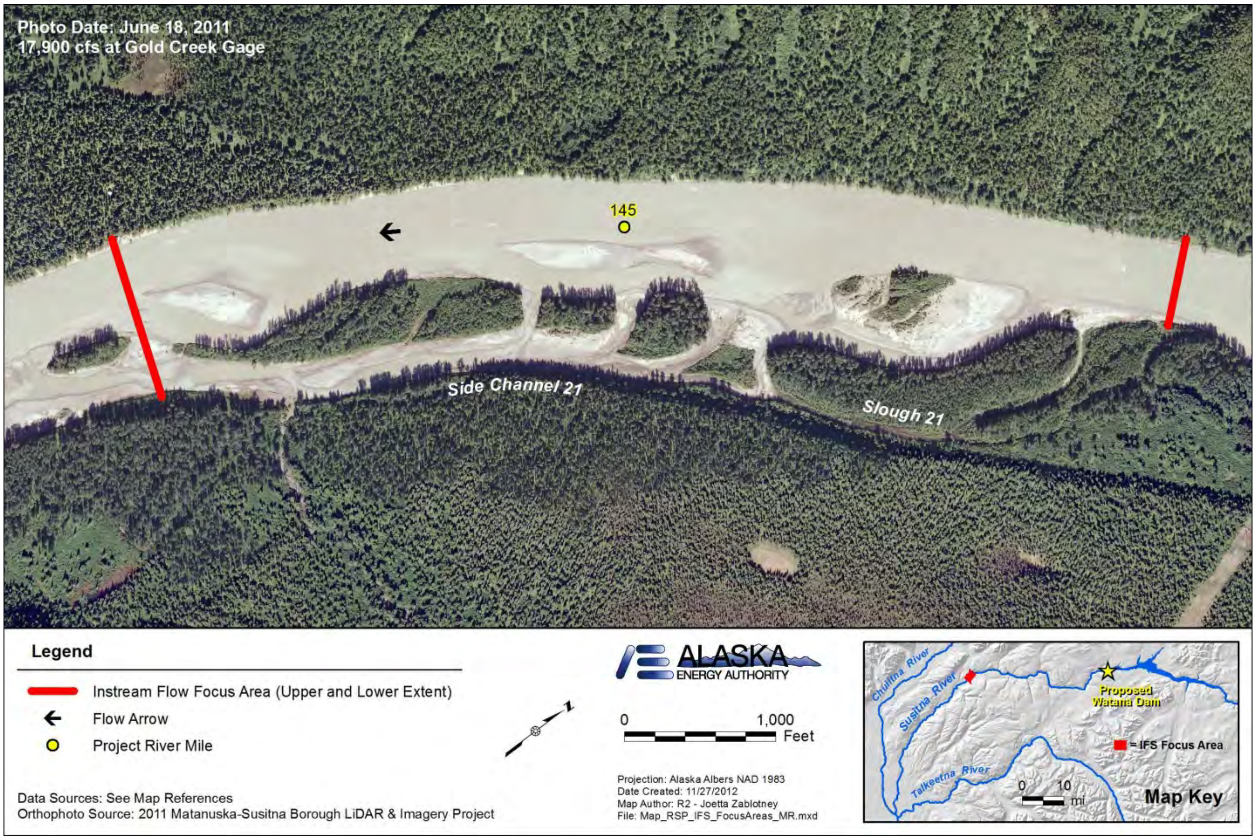

Figure B1-5. Map of Focus Area 5

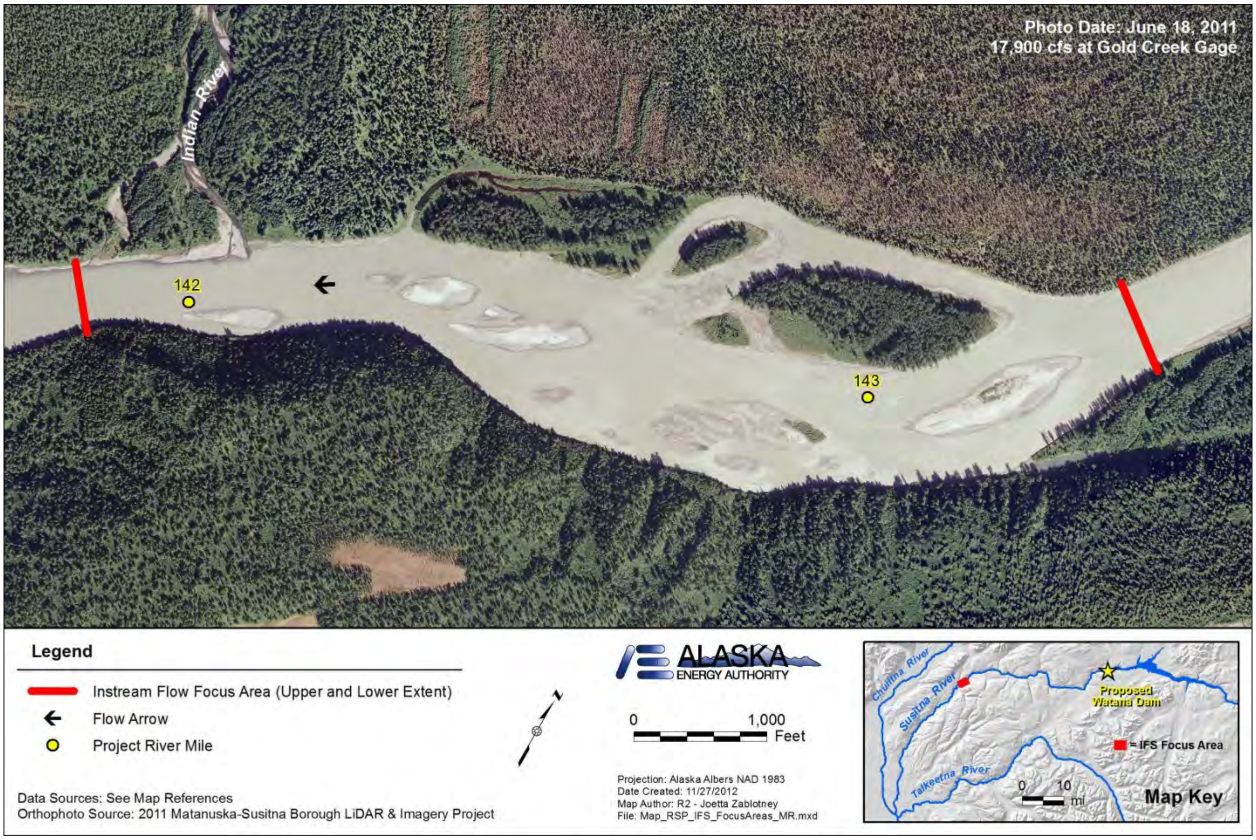

Figure B1-6. Map of Focus Area 6

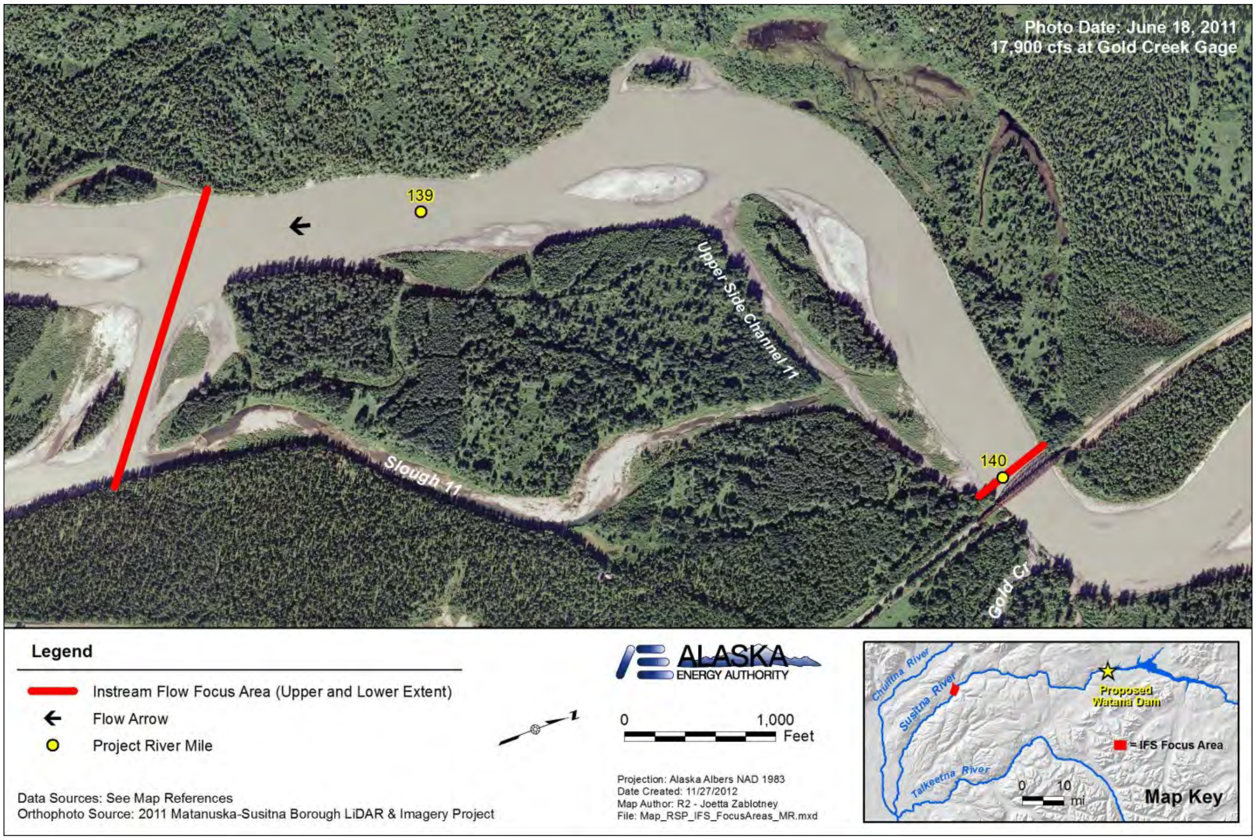

Figure B1-7. Map of Focus Area 7

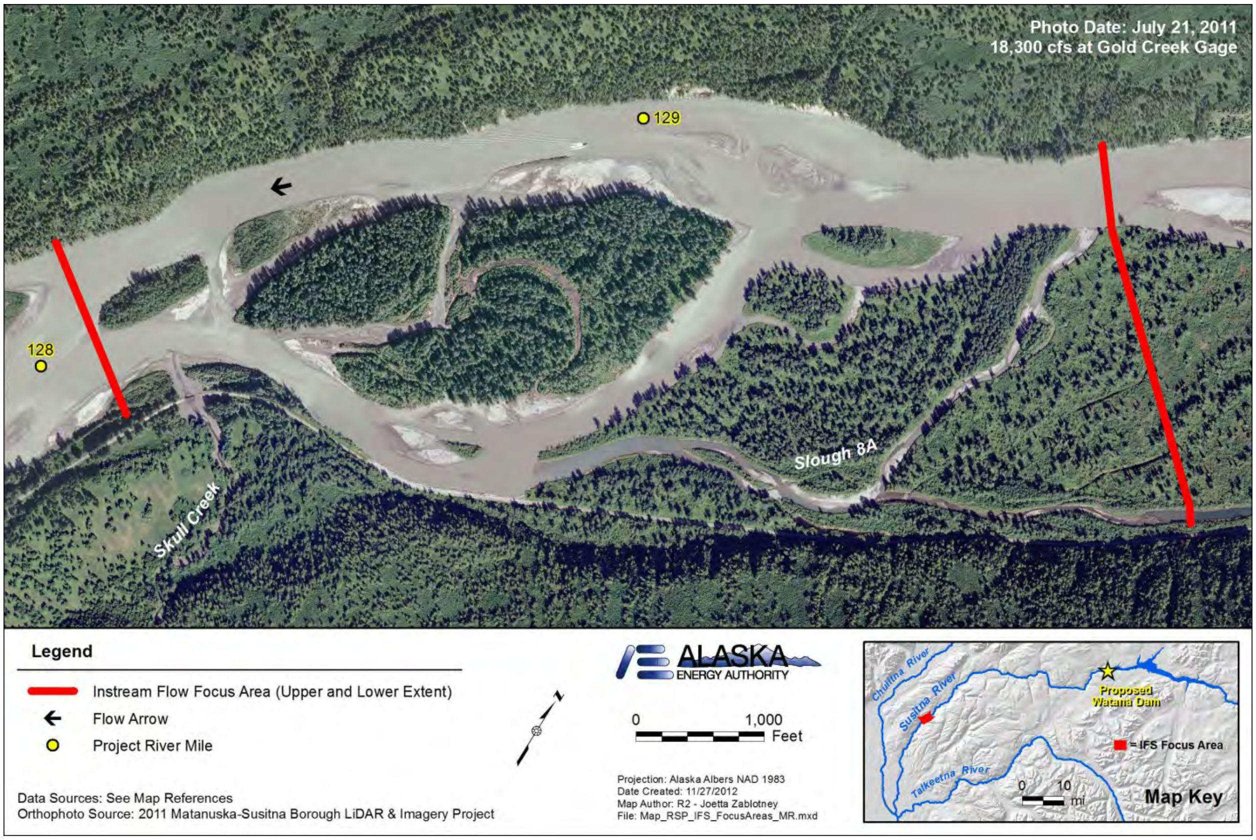

Figure B1-8. Map of Focus Area 8

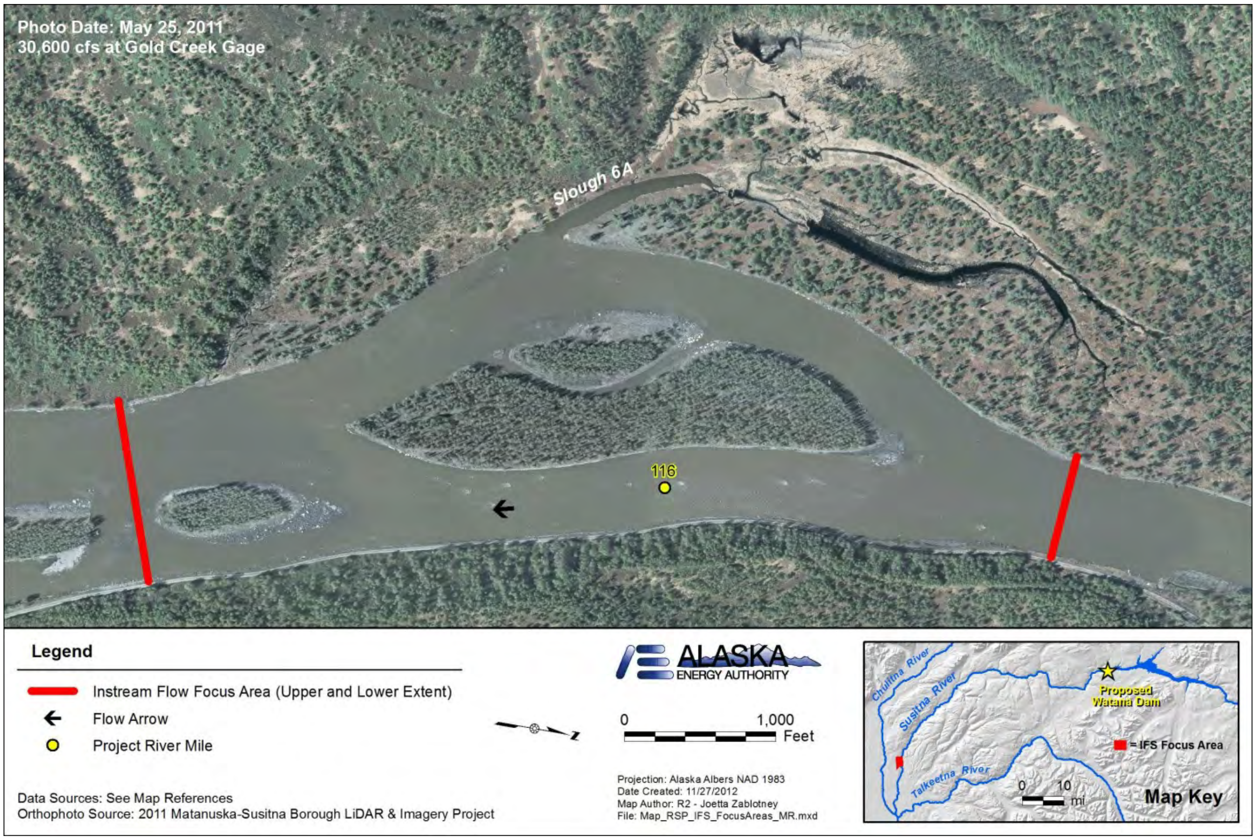

Figure B1-9. Map of Focus Area 9

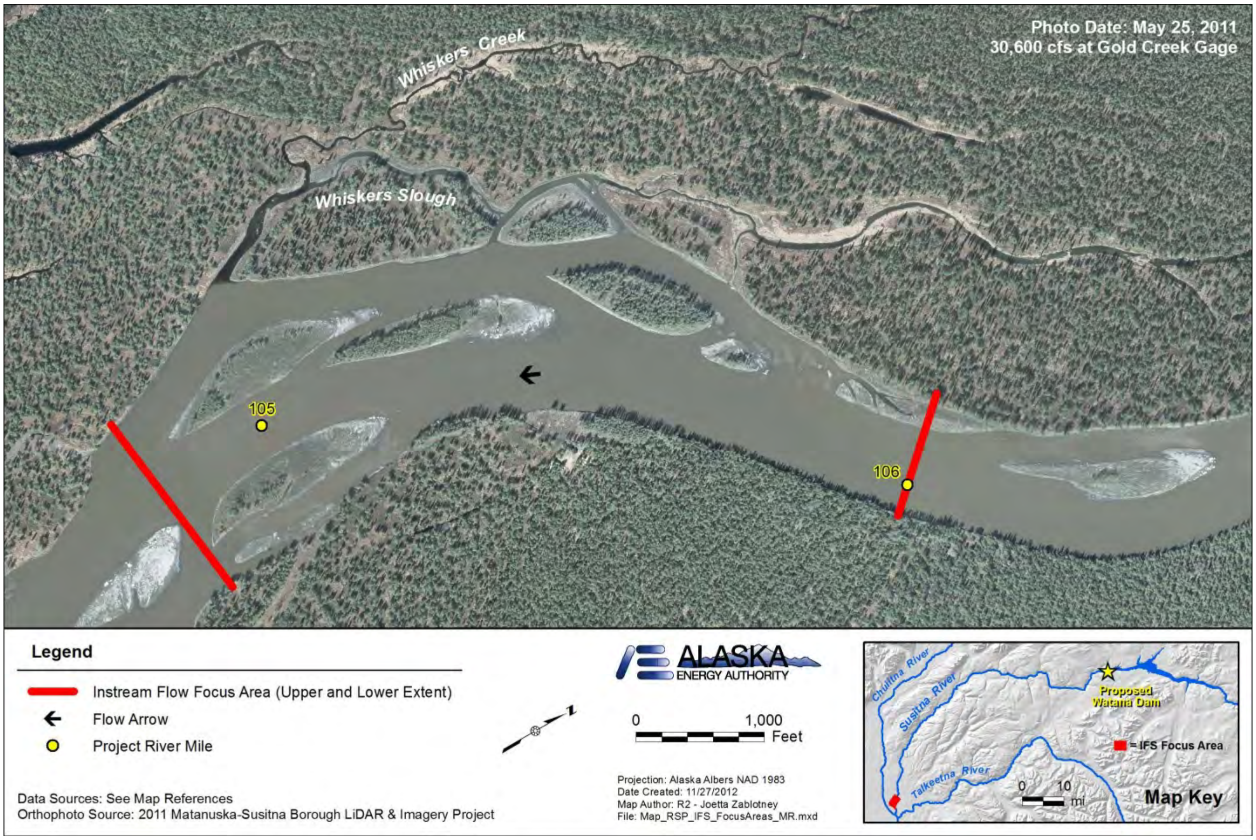

Figure B1-10. Map of Focus Area 10

The Focus Areas will have a higher density of sampling locations, in contrast to the mainstem network, so that prediction of change in water quality conditions from Project operations can be made with a higher degree of resolution. The resolution expected for predicting conditions will be as short as 100-meter (m) longitudinal distances within the Focus Areas. Depending on the length of the Focus Area, transects will be spaced every 100 m to 500 m and water quality samples collected at three locations along each transect. The collection points along a transect will be in open water areas and have 3 to 5 collection points. These will be discrete samples taken at each collection point. The density of monitoring locations within the Focus Areas will be used as a grid to detect and describe groundwater input. Plumes of groundwater input to a Focus Area will be traceable using thermal data or conductivity. The area of groundwater input will be described using the monitoring grid network represented by the transects and sampling points along each transect. The location of open water transects and piezometers will be coordinated with the Instream Flow Study (Section 8) and the Groundwater Study (Section 7.5) to efficiently implement common elements in each of the studies. Piezometers will be installed as part of the Water Quality Monitoring Study so that surface water and groundwater samples are collected at the same time for determination of influence of groundwater on surface water. Collection of groundwater and surface water during each site visit will be used to evaluate the influence of groundwater on surface water quality. Frequency of sampling will be every 2 weeks for a total duration of 6 weeks and coordinated with the Instream Flow and Groundwater studies.

The following parameters that could affect habitat used by anadromous and resident fish in this drainage:

Field Parameters

- Water temperature
- Dissolved oxygen
- Conductivity
- pH

General Chemistry

- Turbidity
- Hardness
- Total nitrogen
- Nitrate+nitrite-nitrogen
- Total phosphorus
- Soluble reactive phosphorus

Metals

- Mercury (total)
- Methylmercury (dissolved)
- Aluminum (dissolved and total)
- Iron (dissolved and total)

Sediment Samples for Mercury/Metals in Reservoir Area Data Collection

This portion of the study was designed to gather specific information on the distribution of Susitna River sediment contaminants of concern in potential source areas. In general, all sediment samples will be taken from sheltered backwater areas, downstream of islands, and in similar riverine locations in which water currents are slowed, favoring accumulation of finer sediment along the channel bottom. Samples will be analyzed for total metals, including aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, and zinc. In addition, sediment size and total organic carbon (TOC) will be included to evaluate whether these parameters are predictors for elevated metal concentrations. Samples will be collected just below and above the proposed dam site. Additional samples will be collected near the mouth of tributaries near the proposed dam site, including Fog, Deadman, Watana, Tsusena, Kosina, Jay, and Goose creeks, and the Oshetna River. The purpose of this sampling will be to determine where metals, if found in the water or sediment, originate in the drainage. Toxics modeling will be conducted to address potential for bioavailability in resident aquatic life. Comparison of bioaccumulation of metals in tissue analysis with results from sediment samples will inform on potential for transfer mechanisms between source and fate.

Most of the contaminants of interest are typically associated with fine sediments, rather than with coarse-grained sandy sediment or rocky substrates. Therefore, the goal of the sampling will be to obtain sediments with at least 5 percent fines (i.e., particle size less than 0.0025 inches [63 micrometers], or passing through a #230 sieve). At some locations, however, larger-sized sediment may be all that are available.

Baseline Metals Levels in Fish Tissue

Two screening level tasks will be conducted. The first will be for methyl mercury in sport fish. Methyl mercury bioaccumulates and the highest concentrations are typically in the muscle tissue of adult predatory fish. Final determination of tissue type(s) for analysis will be coordinated with ADEC's Division of Environmental Health and guidance on fish tissue sampling. Target fish species in the vicinity of the Susitna-Watana Reservoir will be Dolly Varden, Arctic grayling, long nose sucker, lake trout, whitefish species, burbot and resident rainbow trout. Filet samples will be analyzed for methyl and total mercury. Liver samples will also be collected from burbot and analyzed for mercury, methyl-mercury, arsenic, cadmium, and selenium. Fish samples will be submitted to a state-certified analytical laboratory for individual fish muscle tissue analysis. Results will be reported with respect to applicable State and federal standards.

Results from fish tissue analysis will also be used as a baseline for determining how the proposed Project may increase the potential of current metals concentrations to become bioavailable. The projected water conditions in the reservoir will be estimated and current results for metals concentrations re-evaluated for determining potential toxicities to resident and anadromous fish species. Detection of mercury in fish tissue and sediment will prompt further study of naturally occurring concentrations in soils and plants and how parent geology contributes to concentrations of this native element in both compartments of the landscape. The focused study will estimate the extent and magnitude of mercury ~~contamination~~ so that an estimate of increased bioavailability might be made once the reservoir inundates areas where high concentrations of mercury are sequestered. Detectable concentrations of mercury may prompt additional sampling and analysis of tissues in the benthic macroinvertebrate community. The bio-magnification of mercury impact from sediments and plants to the fish community may be facilitated through consumption of impacted food sources like the benthic macroinvertebrates. Impact of this component of a trophic level may also be a conduit for mercury biomagnification in waterfowl and other wildlife that consume this food source.

Pilot Thermal Imaging Assessment of a Portion of the Susitna River

Thermal imagery of a portion of the Susitna River (e.g., 10 miles of the Middle River) was collected in the 2012 season. The primary goal is to establish baseline data for assessing the availability and spatial extent of thermal refugia/upwelling. Data from the thermal imaging will be ground-truthed using in-stream thermographs that will be utilized to calibrate the thermal imagery, assess absolute accuracy, and provide a temporal context for the thermal infrared data collection. In coordination with the Instream Flow and fish studies, a determination will be made as to whether thermal imaging data will be applicable and if additional thermal imagery will be collected during the 2013 field season.

If the pilot study is successful, then a description of thermal refugia throughout the Project area can be mapped using aerial imagery calibrated with on-the-ground verification. The verification data will be collected at the same time as the aerial imagery (or nearly the same time) using the established continuous temperature monitoring network and additional grab sample temperature readings where there may be gaps, such as in select sloughs. The following elements are important considerations for data collection, specifications for data quality, and strategy for relating digital imagery and actual river surface water temperatures.

Remotely sensed thermal images allow for spatially distributed measurements of radiant temperatures in the river. Radiant temperature measurements are made only on the surface layer of the water (top 4 inches [10 centimeters]). Temperature readings can vary depending on the amount of suspended sediment in the water and the turbidity of the water. Collection of data will occur near the end of October when the freeze begins and the contrast between cold surface water and warmer groundwater influence is accentuated. The suspended sediment and turbidity will be diminished during this period of the year when the glacial flour content in the water column is reduced from glacial meltwater.

If the thermal imaging is not successful, the reason for the failure will be evaluated. Future actions will depend on the causes of the failure. Potential causes for failure could include:

- Poor timing for the data acquisition flight.
- Insufficient differences in temperature between groundwater and surface water.
- Complex missing or dilution of the groundwater signal.

Potential solutions would include:

- Re-fly the thermal imaging under better conditions (a greater contrast in temperature between groundwater and surface water).
- Hand held FLIR meters that could be used during stream side studies, and a more focused thermal mapping task within focus areas using handheld temperature meters and probes may prove useful.
- Use of documentation of open water leads as a substitute.
- Outfit the R44 helicopter to take advantage of regular field presence. Thermal imagery could be shot all summer long and brief intervals of ideal conditions could be used.
- The Focus Area results represent habitat identified as representative of the most important for fisheries use as described by the rational for site selection in Section 8.5.4.2 of the RSP. These results can be extrapolated to similar reaches, side channels, and sloughs in other areas of the Susitna drainage not directly monitored in this study to determine thermal refugia for fish.

Groundwater Quality in Selected Habitats

The purpose of this portion of the study will be to characterize the water quality differences between a set of key productive aquatic habitat types (3 to 5 sites) and a set of non-productive habitat types (3 to 5) that are related to the absence or presence of groundwater upwelling to improve the understanding of the water quality differences and related groundwater/surface water processes.

The density of monitoring locations within the Focus Areas will be used as a grid to detect and describe groundwater input. Plumes of groundwater input to a Focus Area will be traceable using thermal data or conductivity. The area of groundwater input will be described using the monitoring grid network represented by transects and sampling points along each transect. The location of open water transects and piezometers will be coordinated with the Instream Flow Study (Section 8) and the Groundwater Study (Section 7.5) to efficiently implement common elements in each of the studies. Piezometers will be installed as part of the Water Quality Monitoring Study so that surface water and groundwater samples are collected at the same time for determination of influence of groundwater on surface water. Collection of groundwater and surface water during each site visit will be used to evaluate the influence of groundwater on surface water quality. Frequency of sampling will be every 2 weeks for a total duration of 6 weeks and coordinated with the Instream Flow and Groundwater studies.

Basic water chemistry (temperature, DO, conductivity, pH, turbidity, redox potential) that define habitat conditions will be collected at selected instream flow, fish population, and riparian study sites. These data will be used to characterize groundwater and surface water interactions.

Table B1-1. List of water quality parameters and frequency of collection

Parameter	Task	Frequency of Collection
In-Situ Water Quality Parameters		
Dissolved Oxygen (DO)	Baseline WQ and Sediment	Each Sampling Event
pH	Baseline WQ and Sediment	Each Sampling Event
Water Temperature	Baseline WQ and Sediment	Each Sampling Event
Specific Conductance	Baseline WQ and Sediment	Each Sampling Event
Turbidity	Baseline WQ and Sediment	Each Sampling Event
Redox Potential	Baseline WQ and Sediment	Each Sampling Event
Color	Baseline WQ (Visual)	Monthly

Parameter	Task	Frequency of Collection
Residues	Baseline WQ (Visual)	One Survey-summer
General Water Quality Parameters (grab samples for laboratory analysis)		
Hardness	Baseline WQ	Monthly
Alkalinity	Baseline WQ	Monthly
Nitrate/Nitrite	Baseline WQ	Monthly
Ammonia as N	Baseline WQ	Monthly
Total Kjeldahl Nitrogen	Baseline WQ	Monthly
Total Phosphorus	Baseline WQ	Monthly
Ortho-phosphate	Baseline WQ	Monthly
Chlorophyll *a*	Baseline WQ	Monthly
Total Dissolved Solids	Baseline WQ	Monthly
Total Suspended Solids	Baseline WQ	Monthly
Turbidity	Baseline WQ	Monthly
TOC	Baseline WQ	One Survey-summer
DOC	Baseline WQ	Monthly
Fecal Coliform	Baseline WQ	One Survey-summer
Petroleum Hydrocarbons	Baseline WQ	One Survey-summer
Radioactivity	Baseline WQ	One Survey-summer
Metals – (Water) Dissolved and Total		
Aluminum	Baseline WQ (Total & Dissolved)	One Survey-summer
Arsenic	Baseline WQ (Total & Dissolved)	Monthly
Barium	Baseline WQ (Total & Dissolved)	Monthly
Beryllium	Baseline WQ (Total & Dissolved)	Monthly
Cadmium	Baseline WQ (Total & Dissolved)	Monthly
Chromium (III & IV)	Baseline WQ (Total & Dissolved)	One Survey-summer
Cobalt	Baseline WQ (Total & Dissolved)	Monthly
Copper	Baseline WQ (Total & Dissolved)	Monthly
Iron	Baseline WQ (Total & Dissolved)	Monthly
Lead	Baseline WQ (Total & Dissolved)	Monthly
Manganese	Baseline WQ (Total &	Monthly

Parameter	**Task**	**Frequency of Collection**
	Dissolved)	
Magnesium	Baseline WQ (Total & Dissolved)	Monthly
Mercury	Baseline WQ (Total & Dissolved)	Monthly
Molybdenum	Baseline WQ (Total & Dissolved)	Monthly
Nickel	Baseline WQ (Total & Dissolved)	Monthly
Selenium	Baseline WQ (Total & Dissolved)	One Survey-summer
Thallium	Baseline WQ (Total & Dissolved)	Monthly
Vanadium	Baseline WQ (Total & Dissolved)	Monthly
Zinc	Baseline WQ (Total & Dissolved)	Monthly
Metals –Sediment (Total)		
Aluminum	Sediment Samples	One Survey-summer
Arsenic	Sediment Samples	One Survey-summer
Cadmium	Sediment Samples	One Survey-summer
Copper	Sediment Samples	One Survey-summer
Iron	Sediment Samples	One Survey-summer
Lead	Sediment Samples	One Survey-summer
Mercury	Sediment Samples	One Survey-summer
Zinc	Sediment Samples	One Survey-summer
Metals – Fish Tissue (Use EPA Sampling Method 1669)		
Total Mercury	Fish Tissue Screening	One Survey-late summer
Methyl-mercury	Fish Tissue Screening	One Survey-late summer
Arsenic	Fish Tissue Screening	One Survey-late summer
Cadmium	Fish Tissue Screening	One Survey-late summer
Selenium	Fish Tissue Screening	One Survey-late summer

Table B1-2. Proposed Susitna River Basin Temperature and Water Quality Monitoring Sites

Susitna River Mile	Description	Susitna River Slough ID	Latitude (decimal degrees)	Longitude (decimal degrees)
15.1	Susitna above Alexander Creek	NA	61.4391	-150.4851
25.8[3]	***Susitna Station***	*NA*	*61.5454*	*-150.516*
28.0	**Yentna River**	NA	61.5876	-150.4831
29.5	**Susitna above Yentna**	NA	61.5759	-150.4270
40.6[3]	**Deshka River**	NA	61.7095	-150.3248
55.0[1]	**Susitna**	NA	61.8622	-150.1844
83.8[3]	**Susitna at Parks Highway East**	NA	62.1748	-150.1732
83.9[3]	Susitna at Parks Highway West	NA	62.1811	-150.1679
95.8	LRX 1	NA	62.3063	-150.1087
97.2	**Talkeetna River**	NA	62.3424	-150.1122
98.1	**Chulitna River**	NA	62.5676	-150.2379
103.0[2,3]	**Talkeetna**	NA	62.3943	-150.134
103.3	*Talkeetna*	*NA*	*62.3972*	*-150.1373*
113.0[2]	LRX 18	NA	62.5252	-150.1144
120.7[2,3]	**Curry Fishwheel Camp**	NA	62.6178	-150.0136
126.0	--	8A	62.6704	-149.9029
126.1[2]	LRX 29	NA	62.6739	-149.8991
129.2[3]	--	9	62.7025	-149.8412
130.8[2]	LRX 35	NA	62.7136	-149.8089
136.5	Susitna near Gold Creek	NA	62.7673	-149.6935
136.8[3]	**Gold Creek**	NA	62.7675	-149.6919
138.0[1]	--	16B	62.7802	-149.6853
138.6[3]	***Indian River***	*NA*	*62.8009*	*-149.664*
138.7[2]	**Susitna above Indian River**	NA	62.7854	-149.6484
140.0	--	19	62.7939	-149.6143
140.1[2]	LRX 53	NA	62.7945	-149.6129
142.0	--	21	62.8163	-149.576
148.0	Susitna below Portage Creek	NA	62.8303	-149.3827
148.8[2]	**Susitna above Portage Creek**	NA	62.8304	-149.3803
148.8	**Portage Creek**	NA	62.8267	-149.3693
165.0[1]	*Susitna*	*NA*	*62.7916*	*-148.997*
180.3[1]	Susitna below Tsusena Creek	NA	62.8134	-148.6568

Susitna River Mile	Description	Susitna River Slough ID	Latitude (decimal degrees)	Longitude (decimal degrees)
181.3[3]	*Tsusena Creek*	*NA*	*62.8217*	*-148.6068*
184.5[1]	***Susitna at Watana Dam site***	*NA*	*62.8226*	*-148.533*
194.1	*Watana Creek*	*NA*	*62.8296*	*-148.259*
206.8	Kosina Creek	NA	62.7822	-147.94
223.7[3]	***Susitna near Cantwell***	*NA*	*62.7052*	*147.538*
233.4	Oshetna Creek	NA	62.6402	-147.383

1 Site not sampled for water quality or temperature in the 1980s or location moved slightly from original location.
2 Proposed mainstem Susitna River temperature monitoring sites for purposes of 1980s SNTEMP model evaluation.
3 Locations with overlap of water quality temperature monitoring sites with other studies.
Locations in bold font represent that both temperature and water quality samples are collected from a site. Locations in italics represent sites which were not installed during the 2012 sampling year.

Table B1-3. Parameters for water quality monitoring and laboratory analysis**.**

Parameter	Analysis Method	Method Detection Limit	Sample Holding Times
In-Situ Water Quality Parameters			
Dissolved Oxygen (DO)	Water Quality Meter	0.2 mg/L	Not Applicable
pH	Water Quality Meter	0.1 pH units	Not Applicable
Water Temperature	Water Quality Meter	0.1°C	Not Applicable
Specific Conductance	Water Quality Meter	0.1 µS/cm	Not Applicable
Turbidity	Water Quality Meter	.05 NTU	Not Applicable
Redox Potential	Water Quality Meter	Unknown	Not Applicable
Color	Platinum-Cobalt Scale (SM)	N/A	Not Applicable
Residues	Defined in 18 ACC 70	N/A	Not Applicable
General Water Quality Parameters (grab samples for laboratory analysis)			
Hardness	EPA - 130.2	2.0 mg/L as $CaCO_3$	180 days
Nitrate/Nitrite	EPA - 353.2	0.031 mg/L	48 hours
Alkalinity	EPA - 2320	3.1 mg/L	14 days
Ammonia as N	EPA - 350.1	0.031 mg/L	28 days
Total Kjeldahl Nitrogen	EPA - 351.2	0.2 mg/L	28 days
Total Phosphorus	EPA - 365.3	0.0031 mg/L	28 days
Ortho-phosphate	EPA - 365.3	0.01 mg/L	48 hours
Chlorophyll *a*	SM 10300	0.2 µg/L	28 days
Total Dissolved Solids	EPA - 160.1	3.1 mg/L	7 days
Total Suspended Solids	EPA - 160.2	0.15 mg/L	7 days
Turbidity	EPA - 180.1	0.05 NTU	48 hours
TOC	EPA - 415.1	.15 mg/L	28 days
DOC	EPA – 415.1	0.07 mg/L	28 days
Fecal Coliform	EPA 1604	1	30 hours
Petroleum Hydrocarbons	EPA 602/624 (TAqH) EPA 610/625 (TAH)	31 µg/L	14 days
Radionuclides[1]	EPA 900.0, 901.1, 903.1, 904.0, 905.0, Alpha Spectroscopy	Varies from 0.7 to 1,000 pCi/L	5 days

Parameter	Analysis Method	Method Detection Limit	Sample Holding Times
Metals – (Water) Dissolved and Total			
Aluminum	EPA – 6010B/6020A	.62 µg/L	48 hours
Arsenic	EPA – 6010B/6020A	.15 µg/L	48 hours
Barium	EPA – 6010B/6020A	0.025 µg/L	48 hours
Beryllium	EPA – 6010B/6020A	0.025 µg/L	48 hours
Cadmium	EPA – 6010B/6020A	0.015 µg/L	48 hours
Chromium (III & IV)	EPA – 6010B/6020A	0.062 µg/L	48 hours
Cobalt	EPA – 6010B/6020A	0.01 µg/L	48 hours
Copper	EPA – 6010B/6020A	0.05 µg/L	48 hours
Iron	EPA – 6010B/6020A	6.2 µg/L	48 hours
Lead	EPA – 6010B/6020A	0.031 µg/L	48 hours
Magnesium	EPA – 6010B/6020A	0.015 µg/L	48 hours
Manganese	EPA – 6010B/6020A	0.015 µg/L	48 hours
Mercury	EPA – 7470A	1.5 ng/L	48 hours
Molybdenum	EPA – 6010B/6020A	0.015µg/L	48 hours
Nickel	EPA – 6010B/6020A	0.062 µg/L	48 hours
Selenium	EPA – 6010B/6020A	0.31 µg/L	48 hours
Thallium	EPA – 6010B/6020A	0.0062 µg/L	48 hours
Vanadium	EPA – 6010B/6020A	0.31 µg/L	48 hours
Zinc	EPA – 6010B/6020A	0.4 µg/L	48 hours
Metals –Sediment (Total)			
Aluminum	EPA - 200.7	Not Known	180 days
Arsenic	EPA - 200.7	3.0 mg/kg	180 days
Cadmium	EPA - 200.7	1.0 mg/kg	180 days
Copper	EPA - 200.7	Not Known	180 days
Iron	EPA - 200.7	Not Known	180 days
Lead	EPA - 200.7	1.5 mg/kg	180 days
Mercury	EPA – 245.5 / 7470A	0.1 mg/kg	28 days
Zinc	EPA - 200.7	3.5 mg/kg	180 days
Metals – Fish Tissue (Use EPA Sampling Method 1669)			
Total Mercury	EPA – 1631	Not Known	7 days
Methylmercury	EPA – 1631	Not Known	7 days

Parameter	Analysis Method	Method Detection Limit	Sample Holding Times
Arsenic	EPA - 1632, Revision A	Not Known	7 days
Cadmium	EPA - 1632	Not Known	7 days
Selenium	EPA - 1632	Not Known	7 days

Note: List of Radionuclides suggested for analysis includes the following: Americium-241; Cesium-137; Lead-210; Plutonium-238, 239, 240; Potassium-40; Radium-226; Radium-228; Strontium-90; Thorium-230, 232; Uranium-234, 235, 238; Tritium Gross Alpha, Gross Beta

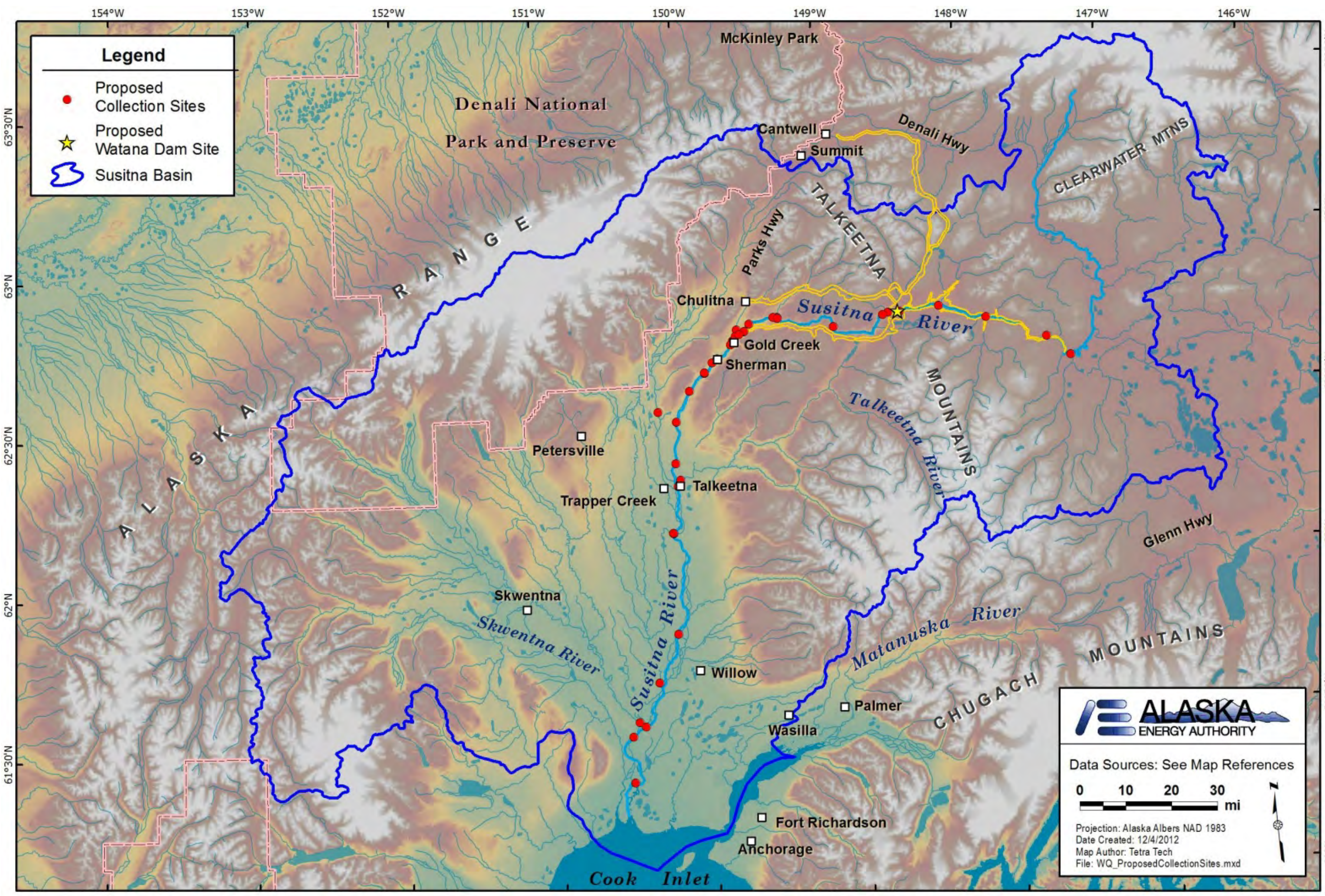

Figure B1-11. Proposed 2012 Stream Water Quality and Temperature Data Collection Sites for the Susitna-Watana Hydroelectric Project

B 2.0 SAMPLING METHODS

Water Quality Data Collection: Monitoring Protocol

Water quality grab samples will be collected during each site visit along a transect of the stream channel/water body, using methods consistent with ADEC and EPA protocols for sampling ambient water and trace metal water quality criteria.

Mainstem areas of the river not immediately influenced by a tributary will be characterized with a single transect. Areas of the mainstem with an upstream tributary that may influence the nearshore zone or that are well-mixed with the mainstem will be characterized by collecting samples at two transect locations: in the tributary and in the mainstem upstream of the tributary confluence. Samples will be collected at 3 equi-distant locations along each transect (i.e. 25% from left bank, 50% from left bank, and 75% from left bank). Samples will be collected from a depth of 0.5 meters below the surface as well as 0.5 meters above the bottom. This will ensure that variations in concentrations, especially metals, are captured and adequately characterized throughout the study area.

These samples will be collected on approximately a monthly basis (four samples from June to September). The period for collecting surface water samples will begin at ice break-up and extend to beginning of ice formation on the river. Limited winter sampling (once in December, and again in March) will be conducted where existing or historic USGS sites are located.

Review of existing data (URS 2011) indicates that few exceedances occur with metals concentrations during the winter months. If the 2013 data sets suggest that mercury concentrations exceed criteria or thresholds, then an expanded 2014 water quality monitoring program will be conducted to characterize conditions on a monthly basis throughout the winter months.

Variation of water quality in a river cross-section is often significant and is most likely to occur because of incomplete mixing of upstream tributary inflows, point-source discharges, or variations in velocity and channel geometry. Water quality profiles at each location on each transect will be conducted for field water quality parameters (e.g., temperature, pH, dissolved oxygen, and conductivity) to determine the extent of vertical and lateral mixing.

Water quality samples will be collected using a davit/cable/winch system. A 50lb+ weight will be attached to the end of the cable to ensure that both the cable and sampling equipment remain vertical throughout the water column. Water quality grab samples are anticipated to be collected via a Kemmerer Sampler, made out of Teflon for low level metals analysis, which will be attached to the davit cable. The sampler will be lowered into the water column via the wench until the desired sampling depth is reached. At that point the rope/cable attached to the sampler will be pulled tight and messenger sent down to close the sampler. Water from the sampler will be then be poured into the appropriate sample containers. If troubles are encountered while using the Kemmerer sampler due to high velocities in the Susitna river, a second sample collection method could be utilized where Tygon tubing is attached to the davit cable and water is pulled from the desired depth via a peristaltic pump. It is unknown at this time which sampling technique is better suited for conditions on the Susitna River and tributaries.

Water quality indicators like conductivity (specific conductance) has been suggested as a surrogate measure for transfer of metals from groundwater to surface water or in mobilization of metals within the river channel. Available USGS data from select continuous gaging stations will be reviewed for increases in specific conductance during monthly and seasonal intervals, and these results will be used to determine if further metals sampling is warranted during additional winter months.

In-Situ Water Quality Sampling

During each site visit, in situ measurements of dissolved oxygen, pH, specific conductance, redox potential, turbidity, and water temperature will be made. A Hanna Instruments HI 98703 Portable Turbidity Meter will be used to measure turbidity, while a Hydrolab® datasonde (MS5) will be used to measure the remaining field parameters during each site visit. Continuous turbidity measurement may be conducted with the Hydrolab datasonde at select locations (e.g., former/current USGS sites where turbidity data are available from the 1980s) and operated during summer and winter conditions. The following list of former and current USGS mainstem Susitna River monitoring sites will be considered for continuous turbidity monitoring: Susitna Station, Sunshine, Gold Creek, Tsusena Creek, and near Cantwell. These locations have historic and current flow data that will be used in water quality modeling (Section 5.6) of effects on turbidity from Project operations. Continuous logging of water quality parameters using a multi-parameter probe (e.g., temperature, pH, dissolved oxygen, and conductivity) may be placed at Focus Area locations (identified in Section 5.5.4.5. The period of deployment will be focused on summer months June through September (four months) as water conditions permit deployment and routine download of data. Maintenance of a multi-parameter probe and risk from damage is high during winter months. Also, freezing conditions will damage sensor apparatus and the logging unit if enclosed by formation of ice.

Standard techniques for pre- and post-sampling calibration of in situ instrumentation will be used to ensure quality of data generation and will follow accepted practice. If calibration failure is observed during a site visit, field data will be corrected according to equipment manufacturer's instructions.

General Water Quality Sampling

Water quality grab sampling will avoid eddies, pools, and deadwater. For sites upstream of the proposed Project site, samples will have to be collected nearshore via wading since sites are only accessible by helicopter. Samples will be collected using a Kemmerer sampler when collecting from a boat or a HDPE collection bottle mounted on an extendable pole when collecting from the river bank. Samples will be collected at 3 equi-distant locations along each transect (i.e. 25% from left bank, 50% from left bank, and 75% from left bank). Samples will be collected from a depth of 0.5 meters below the surface as well as 0.5 meters above the bottom. Sampling will avoid unnecessary collection of sediments in water samples, and touching the inside or lip of the sample container. Sample collection container will be rinsed with deionized water after each station to avoid cross-contamination. Samples will be delivered to ADEC approved laboratories within the holding time frame. Each batch of samples will have a separate completed chain of custody sheet. A field duplicate will be collected for 10 percent of samples (i.e., 1 for every 10 water grab samples). Laboratory quality control samples including duplicate, spiked, and blank samples will be prepared and processed by the laboratory.

Sample numbers will be recorded on field data sheets immediately after collection. Samples intended for the laboratory will be stored/preserved in coolers and kept under the custody of the field team at all times. Samples will be shipped/transported to the laboratory in coolers with ice and cooled to approximately 4 °C. Chain of custody records and other sampling documentation will be kept in sealed plastic bags (Ziploc®) and taped inside the lid of the coolers prior to shipment. Packaging, marking, labeling, and shipping of samples will be in compliance with all regulations promulgated by the U. S. Department of Transportation in the Code of Federal Regulations, 49 CFR 171-177.

Sediment Samples for Mercury/Metals in Reservoir Area Data Collection: Monitoring Protocol

Sediment samples will be collected using an Ekman dredge or a modified Van Veen grab sampler. Sampling devices will be deployed from the boat. Samples may also be collected by wading into shallow near shore areas. To the extent possible, samples will consist of the top 6 inches (15 centimeters) of sediment. Comparison of results from the Susitna drainage will be made with other studies for Blue Lake, Eklutna Lake, and Bradley Lake when similar data are available and where physical settings are comparable.

Sediment samples will be stored in cooler and kept under the custody of the field times at all times. Samples will be shipped/transported to the laboratory in coolers with ice and cooled to approximately 4 °C. Chain of custody records and other sampling documentation will be kept in sealed plastic bags (Ziploc®) and taped inside the lid of the coolers prior to shipment. Packaging, marking, labeling, and shipping of samples will be in compliance with all regulations promulgated by the U. S. Department of Transportation in the Code of Federal Regulations, 49 CFR 171-177.

Baseline Metals Levels in Fish Tissue: Monitoring Protocol

Target fish species in the vicinity of the Susitna-Watana Reservoir will be Dolly Varden, Arctic grayling, whitefish species, burbot, long nose sucker, lake trout, and resident rainbow trout. If possible, filets will be sampled from 7 adult individuals from each species. Body size targeted for collection will represent the non-anadromous phase of each species life cycle (e.g., Dolly Varden will be 3.5 to 5 inches [90 to 125 millimeters] total length to represent the resident portion of the life cycle). Collection times for fish samples will occur in late August and early September 2013. Filet samples will be analyzed for methyl and total mercury. Liver samples will also be collected from burbot and analyzed for mercury, methyl-mercury, arsenic, cadmium, and selenium.

Field procedures will be consistent with those outlined in applicable ADEC and/or EPA sampling protocols (USEPA 2000). Clean nylon nets and polyethylene-gloves will be used during fish tissue collection. The species, fork length, and weight of each fish will be recorded. Fish will be placed in Teflon® sheets and into zipper-closure bags and placed immediately on ice. Fish samples will be submitted to a state-certified analytical laboratory for individual fish muscle tissue analysis. Results will be reported with respect to applicable state and federal standards.

Pilot Thermal Imaging Assessment of a Portion of the Susitna River: Monitoring Protocol

Pilot Thermal Imaging Assessment of a Portion of the Susitna River

Thermal imagery of a portion of the Susitna River (e.g., 10 miles of the Middle River) was collected in the 2012 season. The primary goal is to establish baseline data for assessing the availability and spatial extent of thermal refugia/upwelling. Data from the thermal imaging will be ground-truthed using in-stream thermographs that will be utilized to calibrate the thermal imagery, assess absolute accuracy, and provide a temporal context for the thermal infrared data collection. In coordination with the Instream Flow and fish studies, a determination will be made as to whether thermal imaging data will be applicable and if additional thermal imagery will be collected during the 2013 field season.

Remotely sensed thermal images allow for spatially distributed measurements of radiant temperatures in the river. Radiant temperature measurements are made only on the surface layer of the water (top 4 inches [10 centimeters]). Temperature readings can vary depending on the amount of suspended sediment in the water and the turbidity of the water. Collection of data will occur near the end of October when the freeze begins and the contrast between cold surface water and warmer groundwater influence is accentuated. To maximize thermal contrast between warmer ground water discharge and cooler river temperatures, the sensor will be flown during early morning when solar loading is minimized. The suspended sediment and turbidity will be diminished during the fall when the glacial flour content in the water column is reduced from glacial meltwater.

After processing, the resulting TIR image mosaic will be visually inspected to look for spatial variability in surface temperatures within the study area. Analysts will identify thermal features and areas of ground water discharge either through direct detection of a spring or inferred from bulk temperature patterns. The median temperatures for each sampled image will be plotted versus the corresponding river mile to develop a longitudinal temperature profile. The profile will illustrate how stream temperatures vary spatially along the stream gradient. The location and median temperature of all sampled surface water inflows (e.g. tributaries, surface springs, etc.) will be included on the plot to illustrate how these inflows influence the main stem temperature patterns.

If the pilot study is successful, then a description of thermal refugia throughout the Project area can be mapped using aerial imagery calibrated with on-the-ground verification. The verification data will be collected at the same time as the aerial imagery (or nearly the same time) using the established continuous temperature monitoring network and additional grab sample temperature readings where there may be gaps, such as in select sloughs. The following elements are important considerations for thermal data collection, specifications for data quality, and strategy for relating digital imagery and actual river surface water temperatures.

Radiant Temperature

- Remotely sensed thermal images allow for spatially distributed measurements of radiant temperatures in the river.
- Radiant temperature measurements are made only on the surface layer of the water (top 10cm).
- Temperature readings can vary depending on the amount of suspended sediment in the water and the turbidity of the water.

Spatial Resolution

- The key to good data quality is determining the pixel size of the thermal infrared (TIR) sensor and how that relates to the near-bank environment.
- Best practice is 3 pure-water pixels (ensures that the digital image represented by any 3 contiguous pixels identifies water versus land).
- Very fine resolution (0.2 – 1m) imagery is best used to determine ground water springs and cold-water seeps.
- Larger pixels can be useful for determining characteristic patterns of latitude and longitude thermal variation in riverine landscapes.

Calibrating Temperature

- Water temperatures change during the day, therefore collection will be measured near the same time daily and when water temp is most stable (early afternoon).
- Validation sampling site selections are determined where there is channel accessibility and where there are not known influences of tributaries, or seeps in the area.
- Hand-held ground imaging radiometers can provide validation as long as the precision is at least as good as that expected from airborne TIR measurements.

Availability of historical imagery for thermal analysis will be also being investigated.

Water Sample Processing

Field equipment used for collection, measurement, and testing will be subject to a strict program of control, calibration, adjustment and maintenance. The Kemmerer sampler or tygon tubing/ pump used to collect surface water samples will be routinely inspected to verify that it is working properly. The Van

Veen grab sampler used to collect sediment sample will also be routinely inspected. Routine maintenance of all sample equipment will be conducted prior to each sampling event. Maintenance will include a visual inspection that all parts are present, attached correctly and devoid of any obvious contamination. . The project manager will coordinate ordering replacement parts and repairing samplers. Spare sampling equipment will be available on-site in case of primary equipment failure.

QA/QC and Blank Samples and Frequency

Quality control activities in the field will consist of the following items:

- Adherence to documented procedures in this SAP and the companion QAPP;
- Cross-checking of field measurements and recording to ensure consistency and accuracy; and
- Comprehensive documentation of field observations, sample collection and sample identification information.

Multiple field quality control samples will be collected: one blind field duplicate sample will be collected for every ten sites sampled and sent to the laboratory to test for precision (e.g., repeatability) of analytical procedures. A trip blank will be submitted to the lab to ensure that equipment handling and transport procedures do not introduce contamination to transported project samples. Rinsate blanks will be collected at different periods throughout the program to assure that cross-contamination between samples does not occur.

B 3.0 SAMPLE DOCUMENTATION AND SHIPPING

Field Logbook and Field Log Forms

Thorough documentation of all field sample collection is necessary for proper processing of data and, ultimately, for interpreting study results. Field sample collection will be documented in writing, on forms included in (to be included in Appendix B), as well as on the following forms and labels:

- A field log notebook for general observations and notes
- A Field Data Record Form that contains information about observations and measurements made and samples collected at the site
- Checklists for each sampling event, sampling point, and sampling time.

Copies of the field log books and physical characterization/water quality data sheets and sampling checklists will be supplied to the Field Project Managers at the close of each sampling event. These data will be used in conjunction with inspection checklists to compile the sampling event reports. Formal reports that are generated from the data will be subject to technical and editorial review before submission to AEA, and will be maintained at Tetra Tech's Seattle, Washington, office in the central file (disk and hard copy). The data reports will include a summary of the types of data collected, sampling dates, and any problems or anomalies observed during sample collection.

Samples will be documented and tracked on Field Data Record forms, Sample Identification labels, and Chain of Custody records. The Field Task Leaders (one for each team) will be responsible for ensuring that these forms are completed and reviewed for correctness and completeness by the designated field QC Officer. Tt will maintain copies of these forms in the project files. A sampling report will be prepared following each sampling event. Another person will manually check data entered into any spreadsheet or other format against the original source to ensure accurate data entry. If there is any indication that requirements for sample integrity or data quality have not been met (for samples or measurements collected by Tetra Tech), the Tetra Tech QAO will be notified immediately (with an accompanying explanation of the problems encountered).

Photographic Records

Recording of sampling locations will be documented with photographs using a conventional photo-point procedure. Photographs will be taken at each sampling location and the photograph number and the associated date, description of the photograph, site identification number and GPS coordinates will be recorded in the photographic log. The photos will be stored as digital images and maintained as files, as appropriate, in repositories for information and data used in preparing any reports and documents during the project. Digital photos will be submitted with an index for each set of photographs, identifying the project, site identification number and a description of the photograph.

Investigation-Derived Wastes

Excess sample water collected from each site will be returned to the reservoir or river. Excess preservatives, when needed for preservation of field samples for transport to the laboratory, will be either returned to the original sample reservoir or will be disposed of safely according to the Material Safety Data Sheets (MSDS) directions.

B 4.0 SAMPLE HANDLING AND CUSTODY

Field Data Recording

In-situ field data measurements will be recorded immediately following collection, both, electronically (stored within Hydrolab Surveyor) and on a field data sheet for each station. Field data sheets will be printed on *Rite in the Rain* paper. Promptly following each sample event, scanned copies of field data sheets will be made and stored electronically.

Each sample bottle will have a waterproof sample identification label, tag, or permanent marker identification. All sample bottles will be labeled with an indelible marker before the time of collection. Sample labels will include station designation, date, time, collector's initials, and sample/analysis type. Special analyses to be performed and any pertinent remarks will also be recorded on the label.

Sample Packaging and Shipping Requirements

Samples for laboratory analysis will be collected in containers appropriate for the analytes of interest, filtered if necessary and will be properly preserved until delivery to the analytical laboratory. All samples will be immediately placed in coolers and packed with gel ice after sampling and will remain chilled to 4°C (±2°C) during transportation to the contract laboratory. All samples will be accompanied with completed chain-of-custody forms when shipped, and coolers will be sealed with signed and dated fiber tape for shipment. Tetra Tech maintains specific SOPs (Standard Operating Procedures) for sample chain of custody, sample shipping, and supporting sample documentation.

Chain of Custody

Chain of custody (COC) can be defined as a systematic procedure for tracking a sample or datum from its origin to its final use. Chain of custody procedures is necessary to ensure thorough documentation of handling for each sample, from field collection to data analysis. The purpose of this procedure is to minimize errors, maintain sample integrity, and protect the quality of data collected.

A data sample is considered to be under a person's custody if it is:

- In the individual's physical possession
- In the individual's sight
- Secured in a tamper-proof way by that person, or
- Secured by the person in an area that is restricted to authorized personnel.

Elements of chain-of-custody include:

- Sample identification
- Security seals and locks
- Security procedures
- Chain-of-custody record

The analytical laboratory will provide blank COCs with each bottle order and provide scanned copies of finished COCs with sample results.

B 5.0 ANALYTICAL METHODS

This study will employ both field measurements and collection of samples to be analyzed in the laboratory. Field and laboratory analytical procedures will follow APHA *et al*. (1998) methods. The expected detection or reporting limits for field parameters and laboratory analyses are listed in Table B1-3 along with the anticipated analytical method.

Field Sampling Decisions

Damage to equipment from wildlife, physical forces of the river, or equipment failure will be addressed using the following protocol. Field sampling decisions to deviate or modify field sampling locations or methods will only be made with the approval of the field crew chief. The field crew chief will document the decision on the field note sheets, and email a copy of the sheet or telephone the information to the study manager. If the field decision is large enough in scale to significantly affect the study's data, scope, schedule or budget, the field crew chief is authorized to stop work until further contact and coordination with the study manager can be performed.

Laboratory Operations Documentation

Laboratory data results will be recorded on laboratory data sheets, bench sheets and/or in laboratory logbooks for each sampling event. These records as well as control charts, logbook records of equipment maintenance records, calibration and quality control checks, such as preparation and use of standard solutions, inventory of supplies and consumables, check-in of equipment, equipment parts and chemicals will be kept on file at the laboratory.

Any procedural or equipment problems will be recorded in the field notebooks. Any deviation from this Sampling and Analysis Plan will also be noted in the field notebooks. Data results will include information on field and/or laboratory QA/QC problems and corrective actions.

Standard turnaround time for the analytical samples taken to the contract laboratory will be seven to ten working days and will not exceed twenty-two working days for reporting of data.

Chain-of-custody forms will be kept with the sample during transport and will accompany data results back to Tetra Tech. Training records and data review records will be kept on file at Tetra Tech and the contract laboratory and will be available on request. All sample analysis records and documents are kept at the contract laboratory and will be available to AEA for inspection at any time. In addition to any written report, data collected for the project will be provided electronically via a CD-ROM or e-mail ZIP file format.

All records will be retained by the contract laboratory for five years. All project records at Tetra Tech are retained permanently.

B 6.0 QUALITY CONTROL

Data quality is addressed, in part, by consistent performance of valid procedures documented in the SOPs (Appendix B to this QAPP). It is enhanced by the training and experience of project staff and documentation of project activities This QAPP including its appendices will be distributed to all sampling personnel. A QC Officer (or equivalent) will ensure that samples are taken according to the established protocols and that all forms, checklists, and measurements are recorded and completed correctly during the sampling event.

Measurement performance criteria for data to be collected during this project are discussed in the following sections.

Precision

Precision is a measure of internal method consistency. It is demonstrated by the degree of mutual agreement between individual measurements or enumerated values of the same property of a sample, usually under demonstrated similar conditions. The usability assessment will include consideration of this condition in evaluating field measures from the entire measurement system. Although precision evaluation within 20 percent relative percent difference (RPD) are generally considered acceptable for water quality studies and analyses, no data validation or usability action will be taken for results in excess of the 20 percent limit (unless RPD is specified as acceptable when >20%). Instead, the results will be noted and compared with the balance of the parameters analyzed for a more comprehensive assessment before any negative assessment, disqualification, or exclusion of data.

This QC calculation also addresses uncertainty due to natural variation and sampling error. Precision is calculated from two duplicate samples by RPD as follows:

$$RPD = \frac{|C_1 - C_2|}{\overline{\overline{(C_1, C_2)}}} \times 100\%$$

where C_1 = the first of the two values and C_2 = the second of the two if precision is to be calculated from three or more replicate samples (as is often the case in laboratory analytical work), the relative standard deviation (RSD) will be used and is calculated as

$$RSD = \frac{s}{\overline{\overline{\chi}}}$$

where χ is the of the replicate samples, and s is the standard deviation and is determined by the following equation:

$$SD = \sqrt{\frac{\sum_{i=1}^{n}\left(\chi_i - \overline{\chi}\right)^2}{n-1}}$$

where χ_i is the measured value of the replicate, $\overline{\chi}$ is the mean of the measured values, and n is the number of replicates.

Accuracy

Accuracy is defined as the degree of agreement between an observed value and an accepted reference or true value. Accuracy is determined by using a combination of random error (precision) and systematic error (bias) due to sampling and analytical operations. Bias is the systematic distortion of a measurement process that causes errors in one direction so that the expected sample measurement is always greater or lesser to the same degree than the sample's true value. EPA now recommends that the term *accuracy* not be used and that *precision* and *bias* be used instead.

Because accuracy is the measurement of a parameter and comparison to a *truth*, and the true values of environmental physicochemical characteristics cannot be known, use of a surrogate is required. Accuracy of field measurements will be assumed to be determined through use of precision.

The accuracy of field equipment for the measurement of temperature, DO, conductivity, salinity, and pH will be determined at a minimum of two points that span the expected range of values for these parameters. Instruments used and procedures for determining accuracy include the following:

Accuracy of data entry into the project database will be controlled by double-checking all manual data entries.

Representativeness

Data representativeness is defined as the degree to which data accurately and precisely represents a characteristic of a population, parameter, and variations at a sampling point, a process condition, or an environmental condition. It therefore addresses the natural variability or the spatial and temporal heterogeneity of a population. The number of sampling points and their location within the study area were selected from a random draw to ensure that representative sample collection of each area of the watershed and each assessment characteristic occurs.

Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and entered into the data management system. To achieve this objective, every effort is made to avoid accidental or inadvertent sample or data loss. Accidents during sample transport or lab activities that cause the loss of the original samples will result in irreparable loss of data. Lack of data entry into the database will reduce the ability to perform analyses, integrate results, and prepare reports. Samples will be stored and transported in unbreakable (plastic) containers wherever possible. All sample processing (subsampling, sorting, identification, and enumeration) will occur in a controlled environment within the laboratory. Field personnel will assign a set of continuous identifiers to a batch of samples. Percent completeness (*%C*) for measurement parameters can be defined as follows:

$$\%C = \frac{V}{T} \times 100\%$$

where V = the number of measurements judged valid and T = the total number of measurements planned.

For this project, sampling will be considered complete when no less than 90 percent of the samples collected during a particular sampling event are judged valid.

Comparability

Two data sets are considered to be comparable when there is confidence that the two sets can be considered equivalent with respect to the measurement of a specific variable or group of variables. Comparability is dependent on the proper design of the sampling program and on adherence to accepted sampling techniques, and QA guidelines.

B 7.0 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Periodic regular inspection of equipment and instruments is needed to ensure the satisfactory performance of the systems. Equipment to be used during the sampling event is listed in the appropriate SOPs. Before any piece of sampling or measurement equipment is taken into the field, it will be inspected to ensure that the equipment is appropriate for the task to be performed, all necessary parts of the equipment are intact, and the equipment is in working order. In addition, the equipment will be visually inspected before its use. Broken equipment will be labeled "DO NOT USE" and returned to the Tt office to receive necessary repairs, or it will be disposed of. Backup field equipment will be available during all field activities in the event of equipment failure.

The objective of preventive maintenance is to ensure the availability and satisfactory performance of the measurement systems. All field measurement instruments will receive preventive maintenance in accordance with the manufacturer's specifications.

B 8.0 INSTRUMENT CALIBRATION AND FREQUENCY

Calibrated field instruments will be used for in-field, instantaneous measurement of temperature, DO, conductivity, salinity, and redox potential. Instruments will be calibrated in accordance with manufacturer's specifications and as described in the measurement SOPs. The SOPs include pre- and post-calibration verification on each sampling date. Verification of pH measurement accuracy will be checked against standard solutions in the field and adjustments made to the meter prior to the next measurement, if necessary.

The calibration of temperature, DO, conductivity/salinity, and pH probes will be checked before and after each sampling event, or as deemed necessary by the multiprobe's manufacturer, using certified standard solutions. Field calibrations will be recorded in the field sampling log book. Individual sensors will be considered to be operating correctly if the instrument reading is within 15 percent of the calibration standard value. If the two values are not within 15 percent of each other, the probe will be cleaned and recalibrated. If these two values are still not within 15 percent of each other following cleaning and recalibration, the probe itself will be replaced.

B 9.0 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Supplies and consumables are those items necessary to support the sampling and analysis operation. They include bottleware, calibration solutions, hoses, decontamination supplies, preservatives, and various types of water (e.g., potable, deionized, organic-free). Upon delivery of supplies, field crews will ensure that types and quantities of supplies received are consistent with what was ordered, and with what is indicated on the packing list and invoice for the material. If any discrepancies are found, the supplier will be contacted immediately.

While preparing for specific sampling events, the field sampling Task Leaders will be responsible for acquiring and inspecting materials and solutions that will be used for obtaining the samples for field measurements. Other materials must also meet specific requirements as indicated by the appropriate manufacturer; for example, only certified standard solutions will be used for the multiprobe calibration. Buffers and standards will be checked for expiration dates and appearance (correct color).

B 10.0 NONDIRECT MEASUREMENTS

Comparison of data collected during this field effort to historical data will be used for qualitative assessment only. Assessment of applicability for historical data is outside the scope of this document and is not addressed further in this data collection QAPP.

B 11.0 DATA MANAGEMENT

Samples will be documented and tracked on Field Data Record forms, Sample Identification labels, and Chain of Custody records. The Field Task Leaders (one for each team) will be responsible for ensuring that these forms are completed and reviewed for correctness and completeness by the designated field QC Officer. Tt will maintain copies of these forms in the project files. A sampling report will be prepared following each sampling event. Another person will manually check data entered into any spreadsheet or other format against the original source to ensure accurate data entry. If there is any indication that requirements for sample integrity or data quality have not been met (for samples or measurements collected by Tt), the Tt QAO will be notified immediately (with an accompanying explanation of the problems encountered).

Hard copy data packages will be paginated, fully validated raw data packages that include an analytical narrative with a signed certification of compliance with this QAPP and all method requirements; copies of Chain of Custody forms; sample inspection records; laboratory sample and QC results; calibration summaries; example calculations by parameter; and copies of all sample preparation, analysis, and standards logs adequate to reconstruct the entire analysis. The CD-ROM data will include a full copy of the paginated report scanned and stored in portable document format (PDF) for potential future submission to the client, if requested, and for long-term storage in the project files. Initially, the full raw data package will be submitted to the Tt QAO for assessment of compliance with the program goals and guidance.

All computer files associated with the project will be stored in a project subdirectory by Tt (subject to regular system backups) and will be copied to disk for archive for the 5 years subsequent to project completion. The data may eventually be stored using a data management system specified Alaska Department of Environmental Conservation.

C. ASSESSMENTS AND OVERSIGHT

C 1.0 ASSESSMENT AND RESPONSE ACTIONS

The QA program under which this task order will operate includes technical system audits, with independent checks of the data obtained from sampling, analysis, and data-gathering activities. Tt will review the QA programs that subcontractors follow to ensure similar levels of QA and QC are attained. The essential steps in the QA program are as follows:

- Identify and define the problem
- Assign responsibility for investigating the problem
- Investigate and determine the cause of the problem
- Assign and accept responsibility for implementing appropriate corrective action
- Establish the effectiveness of and implement the corrective action
- Verify that the corrective action has eliminated the problem

Many of the technical problems that might occur can be solved on the spot by the staff members involved; for example, by modifying the technical approach, repairing instrumentation that is not working properly, or correcting errors or deficiencies in documentation. Immediate corrective actions form part of normal operating procedures and are noted in records for the project. Problems not solved this way require more formalized, long-term corrective action. If quality problems that require attention are identified, Tt or the subcontractor will determine whether attaining acceptable quality requires short- or long-term actions. If a failure in an analytical system occurs (e.g., performance requirements are not met), the appropriate QC Officer or subcontractor QA Manager will be responsible for corrective action and will immediately inform the Tt PM or QAO, as appropriate. Subsequent steps taken will depend on the nature and significance of the problem.

The Tt Technical Lead has primary responsibility for monitoring the activities of this project and identifying or confirming any quality problems. These problems will also be brought to the attention of the Tt QAO, who will initiate the corrective action system described above, document the nature of the problem, and ensure that the recommended corrective action is carried out. The Tt QAO has the authority to stop work on the project if problems affecting data quality require extensive effort to resolve and are identified.

The AEA PM and Tt Technical Lead will be notified of major corrective actions and stop work orders. Corrective actions might include the following:

- Re-emphasizing to staff the project objectives, the limitations in scope, the need to adhere to the agreed-upon schedule and procedures, and the need to document QC and QA activities
- Securing additional commitment of staff time to devote to the project
- Retaining outside consultants to review problems in specialized technical areas
- Changing procedures
- The Tt Technical Lead may replace a staff member or subcontractor, as appropriate, if it is in the best interest of the project to do so.
- The Tt QC Officers are responsible for overseeing work as it is performed and periodically conducting checks during the data entry and analysis phases of the project. As data entries, calculations, or other activities are checked, the person performing the check will sign and date a hard copy of the material or complete a review form, as appropriate, and provide this documentation to the Tt Technical Lead for inclusion in the project files. Field audits and technical system audits will not be conducted under this task order.

C 2.0 QA REPORTS TO MANAGEMENT

A draft data report will be prepared and forwarded to the AEA for data analysis completed during winter 2013. The report will include the following:

- Description of the project purpose, goals, and objectives.
- Map(s) of the study area and sampling sites.
- Descriptions of field methods.
- Discussion of data quality and the significance of any problems encountered in the analyses.
- Summary tables of field data.
- Observations regarding significant or potentially significant findings.
- Recommendations based on project goals.

D. DATA VALIDATION AND USABILITY

D 1.0 DATA REVIEW, VERIFICATION, AND VALIDATION

Data validation and review services provide a method for determining the usability and limitations of data and provide a standardized data quality assessment. All Field Data forms will be reviewed by the Tt Technical Lead and Field Task Manager (assisted by the QAO, as needed) for completeness and correctness. Tt will be responsible for reviewing data entries and transmissions for completeness and adherence to QA requirements. Data quality will be assessed by comparing entered data to original data or by comparing results to the measurement performance criteria summarized in Section 4.0 to determine whether to accept, reject, or qualify the data. Results of the review and validation processes will be reported to the Technical Leads.

D 2.0 VERIFICATION AND VALIDATION METHODS

The Tt Technical Leads or designee will review all Field Data Record forms. The Tt QAO will review a minimum of 5 percent of the Field Data Record forms and other records. Any discrepancies in the records will be reconciled with the appropriate associated field personnel and will be reported to the Tt Technical Leads. The AEA PM will be consulted with deficiencies, observations, and findings, as well as with corrective action and technical directive recommendations for consideration and approval.

Data verification requires confirmation by examination or provision of objective evidence that the requirements of these specified QC acceptance criteria are met. Each step of the data collection and analysis process must be evaluated and its conformance to the protocols established in this QAPP verified, including:

- Sampling design
- Sample collection procedures
- Data analysis procedures
- Quality control
- Data format reduction and processing data

Validation involves detailed examination of the complete data package using professional judgment to determine whether the established procedures were followed. Validation will be done by the Study Lead.

Tetra Tech and URS managers for the project will review all results to verify that methods and protocols specified in this QAPP were followed; that all instrument calibrations, quality control checks, and

intermediate calculations were performed appropriately; and that the final reported data are consistent, correct, and complete, with no omissions or errors.
Evaluation criteria will include the acceptability of instrument calibrations and precision data and the appropriateness of assigned data qualifiers, if any. The study lead will review the data packages and companion field notations to determine if the results met the MQOs for bias, precision, and accuracy for that sampling interval (monthly) and to ensure that all analyses specified on the "Chain of Custody" form were performed. Based on these assessments, the data will either be accepted, accepted with appropriate qualifications, or rejected.

After the field data have been reviewed and verified by the project manager, they will be independently reviewed by QA officer for errors before closing out the study. The initial data review will consist of a 10 percent random sampling of the project data. If any errors are discovered during the initial data review, a full independent review will be undertaken QA officer.

D 3.0 RECONCILIATION WITH USER REQUIREMENTS

As soon as possible following completion of the sample collection and analyses, Tt will assess the precision, accuracy, and completeness measures and compare them with the criteria discussed in Section A 4.0. This will be the final determination of whether the data collected are of the correct type, quantity, and quality to support their intended use for this project. Any problems encountered in meeting the performance criteria (or uncertainties and limitations in the use of the data) will be discussed with the project QA personnel and the Alaska Energy Authority PM, and will be reconciled if possible.

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APPENDIX A: LOCATION MAPS

Figure A-1. Map of site Susitna above Alexander Creek at RM 15.1

Figure A-2. Map of site Susitna Station at RM 25.8

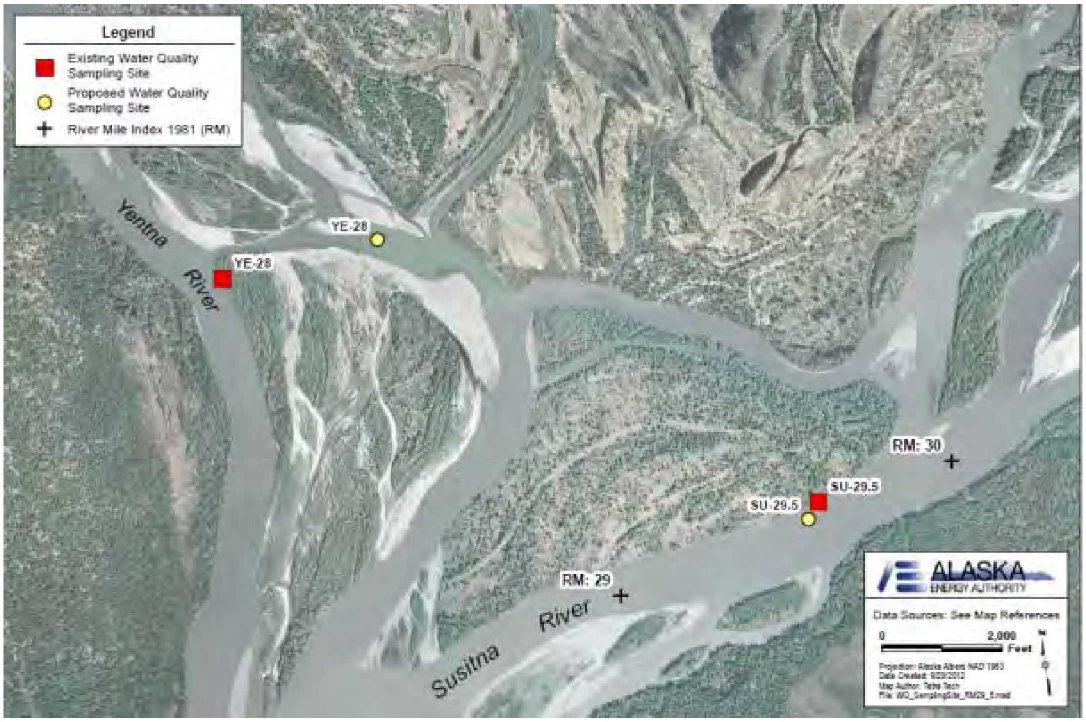

Figure A-3. Map of site Yentna River at RM 28

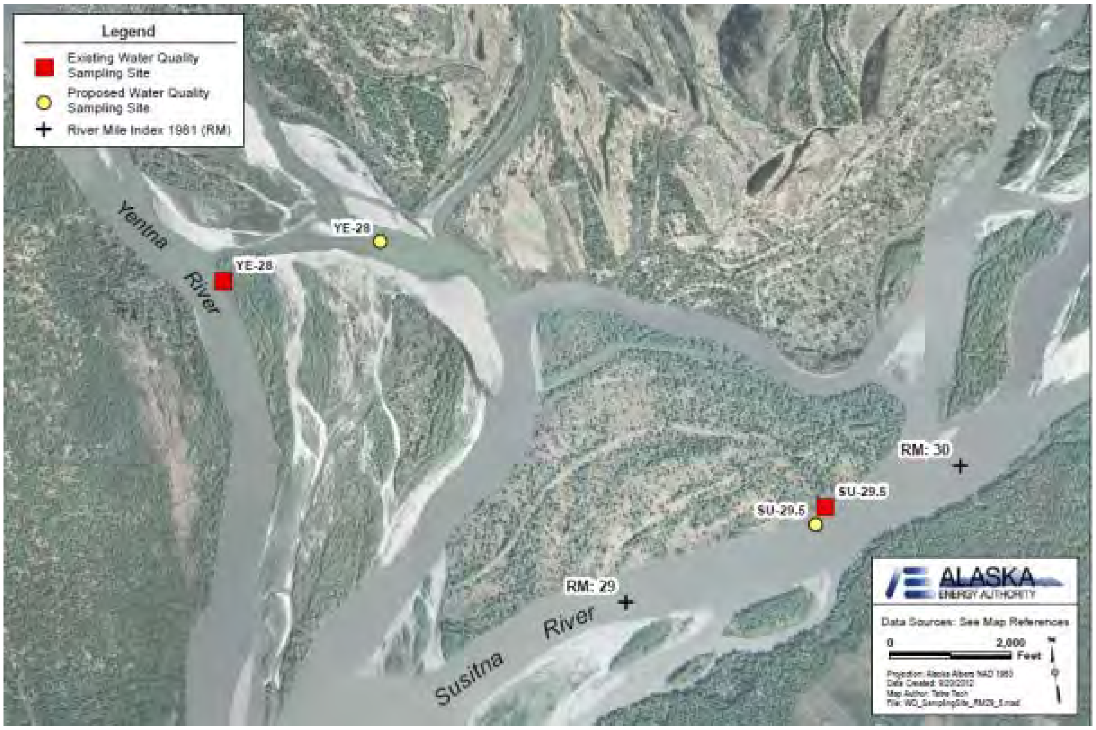

Figure A-4. Map of site Susitna above Yentna at RM 29.5

Figure A-5. Map of site Deshka River at RM 40.6

Figure A-6. Map of site Susitna at RM 55

Figure A-7. Map of site Susitna at Parks Highway East at RM 83.3

Figure A-8. Map of site Susitna at Parks highway West at RM 83.9

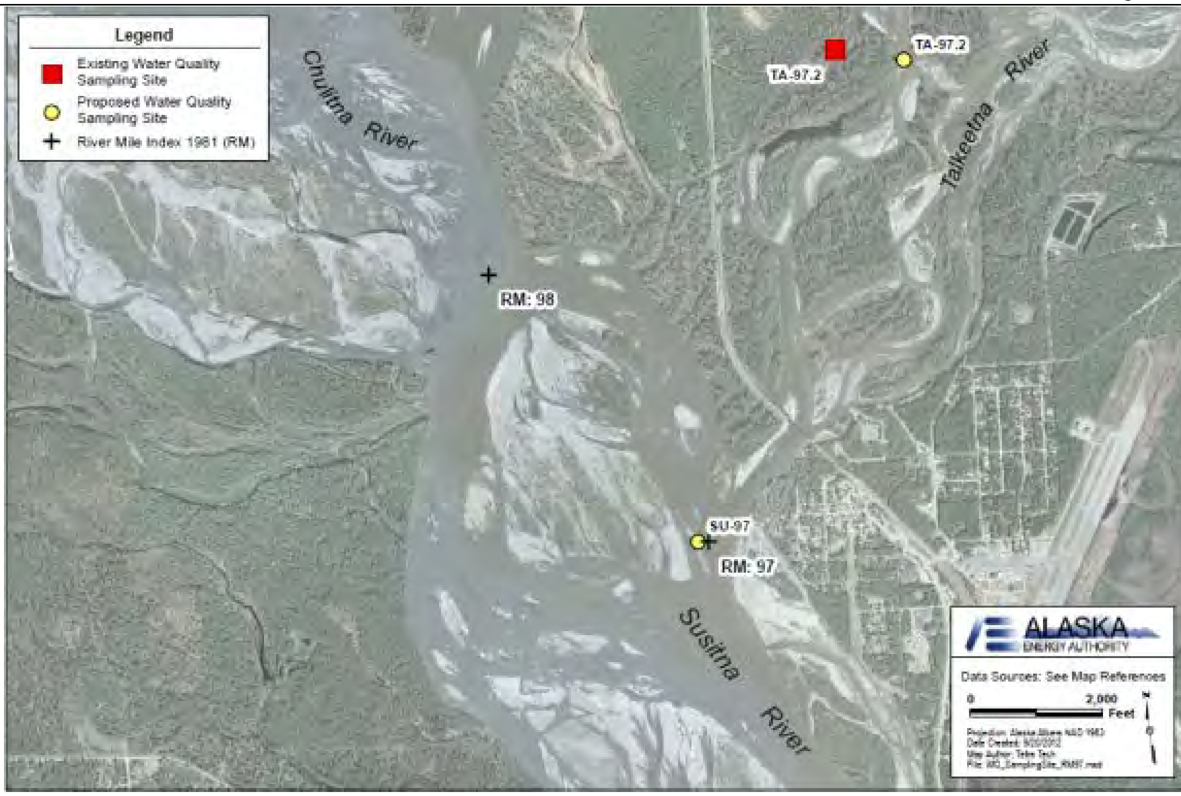

Figure A-9. Map of site Talkeetna at RM 97.2

Figure A-10. Map of site Talkeetna at RM 103

Figure A-11. Map of site Talkeetna at RM 103.3

Figure A-12. Map of site LRX 18 at RM 113

Figure A-13. Map of site Curry Fishwheel Camp at RM 120.7

Figure A-14. Map of Site Slough 8A at RM 126

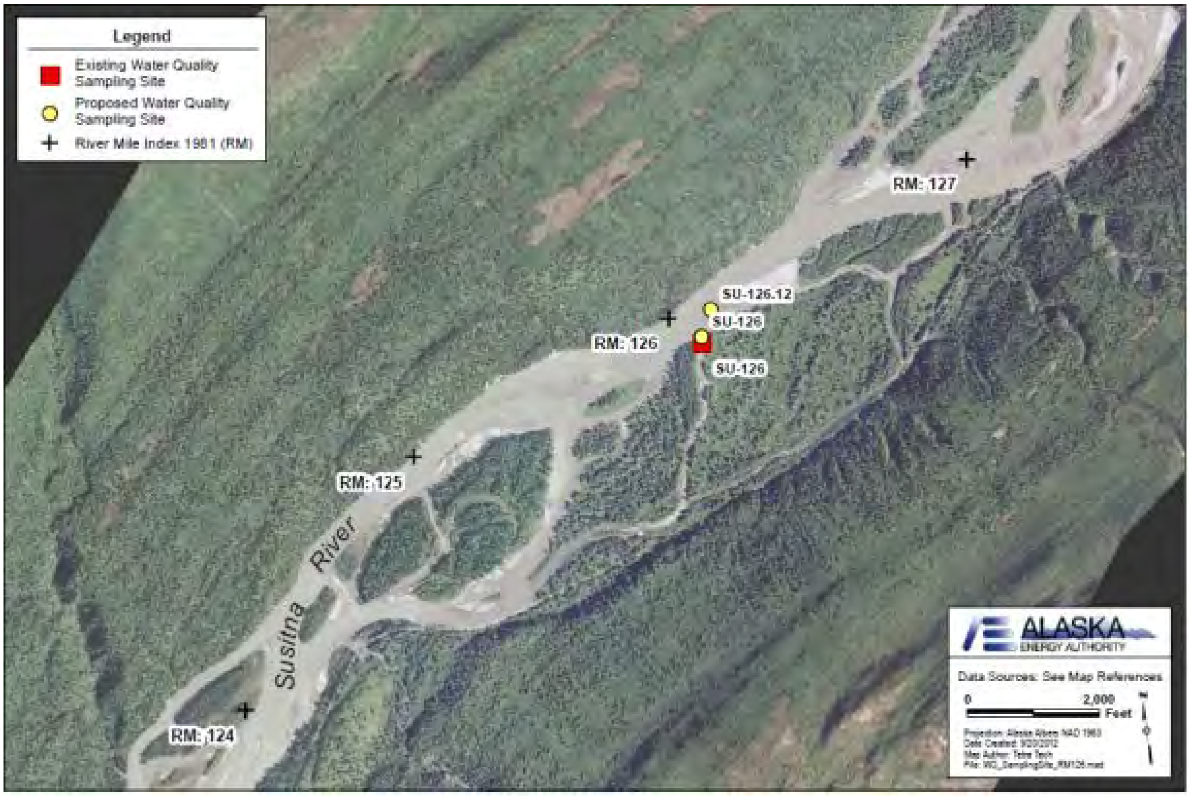

Figure A-15. Map of site LRX 29 at RM 126.1

Figure A-16. Map of site Slough 9 at RM 129.2

Figure A-17. Map of site LRX 35 at RM 130.8

Figure A-18. Map of site Susitna near Gold Creek at RM 136.5

Figure A-19. Map of site Gold Creek at RM 136.8

Figure A-20. Map of site Slough 16B at RM 138

Figure A-21. Map of site Indian River at RM 138.6

Figure A-22. Map of site Susitna above Indian River at RM 138.7

Figure A-23. Map of site Slough 19 at RM 140

Figure A-24. Map of site LRX 53 at RM 140.1

Figure A-25. Map of site Slough 21 at RM 142

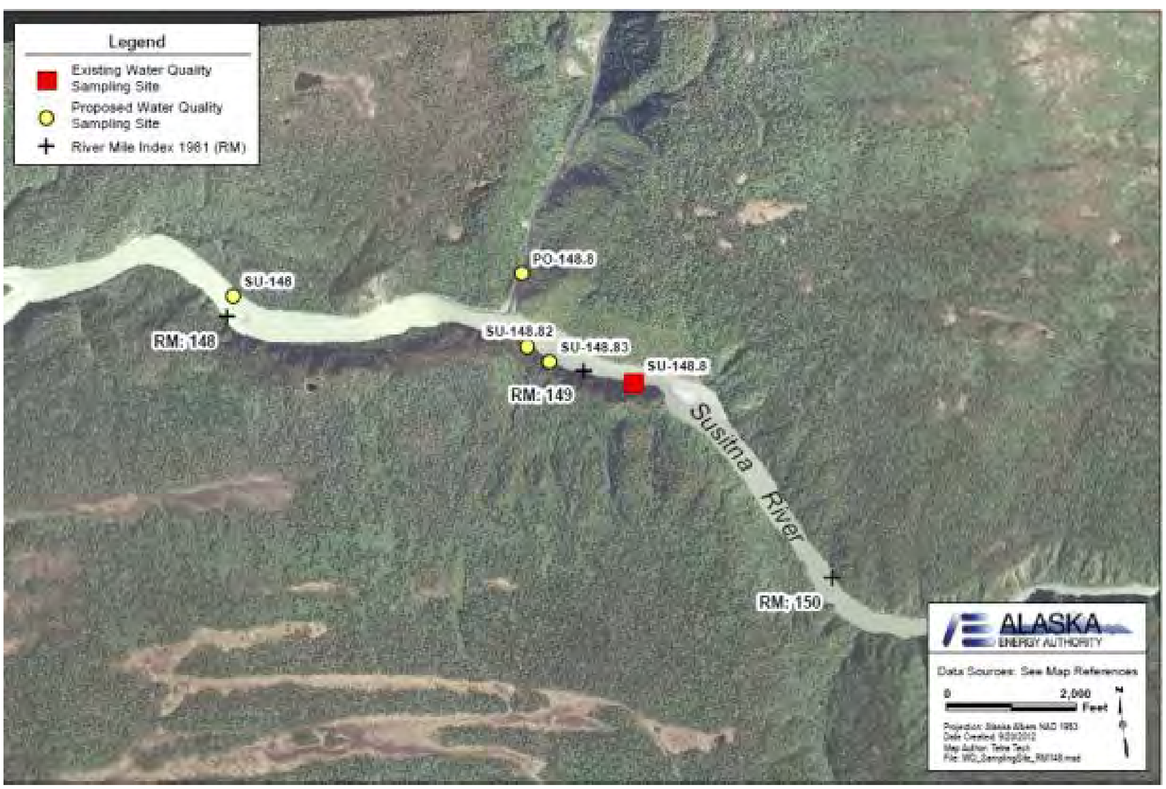

Figure A-26. Map of site Susitna below Portage Creek at RM 148

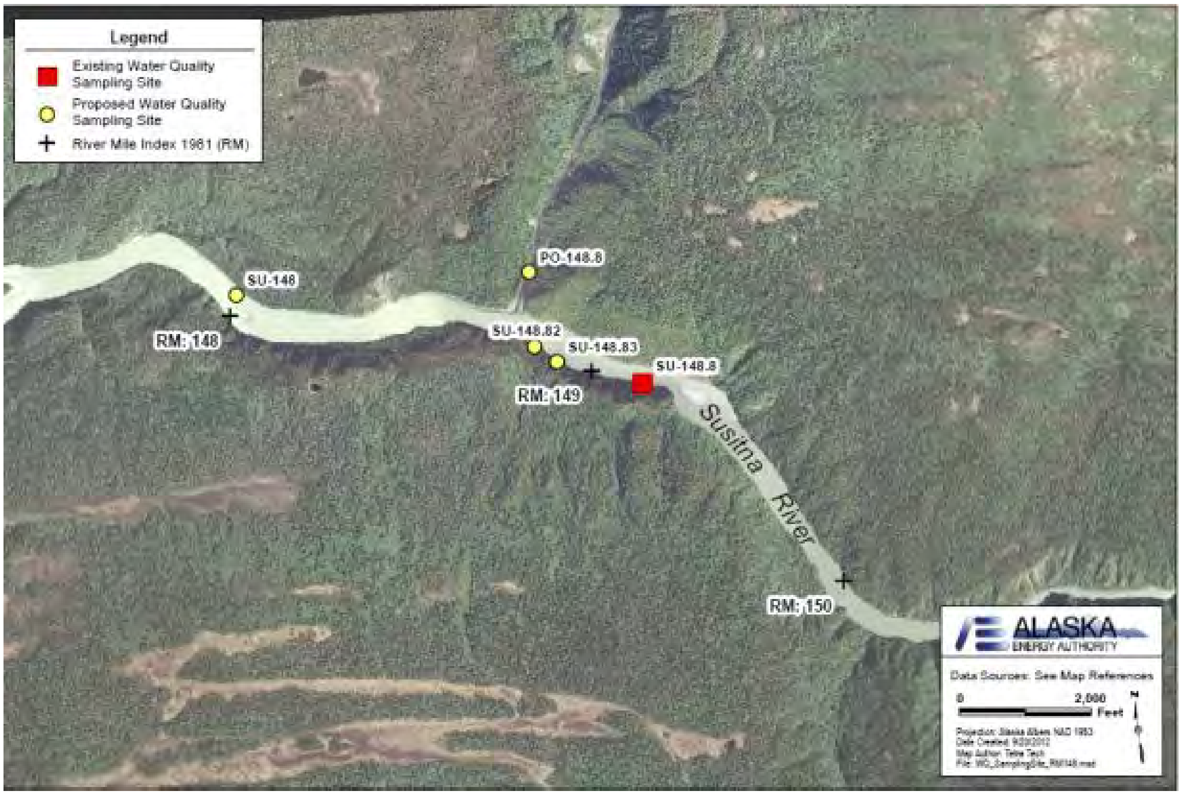

Figure A-27. Map of site Susitna above Portage Creek at RM 148.8

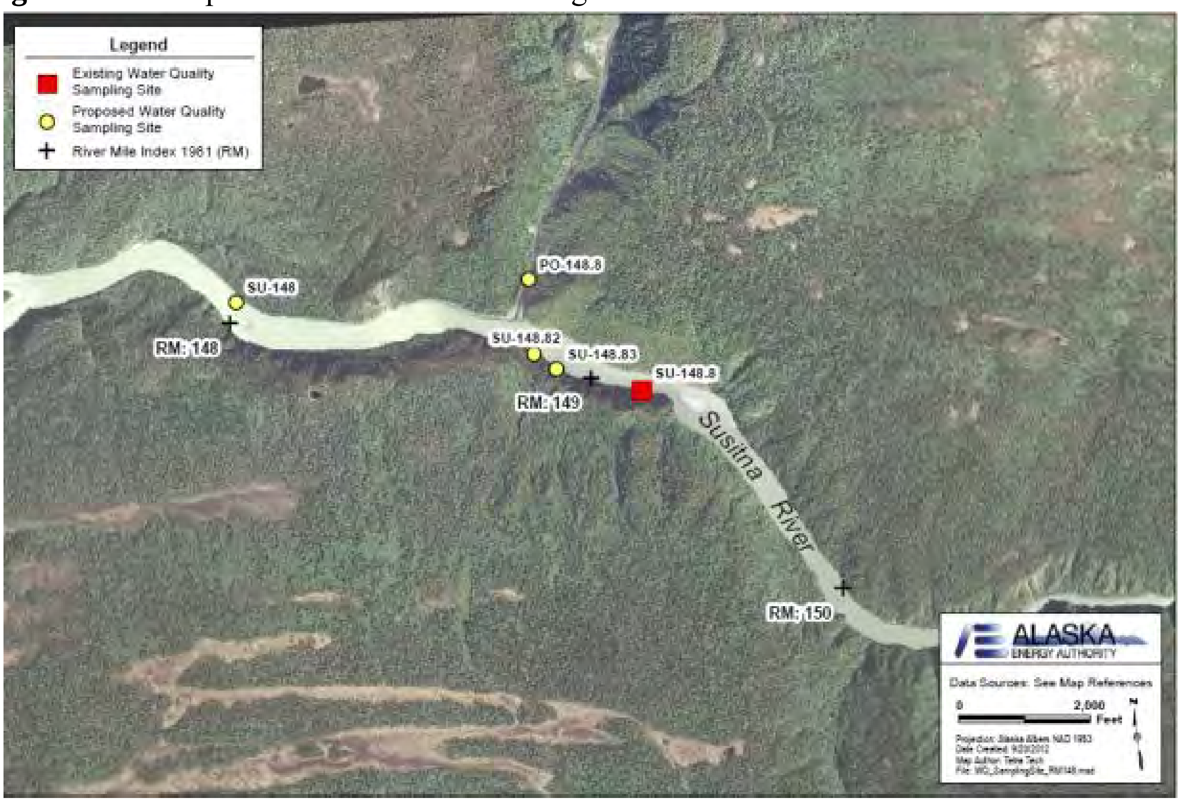

Figure A-28. Map of site Portage Creek at RM 148.8

Figure A-29. Map of site Susitna at RM 165

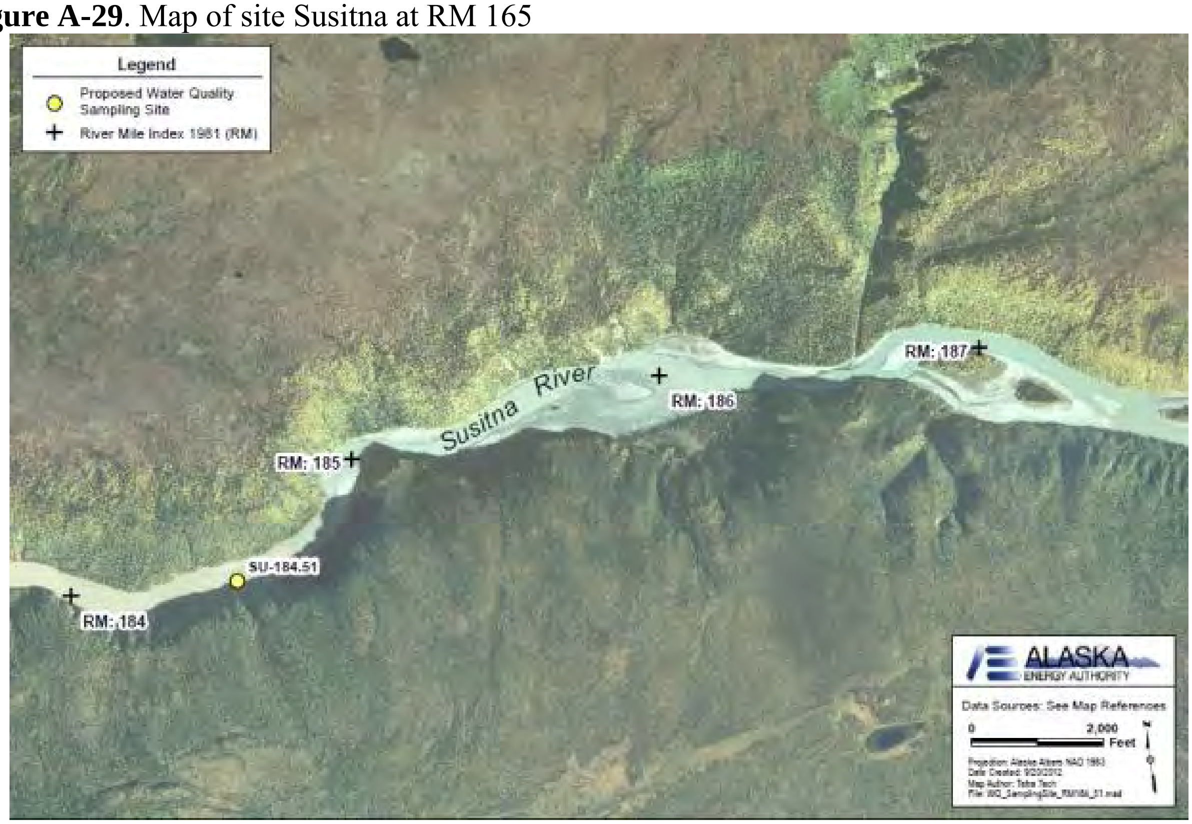

Figure A-30. Map of site Susitna at Watana Dam at RM 184.5

Figure A-31. Map of site Watana Creek at RM 194.1

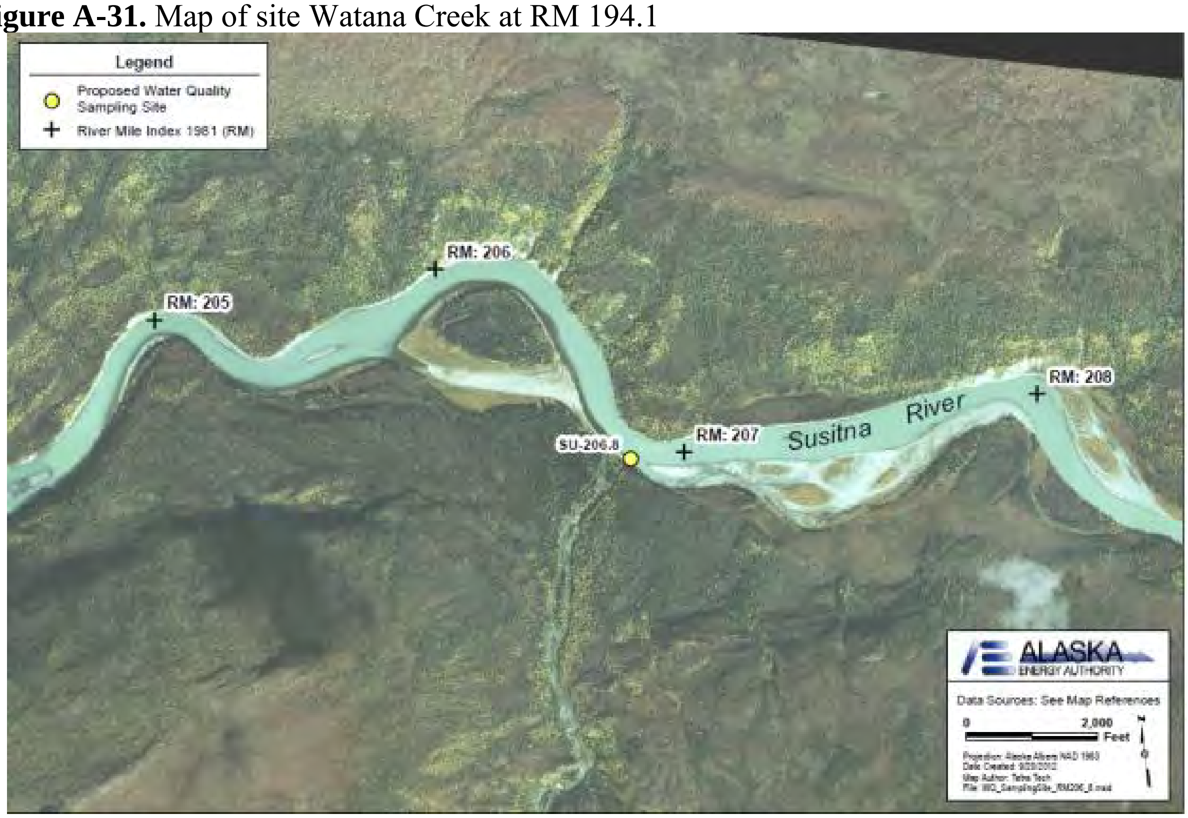

Figure A-32. Map of site Kosina Creek at RM 206.8

Figure A-33. Map of site Susitna near Cantwell at RM 223.7

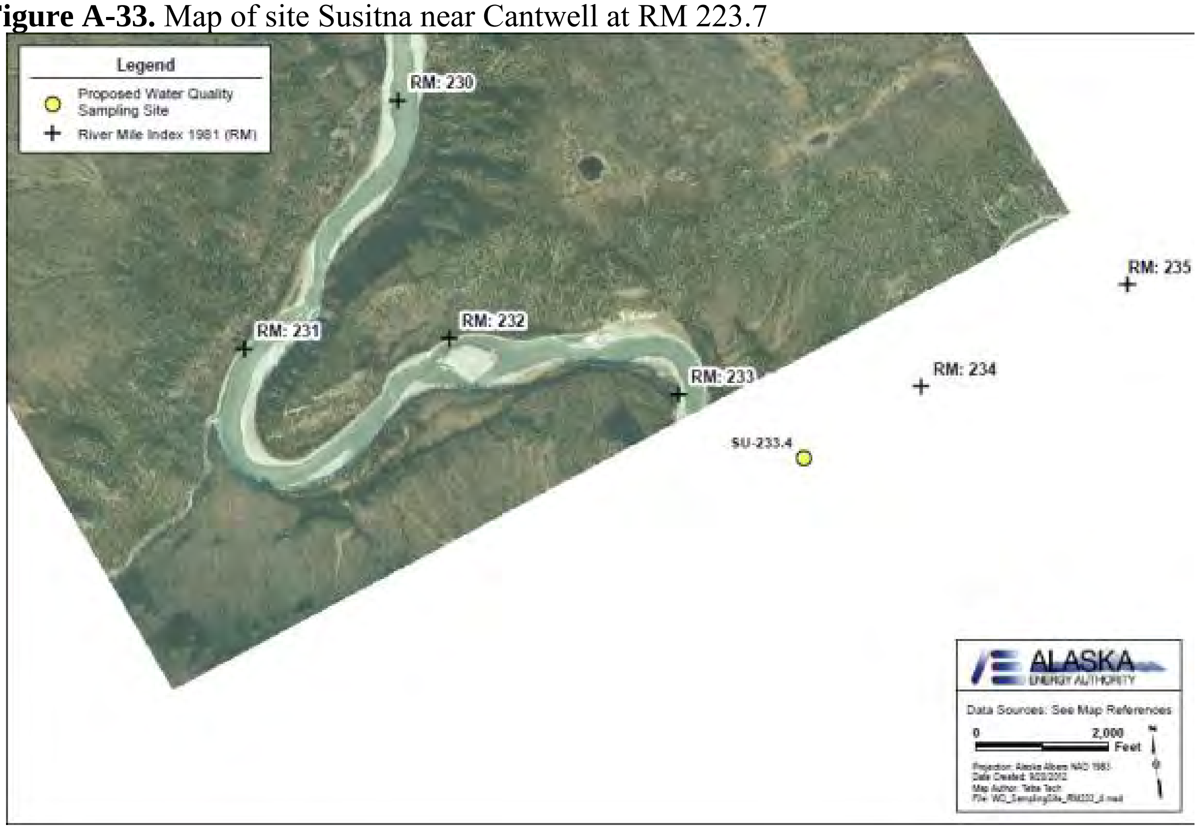

Figure A-34. Map of site Oshetna Creek at RM 233.4

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APPENDIX B: Temperature Probe Field Data Forms

a. **Temperature Logger Calibration Check Form**
b. **Field Deployment Form**

Date: __________

Temperature Logger Calibration Check Form

Technicians:

____

	Time	NIST SN-	Thermistor #	Red Liquid SN-	SN-	SN-
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

	Time	NIST SN-	Thermistor #	Red Liquid SN-	SN-	SN-
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

ATTACHMENT 5-2

WATER QUALITY MODELING STUDY
SAMPLING AND ANALYSIS PLAN (SAP) / QUALITY ASSURANCE PROJECT PLAN (QAPP)

Sampling and Analysis Plan/Quality Assurance Project Plan

for the

Susitna – Watana Hydroelectric Project

Water Quality Modeling Study
Susitna River, Southcentral Alaska

FERC Project No. 14241

Contract No. AEA-11-025

Prepared for:

Alaska Energy Authority
813 West Northern Lights
Anchorage, AK 99503

Prepared by:

URS/Tetra Tech, Inc.
700 G Street, Suite 500
Anchorage AK, 99501

November 7, 2012
QAPP 352, Revision 0

This quality assurance project plan (QAPP) has been prepared according to guidance from the Alaska Department of Environmental Conservation and *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5, EPA/240/B-01/003, U.S. Environmental Protection Agency (EPA), Quality Assurance Division, Washington, DC, March 2001 [Reissued May 2006]) to ensure that environmental and related data collected, compiled, and/or generated for this project are complete, accurate, and of the type, quantity, and quality required for their intended use. Tetra Tech will conduct work in conformance with the quality assurance program described in the quality management plan for Tetra Tech's Fairfax Group and with the procedures detailed in this QAPP.

Approvals:

Betsy McGregor Assistant Director Alaska Energy Authority	Date	Paul Dworian Principal Manager URS Corporation	Date
Robert Plotnikoff Technical Lead Tetra Tech, Inc.	Date	Andrew Parker TMDL Modeling Manager Tetra Tech, Inc.	Date
Harry Gibbons, Ph.D. Project Manager Tetra Tech, Inc.	Date	John Hamrick, Ph.D. Principal Modeler Tetra Tech, Inc.	Date
Gene Welch QA Officer Tetra Tech, Inc.	Date	Susan Lanberg QA Officer Tetra Tech, Inc.	Date

Contents

RECONCILIATION WITH USER REQUIREMENTS

ACRONYMS AND ABBREVIATIONS

AEA	Alaska Energy Authority
°C	degrees Celsius
cm	centimeters
DO	Dissolved oxygen
DQI	Data quality indicators
DQO	Data Quality Objectives
EPA	Environmental Protection Agency
g	grams
m	meter(s)
µS/cm	microSiemens per centimeter
mg/L	milligrams per liter
NPS	Nonpoint source
PDF	Portable Document Format
PM	Project Manager
QA	Quality assurance
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QAPP	Quality assurance project plan
QC	Quality control
QCO	Quality Control Officer
RPD	Relative percent difference
RSD	Relative standard deviation
SFPR	South Fork Palouse River
SOP	Standard Operating Procedure
TMDL	Total Maximum Daily Load
TL	Technical Lead
Tt	Tetra Tech, Inc.

DISTRIBUTION

This document will be distributed to the following people who are involved in this project, as well as to all responsible subcontractors.

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A. PROJECT MANAGEMENT ELEMENTS

A 1.0 PROJECT/TASK ORGANIZATION

The Alaska Energy Authority (AEA) is preparing a License Application that will be submitted to the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project (Project). The application will use the Integrated Licensing Process (ILP). The Project is located on the Susitna River, an approximately 300 mile long river in the South-central region of Alaska. The Project's dam site will be located at River Mile (RM) 184. The results of this study and of other proposed studies will provide information needed to support the FERC's National Environmental Policy Act (NEPA) analysis for the Project license.

Construction and operation of the Project as described in the Pre-Application Document (PAD, AEA 2011) is expected to change some of the water quality characteristics of the resulting riverine portion of the drainage downstream of the dam site as well as the inundated area that will become the reservoir. This study plan outlines the objectives and methods for developing a modeling framework that will adequately characterize water quality and stream temperatures in the Susitna River within and downstream of the proposed Project area.

The purpose of this document is to present the quality assurance project plan (QAPP) for developing water quality model(s) based on calibration data collected in the Baseline Water Quality Study of the Susitna River (Section 5.5 of the Revised Study Plan). A modeling team comprised of scientists and engineers from Tetra Tech's (Tt) Fairfax, Virginia and Seattle, Washington offices will calibrate then conduct modeling of both the riverine and reservoir environments.

This QAPP provides general descriptions of the work to be performed to develop and apply models and to ensure that objectives are met and that procedures will be used to ensure results are scientifically valid and defensible and that uncertainty in the model has been reduced to a known and practical minimum through a sensitivity analysis.

The organizational aspects of a program provide the framework for conducting tasks. The organizational structure can also facilitate project performance and adherence to quality control (QC) procedures and quality assurance (QA) requirements. Key project roles are filled by those persons responsible for ensuring the precision and accuracy related to model development and application. The key personnel involved in the Water Quality Modeling Study of the Susitna River are listed in Table A1-1.

Table A1-1. Project/Task Organization and Responsibility Summary

Personnel	Responsibility	Address/E-Mail	Phone Number
Betsy McGregor	Responsible for project coordination with local, county, state, and federal government officials; and for reviewing drafts of the study plan, QAPP and summary data reports	Alaska Energy Authority 813 W Northern Lights Blvd Anchorage, AK 99503 bmcgregor@aidea.org	907-771-3957
Paul Dworian	Responsible for directing daily project activities and tracking product delivery. Communicates with AEA Environmental Manager on project schedule and timing for product delivery.	URS Corporation 700 G Street, Suite 500 Anchorage, AK 99501 paul_dworian@urs.com	907-261-6735
Robert Plotnikoff	Responsible for preparing the project QAPP and providing input for modeling and preparation of the draft and final data reports.	Tetra Tech, Inc. 1420 5th Ave. Suite 550 Seattle, WA 98101 robert.plotnikoff@tetratech.com	206-728-9655
Andrew Parker	Serves as the Modeling Manager and is responsible for providing input for the QAPP, coordinating modeling efforts and secondary data collection, and preparing the draft and final reports.	Tetra Tech, Inc. 10306 Eaton Place, Suite 340 Fairfax, VA 22030 andrew.parker@tetratech.com	703-385-6000
John Hamrick, Ph.D.	Serves as the Principal Modeler and is responsible for developing the hydrodynamic, temperature, and water quality model.	Tetra Tech, Inc. 10306 Eaton Place, Suite 340 Fairfax, VA 22030 john.hamrick@tetratech.com	703-385-6000
Harry Gibbons, Ph.D.	Serves as the Project Manager and is responsible for managing the project, overseeing preparation of the project QAPP, reviewing analysis of project data, and review of the draft and final data reports. Serves as the principal project team contact for the technical aspects of the study	Tetra Tech, Inc. 1420 5th Ave. Suite 550 Seattle, WA 98101 harry.gibbons@tetratech.com	206-728-9655
Susan Lanberg	Serves as the Quality Assurance Officer and is responsible for providing support to the Tt Project Manager in preparing and	Tetra Tech, Inc. 10306 Eaton Place, Suite 340 Fairfax, VA 22030 susan.lanberg@tetratech.com	703-385-6000

	distributing the QAPP; reviewing and approving the QAPP; and monitoring QC activities to determine conformance		
Gene Welch	Provides technical assistance on QA/QC issues during the implementation and assessment of the project. Determines the applicability of model results in comparing against effects to aquatic life.	Tetra Tech, Inc. 1420 5th Ave. Suite 550 Seattle, WA 98101 gene.welch@tetratech.com	206-728-9655

Additional technical staff will be responsible for conducting specific tasks during the project (e.g., secondary data collection, model configuration, model calibration, model validation, model scenario analysis, and reporting) at the direction and discretion of the Modeling Manager. The Modeling Manager will supervise the technical staff participating in the project, including implementing the QC program, completing assigned work on schedule with strict adherence to procedures established in the approved QAPP, and completing required documentation. The Modeling Manager will direct the work of the modeling team including secondary data collection, model configuration, model calibration, model validation, model scenario analysis, and reporting. They must perform all work in adherence with the project work plan and QAPP.

Additional oversight will be provided by the QC Officers (QCO), who are responsible for performing evaluations to ensure that QC is maintained throughout the sampling process, that the data collected will be of optimal validity and usability, and that limitations of the data set are minimized as much as is possible. The QCO is any senior technical staff assigned the responsibility of providing a second-level review of all documentation and records developed. The QC evaluations will include double-checking work as it is completed and providing written documentation of these reviews (minimally initialing and dating documents as they are reviewed) to ensure that the standards set forth in the QAPP are met or exceeded. Other QA/QC staff, such as technical reviewers and technical editors selected as needed, will provide peer review oversight on the content of work products and ensure that work products comply with the client’s specifications.

Technical staff involved with the program will be responsible for reading and understanding this QAPP and complying with and adhering to its requirements in executing their assigned tasks relative to this project.

A 2.0 PROBLEM DEFINITION/BACKGROUND

Construction and operation of the Project as described in the Pre-Application Document (PAD, AEA 2011) is expected to change some of the water quality characteristics of the resulting riverine portion of the drainage downstream of the dam site as well as the inundated area that will become the reservoir.

The study area includes the Susitna River within the proposed Watana Reservoir and downstream of the proposed Watana Dam. Water quality studies will be conducted from river mile 15.1 (Susitna River above Alexander Creek) to river mile 233.4 (at Oshetna Creek, just above the upper extent of the proposed reservoir area) and within select tributaries. The proposed dam would be located at river mile 184.5. The dam would create a reservoir 42.5 miles long and 1 to 2 miles wide, with a normal reservoir surface area of approximately 23,546 acres and a normal maximum pool elevation of 2,050 feet.

The collective goal of the water quality studies is to assess the impacts of the proposed Project operations on water quality in the Susitna River basin with particular reference to state water quality standards. Predicting the potential impacts of the dam and its proposed operations on water quality will require the development of a water quality model. The goal of the Water Quality Modeling Study will be to utilize the extensive information collected from the Baseline Water Quality Study to develop a model(s) in which to evaluate the potential impacts of the proposed Project and operations on various physical parameters within the Susitna River watershed.

There are a large number of water quality models available for use on the Susitna-Watana Project. Selection of the appropriate model is based on a variety of factors, including cost, data inputs, model availability, time, licensing participant familiarity, ease of use, and available documentation. Under the current study, a multi-dimensional model capable of representing reservoir flow circulation, temperature stratification, and dam operations among other parameters is necessary. The proposed model must account for water quality conditions in the proposed Susitna-Watana Reservoir, including temperature, dissolved oxygen (DO), suspended sediment and turbidity, chlorophyll a, nutrients, and metals; and water quality conditions in the Susitna River downstream of the proposed dam. The model must also simulate current Susitna River baseline conditions (in the absence of the dam) for comparison to conditions in the presence of the dam and reservoir.

In the 1980s, hydrologic and temperature modeling was conducted in the Susitna River basin to predict the effects of one or more dams on downstream temperatures and flows. The modeling suite used was called H2OBAL/SNTEMP/DYRESM. The modeling suite addressed temperature and had some limited hydrodynamic representation, but it lacked the ability to predict vertical stratification or local effects. In addition, the modeling suite lacked a water quality modeling component.

A 3.0 PROJECT/TASK DESCRIPTION

The collective goal of the water quality studies is to assess the impacts of the proposed Project operations on water quality in the Susitna River basin with particular reference to state water quality standards. Predicting the potential impacts of the dam and its proposed operations on water quality will require the development of a water quality model. The goal of the Water Quality Modeling Study will be to utilize the extensive information collected from the Baseline Water Quality Study to develop a model(s) to evaluate the potential impacts of the proposed Project and operations on various physical parameters within the Susitna River watershed.

The Water Quality Modeling Study for the Susitna River will begin November 2012 and continue through December 2014. Table A3-1 gives the projected schedule of activities and deliverables.

Table A3-1. Schedule for the Water Quality Modeling Study Elements and Production of Associated Deliverables

Modeling Activity	Timeline
Coordination with water quality data collection and analysis	4Q 2012 – 1Q 2014
Model Evaluation/Selection	3Q 2012
Model Calibration (Water Quality)	3Q 2013 – 4Q 2013
Initial Study Report	1Q 2014
Re-calibration adjustments	2Q 2014 – 3Q 2014
Verification runs	3Q - 2014
Generate Results for Operational Scenarios	2Q 2014 – 4Q 2014
Updated Study Report	1Q 2015

A 4.0 DATA QUALITY OBJECTIVES AND CRITERIA

Data quality objectives (DQOs) are qualitative and quantitative statements that are used in the project planning and implementation to clarify the intended use of the data, define the type of data needed to support the decision, identify the conditions under which the data should be collected, and specify tolerable limits on the probability of making a decision error because of uncertainty in the data (if applicable). Data users develop DQOs to specify the data quality needed to support specific decisions. Project quality objectives and criteria for measurement data will be addressed in the context of the two tasks discussed above: (1) evaluating the quality of the data used, and (2) assessing the results of the model application.

Sections 4.1 through 4.7 describe DQOs and criteria for model inputs and outputs for this project, written in accordance with the seven steps described in EPA's *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4) (USEPA 2006b).

A4.1 State the Problem

Construction and operation of the Project as described in the Pre-Application Document (PAD, AEA 2011) is expected to change some of the water quality characteristics of the resulting riverine portion of the drainage downstream of the dam site as well as the inundated area that will become the reservoir.

The study area includes the Susitna River within the proposed Watana Reservoir and downstream of the proposed Watana Dam. Water quality studies will be conducted from river mile 15.1 (Susitna River above Alexander Creek) to river mile 233.4 (at Oshetna Creek, just above the upper extent of the proposed reservoir area) and within select tributaries. The proposed dam would be located at river mile 184. The dam would create a reservoir 42.5 miles long and 1 to 2 miles wide, with a normal reservoir surface area of approximately 23,546 acres and a normal maximum pool elevation of 2,050 feet.

The collective goal of the water quality studies is to assess the impacts of the proposed Project operations on water quality in the Susitna River basin with particular reference to state water quality standards. Predicting the potential impacts of the dam and its proposed operations on water quality will require the development of a water quality model.

A4.2 Identify the Study Question

The goal of the Water Quality Modeling Study will be to utilize the extensive information collected from the Baseline Water Quality Study to develop a model(s) in which to evaluate the potential impacts of the proposed Project and operations on various physical parameters within the Susitna River watershed.

The objectives of the Water Quality Modeling Study are as follows:

- With input from licensing participants, implement an appropriate reservoir and river water temperature model for use with past and current monitoring data.
- Using the data developed in Section 5.5 (Baseline Water Quality Study) and 7.6 (Ice Processes Study) in the Revised Study Plan, model water quality conditions in the

proposed Watana Reservoir, including (but not necessarily limited to), temperature, DO, suspended sediment and turbidity, chlorophyll-a, nutrients, ice, and metals.

- Model water quality conditions in the Susitna River from the proposed site of the Watana Dam downstream, including (but not necessarily limited to) temperature, suspended sediment and turbidity, and ice processes (in coordination with the Ice Processes Study).

Concentrations of water quality parameters including metals in sediment immediately below the proposed Project are unknown. Metals in these sediments may become mobile once the Project begins operation. Monitoring information in the immediate vicinity of the reservoir and riverine habitat will be important for developing two models (reservoir and riverine) and coupled for predicting expected water quality conditions below the proposed dam.

A4.3 Identify Information Needs

Review of existing water quality and sediment transport data revealed several gaps that present challenges for calibrating a water quality model (URS 2011). Analysis of existing data was used to identify future studies needed to develop the riverine and reservoir water quality models and to eventually predict pre-Project water quality conditions throughout the drainage. Some general observations based on existing data are as follows:

- Large amounts of data were collected during the 1980s. A comprehensive data set for the Susitna River and tributaries is not available.
- The influence of major tributaries (Chulitna and Talkeetna rivers) on Susitna River water quality conditions is unknown. There are no monitoring stations in receiving water at these mainstem locations.
- Continuous temperature data and seasonal water quality data are not available for the Susitna River mainstem and sloughs potentially used for spawning and rearing habitat.

A4.4 Specify the Characteristics that Define the Population of Interest

Tetra Tech will use extensive information collected from the Baseline Water Quality Study to develop a model(s) in which to evaluate the potential impacts of the proposed Project and operations on various physical parameters within the Susitna River watershed . Specifically, Tetra Tech will use hydrodynamic models coupled to water quality models to simulate coupled physical, chemical, and biological processes.

In most cases, the statistical criteria for loads and concentrations are detailed in the error discussion in Section 4.6.

A4.5 Develop the Strategy for Information Synthesis

Tetra Tech will use a systematic planning process to develop models for evaluating the potential impacts of the proposed Project and operations on various physical parameters within the Susitna River watershed. That process takes into account the accuracy and precision needed for the models to predict a given quantity at the application site of interest to satisfy regulatory objectives.

Acceptance criteria that result from systematic planning address the following types of components for modeling projects. Criteria used in selecting the appropriate model will be documented in the modeling reports and typically include the following:

- Technical criteria (concerning the requirements for the model's simulation of the physical system)
- Regulatory criteria (concerning constraints imposed by regulations, such as WQSs)
- User criteria (concerning operational or economic constraints, such as hardware/software compatibility)

The Tetra Tech Modeling Manager compared available models to select the most ones to use for this study. In addition, existing model programming language can be converted into a different programming language to enhance software compatibility. The models that will be used are

A4.6 Specify Performance and Acceptance Criteria

Quantitative measures, sometimes referred to as calibration criteria, include the *relative error* between model predictions and observations. The relative error is the ratio of the absolute mean error to the mean of the observations and is expressed as a percent.

Models will be deemed acceptable when they are able to simulate field data within predetermined statistical measures. A variety of performance targets have been documented in the literature, including Donigian (2000). Specific targets will be specified once the data have been reviewed and the model initially configured.

Table 4. Statistical Measures for Model Comparisons (Donigian 2000)

State Variable	**Percent Difference between Simulated and Observed Values**		
	Very Good	Good	Fair
Salinity	<15	15-25	25-40
Water Temperature	<7	8-12	13-18
Water Quality / Dissolved Oxygen	<15	15-25	25-35
Nutrients / Chlorophyll a	<30	30-45	45-60

An overall assessment of the success of the calibration can be expressed using calibration levels.

- Level 1: Simulated values fall within the target range (highest degree of calibration).
- Level 2: Simulated values fall within two times the associated error of the calibration target.
- Level 3: Simulated values fall within three times the associated error of the calibration target.
- Level 4: Simulated values fall within *n* times the associated error of the calibration target (lowest degree of calibration).

The model will be considered calibrated when it reproduces data within an acceptable level of accuracy determined in consultation with AEA and stakeholder agencies.

A4.7 Optimize the Design for Obtaining and Generating Adequate Data or Information

The data requirements of this project encompass aspects of both laboratory analytical results obtained as secondary data and database management to reduce sources of errors and uncertainty in the use of the data. Data commonly required for populating a database to supply data for calibrating a model are listed in Table 6.

Table 6. Secondary environmental data to be collected for the Susitna – Watana Hydroelectric Project Water Quality Modeling Study

Data type	Example measurement endpoint(s) or units
Geographic or location information (typically in Geographic Information System [GIS] format)	
Topography (stream networks, watershed boundaries, contours, or digital elevation)	Elevation in feet and meters (North American Vertical Datum of 1988; NAVD88); percent slope
Water quality and biological monitoring station locations	Latitude and longitude, decimal degrees (North American Datum 1983; NAD83)
Meteorological station locations	Latitude and longitude, decimal degrees (NAD83)
Permitted facility locations	Latitude and longitude, decimal degrees (NAD83)
Impaired waterbodies (georeferenced 2009 303(d)-listed AUs)	Latitude and longitude, decimal degrees (NAD83)
Dam locations	Latitude and longitude, decimal degrees (NAD83)
Flow	
Historical record (daily, hourly, 15-minute interval)	Cubic feet per second (cfs)
Dam release flow records	Cfs
Peak flows	Cfs
Meteorological data	
Rainfall	Inches
Temperature	°C
Wind speed	Miles per hour
Dew point	°C
Humidity	Percent or grams per cubic meter
Cloud cover	Percent
Solar radiation	Watts per square meter
Water quality (surface water, groundwater)	
Chemical monitoring data	Milligrams per liter (mg/L)
Discharge Monitoring Report	Discharge characteristics including flow and chemical composition
Permit Limits	mg/L
Regulatory or policy information	
Applicable state water quality standards	mg/L

Data type	Example measurement endpoint(s) or units
EPA water quality standards	mg/L

Secondary data will be downloaded electronically from various sources to reduce manual data entry whenever possible. Secondary data will be organized into a standard model application database. A screening process will be used to scan through the database and flag data that are outside typical ranges for a given parameter.

Tetra Tech documents all data sources, including full reference citations in a bibliography and parenthetical references in report text. Tetra Tech also maintains paper and electronic copies of all references. Documentation for all data sources (i.e., full bibliographical information and metadata where appropriate) will be collected and recorded.

A 5.0 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

This QAPP and supporting materials will be distributed to all participants. The Modeling Manager will conduct a procedural review before the modeling team begins work. The procedural review will include the requirements of the QAPP and Revised Study Plan. All relevant project personnel will have experience in water quality modeling.

A 6.0 DOCUMENTATION AND RECORDS

The Tetra Tech Project Manager will distribute the QAPP to all participants. The Tetra Tech Project Manager and Modeling Manager will maintain files, as appropriate, as repositories for information and data used in preparing any reports and documents during the project and will supervise the use of materials in the project files. The following information will be included:

- Any reports and documents prepared
- Contract and Task Order information
- Project QAPP
- Results of technical reviews, data quality assessments, and audits
- Communications (memoranda; internal notes; telephone conversation records; letters; meeting minutes; and all written correspondence among the project team personnel, subcontractors, suppliers, or others)
- Maps, photographs, and drawings
- Studies, reports, documents, and newspaper articles pertaining to the project
- Special data compilations
- Spreadsheet data files: physical measurements, analytical chemistry data (hard copy and disk)

The model application will include complete record keeping of each step of the modeling process. The documentation will consist of reports and files addressing the following items:

- Assumptions
- Parameter values and sources

- Nature of grid, network design, or subwatershed delineation
- Changes and verification of changes made in code
- Actual input used
- Output of model runs and interpretation
- Calibration and performance of the model(s)

Modeling reports will be subject to technical and editorial review before submission to Alaska Energy Authority and will be maintained at Tt's Seattle, Washington office in the central file (disk and hard copy).

If any change(s) in this QAPP are required during the study, a memo will be sent to each person on the distribution list describing the change(s), following approval by the appropriate persons. The memos will be attached to the QAPP. Unless other arrangements are made, records will be maintained for a minimum of 5 years following expiration of the contract.

B. MODEL IMPLEMENTATION

B 1.0 MODELING DESIGN

This QAPP is prepared as part of the implementation of the 2013-2014 Water Quality Modeling Study Plan. The QAPP is standard documentation prepared before any water model development begins. These documents follow guidelines for the State of Alaska and U.S. Environmental Protection Agency Region 10 Credible Data Policy (ADEC 2005). The following sections document how the model will be developed and post-Project water quality conditions within the Susitna River basin can be characterized.

Model Selection

This section assesses potential water quality models and identifies key considerations for the selection of the appropriate modeling platform. In coordination with licensing participants, a final modeling platform will be selected and implemented.

For the current project, the model will need to be capable of simulating both river and reservoir environments. It must also be a multi-dimensional dynamic model that includes hydrodynamics, water temperature, water quality, and sediment transport modules and considers ice formation and breakup. Ice dynamics evaluated in the Ice Processes Study will be used to inform the water quality model. Ice formation and breakup will have a profound impact on hydrodynamics and water quality conditions in the reservoir and riverine sections of the basin. Ice cover affects transfer of oxygen to and from the atmosphere and this directly impacts the dissolved oxygen concentration at points along the water column. The output from the ice study (Section 7.5 Revised Study Plan) will provide boundary conditions for the water quality model.

The model will be configured for the reservoir and internally coupled with the downstream river model. This will form a holistic modeling framework which can accurately simulate changes in the hydrodynamic, temperature, and water quality regime within the reservoir and downstream. A model for use in this study should feature an advanced turbulence closure scheme to represent vertical mixing in reservoirs, and be able to predict future conditions. Thus, it will be capable of representing the temperature regime within the reservoir without resorting to arbitrary assumptions about vertical mixing coefficients.

The model will need to have the ability to simulate an entire suite of water quality parameters, and the capacity for internal coupling with the hydrodynamic and temperature modeling processes. The model will be configured to simulate the impact of the proposed Project on temperature as well as DO, nutrients, algae, turbidity, TSS, and other key water quality features both within the reservoir and for the downstream river. This avoids the added complexity associated with transferring information among multiple models and increases the efficiency of model application.

Other important factors when selecting a water quality model include the following:

- The model and code are easily accessible and are part of the public domain.
- The model is commonly used and accepted by EPA and other public regulatory agencies.
- The water quality model will be available for current and future use and remain available for the life of the project and beyond (including upgraded versions).
- Model output can be compared to relevant ADEC water quality criteria (18 ACC 70.020(b)).

The following sections summarize the capabilities of models considered for use on this project.

H2OBAL/SNTEMP/DYRESM Model Review

The existing H2OBAL/SNTEMP/DYRESM model of the Susitna River basin is perhaps the most obvious candidate model to implement when assessing the effects of the originally proposed Project. The existing model was expressly configured to represent the unique conditions in the Susitna River basin. However, the modeling suite is limited to flow and temperature predictions. Hydrodynamics are simplified, and water quality is not addressed.

The Arctic Environmental Information and Data Center (AEIDC) previously completed a study that examined the temperature and discharge effects if the proposed Project was completed and compared the effects to the natural stream conditions, without a dam and reservoir system (AEIDC 1983a). The study also assessed the downstream point at which post-project flows would be statistically the same as natural flows. Multiple models were used in the assessment: SNTEMP, a riverine temperature model, H2OBAL, a water balance program and DYRESM, a reservoir hydrodynamic model.

The simulation period covered the years 1968 through 1982. Only the summer period was simulated, using historical meteorological and hydrological data to represent normal, maximum and minimum stream temperature conditions, represented by the years 1980, 1977, and 1970, respectively (AEIDC 1983a). Post-project modifications were applied to these summer periods to compare natural conditions to post-project stream temperatures. Due to a lack of data, a monthly time-step was used in these summer condition simulations.

Mainstem discharges from the Susitna-Watana Dam site were estimated from statistically-filled streamflow data and the H2OBAL program, which computes tributary inflow on a watershed area-weighted basis. Post-project flows were predicted for both a one-dam scenario and a two-dam scenario using release discharge estimates from a reservoir operation schedule scenario in the FERC license application. Flows derived from H2OBAL were input into SNTEMP.

SNTEMP is a riverine temperature simulation model that can predict temperature on a daily basis and for longer time periods. This allows for the analysis of both critical river reaches at a fine scale and the full river system over a longer averaging period (AEIDC 1983b). SNTEMP was selected because it contains a regression model that can fill in data gaps in temperature records. This is useful because data records in the Susitna River watershed are sparse. SNTEMP can also be calibrated to adjust for low-confidence input parameters. SNTEMP outputs include average daily water temperatures and daily maximum and minimum temperatures.

SNTEMP contains several sub-models, including a solar radiation model that predicts solar radiation based on stream latitude, time of year, topography, and meteorological conditions (AEIDC 1983b). SNTEMP was modified to include the extreme shading conditions that occur in the basin by developing a monthly topographic shading parameter. Modifications were also made to represent the winter air temperature inversions that occur in the basin. Sub-models are also included for heat flux, heat transport, and flow mixing.

SNTEMP validation indicated that upper tributary temperatures were under-predicted (AEIDC 1983b). Most of the data for the tributaries were assumed or estimated, leading to uncertainty. Five key poorly defined variables were identified as possible contributors to the under-prediction of temperatures: stream flow, initial stream temperature, stream length, stream width and distributed flow temperatures. Distributed flow temperatures were highlighted as the most important of the five variables. During calibration, groundwater temperature parameters were adjusted to modify distributed flow and improve tributary temperature prediction.

Water temperatures are derived from USGS gages, but when data was lacking, SNTEMP computed equilibrium temperatures and then estimated initial temperatures from a regression model. AEIDC noted that the reliability of the regression models "restricts the accuracy of the physical process temperature simulations" (1983a). The level of confidence in the regression model varies by the amount of gage data available. Continuous data yielded higher confidence, while years with only grab sample data notably decreased the confidence in the predicted temperatures.

The DYRESM model is a one-dimensional, hydrodynamic model designed specifically for medium size reservoirs (Patterson, et al. 1977). The size limitation ensures that the assumptions of the model algorithm remain valid. DYRESM predicts daily temperature and salinity variations with depth and the temperature and salinity of off-take supply. The reservoir is modeled as horizontal layers with variable vertical location, volume, temperature and salinity. Mixing between layers is through amalgamation. Inflow and withdrawal are modeled by changes in the horizontal layer thickness and insertion or removal of layers, as appropriate. The model incorporates up to two submerged off-takes and one overflow outlet. Model output is on a daily time-step.

The DYRESM model was run to simulate the reservoir scenario for 1981 conditions (AEIDC 1983a). Other reservoir release temperature estimates were not available. The AEIDC report cautions that the results from 1981 may not be representative of other years due to annual variations in meteorology, hydrology, reservoir storage, and power requirements. The lack of reservoir release temperature data limited the simulation of downstream temperatures under operational conditions to one year. AEIDC noted that the "effort to delineate river reaches where post-project flows differ significantly from natural flows has been unsuccessful" (AEIDC 1983a). This was attributed in large part to the lack of estimates for the reservoir release temperatures. Additional data was needed to increase the predictive ability of SNTEMP.

Perhaps the biggest limitations of the existing H2OBAL/SNTEMP/DYRESM modeling suite are the lack of suitable data, simplified hydrology and the lack of a water quality component. Modeling is limited to discharge and temperature. Other issues that limit the suitability of the modeling suite for the Water Quality Modeling Study are the chronic under-prediction of upper tributary temperatures, and the inability to predict vertical stratification within the reservoir.

Other Modeling Approaches

Two other modeling approaches may provide better results than the previously used H2OBAL/SNTEMP/DYRESM model. These are discussed below.

Two-Dimensional Approach (Ce-Qual-W2)

The U.S. Army Corps of Engineers' CE-QUAL-W2 model is a two-dimensional, longitudinal/vertical (laterally averaged), hydrodynamic and water quality model (Cole, et al. 2000). The model can be applied to streams, rivers, lakes, reservoirs, and estuaries with variable grid spacing, time-variable boundary conditions, and multiple inflows and outflows from point/nonpoint sources and precipitation.

The two major components of the model include hydrodynamics and water quality kinetics. Both of these components are coupled (i.e., the hydrodynamic output is used to drive the water quality output at every time-step). The hydrodynamic portion of the model predicts water surface elevations, velocities, and temperature. The water quality portion of the model can simulate 21 constituents including DO, suspended sediment, chlorophyll *a*, nutrients, and metals. A dynamic shading algorithm is incorporated to represent topographic and vegetative cover effects on solar radiation.

Three-Dimensional Approach (EFDC)

The Environmental Fluid Dynamics Code (EFDC) model was originally developed at the Virginia Institute of Marine Science and is considered public domain software (Hamrick 1992). This model is now being supported by EPA. EFDC is a dynamic, three-dimensional, coupled water quality and hydrodynamic model. In addition to hydrodynamic, salinity, and temperature transport simulation capabilities, EFDC is capable of simulating cohesive and non-cohesive sediment transport, near field and far field discharge dilution from multiple sources, eutrophication processes, the transport and fate of toxic contaminants in the water and sediment phases, and the transport and fate of various life stages of finfish and shellfish. The EFDC model has been extensively tested, documented, and applied to environmental studies world-wide by universities, governmental agencies, and environmental consulting firms.

The structure of the EFDC model includes four major modules: (1) a hydrodynamic model, (2) a water quality model, (3) a sediment transport model, and (4) a toxics model. The water quality portion of the model simulates the spatial and temporal distributions of 22 water quality parameters including DO, suspended algae (3 groups), periphyton, various components of carbon, nitrogen, phosphorus and silica cycles, and fecal coliform bacteria. Salinity, water temperature, and total suspended solids are needed for computation of the 22 state variables, and they are provided by the hydrodynamic model. EFDC incorporates solar radiation using the algorithms from the CE-QUAL-W2 model.

Qualitative Comparison of Models

Table B1-1 presents an evaluation of the models' applicability to a range of important technical, regulatory, and management considerations. Technical criteria refer to the ability to simulate the physical system in question, including physical characteristics/processes and constituents of interest. Regulatory criteria make up the constraints imposed by regulations, such as water quality standards or procedural protocol. Management criteria comprise the operational or economic constraints imposed by the end-user and include factors such as financial and technical resources. The relative importance of each consideration, as it pertains to the Project, are presented alongside the models' applicability ratings. Although the evaluation is qualitative, it is useful in selecting a model based on the factors that are most critical to this project.

Technical Considerations

The following discussion highlights some of the key technical considerations for modeling associated with the Susitna-Watana Project and compares the ability of CE-QUAL-W2 and EFDC to address these considerations. For informational purposes, the H2OBAL/SYNTEMP/DYRESM modeling suite is also discussed in the technical considerations. Based on a review of the literature, some key factors that will likely be important in the modeling effort include:

1. Predicting vertical stratification in the reservoir when the dam is present;
2. Nutrient and algae representation;
3. Sediment transport;
4. Ability to represent metals concentrations;
5. Integration between temperature and ice dynamics models; and
6. Capability of representing local effects.

Predicting Vertical Stratification

Both EFDC and CE-QUAL-W2 are equipped with turbulence closure schemes which allow prediction of temporally/spatially variable vertical mixing strength based on time, weather condition, and reservoir operations. Therefore, both are capable of evaluating the impact of dam/reservoir operations/climate change on reservoir stratification. In contrast, the existing H2OBAL/SYNTEMP/DYRESM model does not have the necessary predictive capability because vertical stratification is represented based on parameterization through calibration. Therefore, it cannot represent the response of vertical mixing features to the changes in external forces.

Nutrient and Algae Representation

Both EFDC and CE-QUAL-W2 are capable of simulating dynamic interactions between nutrients and algae in reservoirs and interactions between nutrients and periphyton in riverine sections. This is very important for addressing the potential impact of the proposed Project on water quality and ecology in the river. EFDC has better nutrient predictive capabilities due to its sediment diagenesis module, which simulates interactions between external nutrient loading and bed-water fluxes. EFDC is thus capable of predicting long-term effects of the proposed Project. CE-QUAL-W2 does not have such a predictive capability. The existing H2OBAL/SNTEMP/DYRESM modeling suite is not capable of representing nutrient and algae interactions.

Sediment Transport

EFDC is fully capable of predicting sediment erosion, transport, and settling/deposition processes. CE-QUAL-W2 has limited sediment transport simulation capabilities. It handles water column transport and settling; however, it is not capable of fully predicting sediment bed re-suspension and deposition processes. H2OBAL/SNTEMP/DYRESM is not capable of simulating sediment transport.

Ability to Represent Metals Concentrations

EFDC is fully capable of simulating fate and transport of metals in association with sediments in both rivers and reservoirs. CE-QUAL-W2 does not have a module to simulate metals; however, a simplified representation can be implemented using the phosphorus slot in the model and simple partitioning (to couple with its basic sediment transport representation). The H2OBAL/SNTEMP/DYRESM is not capable of addressing metals issues.

Integration between Temperature and Ice Dynamics Models

The CE-QUAL-W2 model has a coupled temperature-ice simulation module, which is of moderate complexity and predictive capability. EFDC has a slightly simpler ice representation which was previously applied to a number of Canadian rivers (e.g., Lower Athabasca River and the North Saskatchewan River in Alberta, Canada). Both models, however, can be coupled to external ice models with a properly designed interface to communicate temperature results. Fully predictive simulation within either model would require code modification to handle the interaction between temperature simulation, ice formation and transport, hydrodynamics simulation, and water quality simulation.

Capability of Representing Local Effects

CE-QUAL-W2 is a longitudinal-vertical two-dimensional model; therefore, it is capable of resolving spatial variability in the longitudinal and vertical directions. It is not capable of representing high resolution local effects such as lateral discharge, areas impacted by secondary circulation, or certain habitat characteristic changes. EFDC is a three-dimensional model which can be configured at nearly any spatial resolution to represent local effects. H2OBAL/SNTEMP/DYRESM is a one-dimensional modeling suite and therefore has limited capability representing local effects.

Reservoir and River Downstream of Reservoir Modeling Approach

Reservoir modeling will focus on the length of the river from above the expected area of reservoir inundation to the proposed dam location. It will involve first running the initial reservoir condition. This initial condition represents current baseline conditions in the absence of the dam. Subsequently, the model will represent the proposed reservoir condition, when the dam is in place. The reservoir representation will be developed based on the local bathymetry and dimensions of the proposed dam. It is recommended that a three-dimensional model be developed for the proposed reservoir to represent the spatial variability in hydrodynamics and water quality in longitudinal, vertical and lateral directions. The model will be able to simulate flow circulation in the reservoir, turbulence mixing, temperature dynamics, nutrient fate and transport, interaction between nutrients and algae, sediment transport, and metals transport. The key feature that needs to be captured is water column stratification during the warm season and the de-stratification when air temperatures cool down. The capability of predictively representing the stratification/de-stratification period is of critical importance for evaluating the impact of the dam since this is the critical water quality process in the reservoir.

With the dam in place, the original river will be converted into a slow flowing reservoir; therefore, any sediment previously mobilized will likely settle in the reservoir, disrupting the natural sediment transport processes. Before the construction of the dam, primary production is likely driven by periphyton. After construction of the dam, periphyton will be largely driven out of existence due to deep water conditions typical of a reservoir environment. In lieu of periphyton, phytoplankton will likely be the dominant source of primary production of the ecological system with the dam in place. Nutrients from upstream will have longer retention in the reservoir, providing nutrient sources to fuel phytoplankton growth. All processes would need to be predictively simulated by both the reservoir model and the pre-reservoir river model for the same river segment.

Because the dam is not in place when the model is constructed, proper calibration of the model using actual reservoir data is not possible. To achieve reasonable predictions of water quality conditions in the proposed reservoir, a literature survey will be conducted to acquire parameterization schemes of the model. An uncertainty analysis approach will also be developed to account for the lack of data for calibration, therefore enhancing the reliability of reservoir model predictions.

Downstream of the proposed dam location, a river model will also be developed to evaluate the effects of the proposed Project. It is anticipated that the same model platform used for the reservoir model will be implemented for the river model (at a minimum the two models will be tightly coupled). The river model will be capable of representing conditions in both the absence and presence of the dam. The downstream spatial extent of this model is yet to be determined, but it is likely it will extend to shortly downstream of the Susitna-Talkeetna-Chulitna confluence (e.g., Sunshine USGS Gage). If water quality modeling indicates that water quality effects extend into the lower river downstream of the initial modeling effort, then, as appropriate, water quality modeling will extend farther downstream. This would require additional channel topography and flow data at select locations in order to develop a model for predicting water quality conditions under various Project operational scenarios.

Flow, temperature, TSS, DO, nutrients, turbidity (continuous at USGS sites & bi-weekly at additional locations required for calibrating the model), and chlorophyll-a output from the reservoir model will be directly input into the downstream river model. This will enable downstream evaluation of potential impacts of the proposed Project on hydrodynamic, temperature, and water quality conditions.

The river model will be calibrated and validated using available data concurrently with the initial reservoir condition model (representing absence of the dam). Output from the models will be used directly in other studies (e.g., Ice Processes, Productivity, and Instream Flow studies).

The model will be calibrated in order to simulate water quality conditions for load following analysis. Organic carbon content from inflow sources will be correlated with mercury concentrations determined from the Baseline Water Quality Study discussed below. Predicted water quality conditions established by Project operations and that promote methylation of mercury in the bioaccumulative form will be identified by location and intensity in both riverine and reservoir habitats. Water temperature modeling and routing of fluctuating flows immediately prior to and during ice cover development may be conducted with a separate thermodynamics based ice process model (e.g., CRISSP 1D).

Table B1-1. Evaluation of models based on technical, regulatory, and management criteria

●High Suitability ◐ Medium Suitability ○ Low Suitability

Considerations	Relative Importance	H2OBAL/SNTEMP/DYRESM	CE QUAL W2	EFDC
Technical Criteria				
Physical Processes:				
• advection, dispersion	High	◐	●	●
• momentum	High	○	●	●
• compatible with external ice simulation models	High	○	●	●
• reservoir operations	High	◐	●	●
• predictive temperature simulation (high latitude shading)	High	◐	●	●
Water Quality:				
• total nutrient concentrations	High	○	●	●
• dissolved/particulate partitioning	Medium	○	●	●
• predictive sediment diagenesis	Medium	○	○	●
• sediment transport	High	○	◐	●
• algae	High	○	●	●
• dissolved oxygen	High	○	●	●
• metals	High	○	◐	●
Temporal Scale and Representation:				
• long term trends and averages	Medium	◐	◐	●
• continuous – ability to predict small time-step variability	High	○	●	●

●High Suitability ◐ Medium Suitability ○ Low Suitability				
Considerations	**Relative Importance**	**H2OBAL/SNTEMP/DYRESM**	**CE QUAL W2**	**EFDC**
Spatial Scale and Representation:				
• multi-dimensional representation	High	○	◐	●
• grid complexity - allows predictions at numerous locations throughout model domain	High	○	◐	●
• suitability for local scale analyses, including local discharge evaluation	Medium	○	◐	●
Regulatory Criteria				
Enables comparison to AK criteria	High	○	●	●
Flexibility for analysis of scenarios, including climate change	High	◐	●	●
Technically defensible (previous use/validation, thoroughly tested, results in peer-reviewed literature, TMDL studies)	High	◐	●	●
Management Criteria				
Existing model availability	High	●	●	●
Data needs	High	●	●	●
Public domain (non-proprietary)	High	●	●	●
Cost	Medium	●	◐	◐
Time needed for application	Medium	N/A	◐	◐
Licensing participant community familiarity	Low	●	◐	◐
Level of expertise required	Low	●	●	●
User interface	Low	◐	◐	◐
Model documentation	Medium	◐	●	●

B 2.0 MODEL CALIBRATION FREQUENCY

A model calibration is a measure of how well the model results represent field data. The use of a calibrated model, the scientific veracity of which is well defined, is of paramount importance.

The Tetra Tech Modeling Manager will direct the model calibration efforts. Some model parameters will need to be estimated using site-specific field data for the model's application. Some example parameters follow:

- Kinetic coefficients and parameters (e.g., partition coefficients, decay coefficients)
- Forcing terms (e.g., sources and sinks for state variables)
- Boundary conditions (specified concentrations, flows)

Models are often calibrated through a subjective trial-and-error adjustment of model input data because a large number of interrelated factors influence model output. The model calibration *goodness of fit* measure can be either qualitative or quantitative. Qualitative measures of calibration progress are commonly based on the following:

- Graphical time-series plots of observed and predicted data
- Graphical transect plots of observed and predicted data at a given time interval
- Comparison between contour maps of observed and predicted data, providing information on the spatial distribution of the error
- Scatter plots of observed versus predicted values in which the deviation of points from a 45-degree straight line gives a sense of fit
- Tabulation of measured and predicted values and their deviations

The EFDC model will be calibrated to the best available data, including literature values and interpolated or extrapolated existing field data. If multiple data sets are available, an appropriate period and corresponding data set will be chosen on the basis of factors characterizing the data set, such as corresponding weather conditions, amount of data, and temporal and spatial variability of data. The model will be considered calibrated when it reproduces data within an acceptable level of accuracy or approved by AEA.

Quantitative calibration measures include time series error measures, and other statistic based dimensionless performance indices. Quantitative measures allow comparison of the level of calibration and performance between modeling studies of different water bodies and different modeling studies of a specific water body. Time series error measures, particularly root mean square errors, are typically used to evaluate model performance with respect to predicting water surface elevation, temperature and salinity. The limits used will be documented in the modeling report.

As shown in the project schedule provided in Table A3-1, model calibration will be performed in the third and fourth quarters of 2013. This QAPP will be updated to include a description of modeling calibration before the third quarter of 2013.

B 3.0 NONDIRECT MEASUREMENT

Nondirect measurements are data that were previously collected under many different efforts outside of this project. Secondary data for this project will be in the form of electronic data sets and reports provided by ADEC and those data generated from the 1980s studies. All numeric data will be downloaded or received in electronic format, which the project team will directly download and use. Tetra Tech will perform general quality checks of the transfer of data from any source databases to another database, spreadsheet, or document. Someone other than the person who originally transferred the data will perform these checks.

B 4.0 DATA MANAGEMENT

The data management process and the computer hardware and software configuration requirements will be developed and submitted to the AEA technical team for review before model equations and related algorithms are coded into an integrated, efficient computer code. Modeling staff members will work closely with the Tetra Tech Modeling Manager and will consult with experts as necessary to ensure the theory is accurately represented in the code. The modeling code is continually checked by the developers and compared to bench test runs to ensure the accuracy of the mechanistic equations and solution techniques. A Modeling QC Officer will conduct internal reviews of the computer code.

C. ASSESSMENTS AND OVERSIGHT

C 1.0 ASSESSMENT AND RESPONSE ACTIONS

The QA program under which this task order will operate includes technical system audits. The essential steps in the QA program are as follows:

- Identify and define the problem
- Assign responsibility for investigating the problem
- Investigate and determine the cause of the problem
- Assign and accept responsibility for implementing appropriate corrective action
- Establish the effectiveness of and implement the corrective action
- Verify that the corrective action has eliminated the problem

Many of the technical problems that might occur can be solved on the spot by the staff members involved; for example, by modifying the technical approach or correcting errors or deficiencies. Immediate corrective actions form part of normal operating procedures and are noted in records for the project. Problems not solved this way require more formalized, long-term corrective action. If quality problems that require attention are identified, Tt or the subcontractor will determine whether attaining acceptable quality requires short- or long-term actions. If a failure in an analytical system occurs (e.g., performance requirements are not met), the appropriate QC Officer or subcontractor QA Manager will be responsible for corrective action and will immediately inform the Tt PM or QAO, as appropriate. Subsequent steps taken will depend on the nature and significance of the problem.

The Tt Modeling Manager has primary responsibility for monitoring the modeling activities of this project and identifying or confirming any quality problems. These problems will also be brought to the attention of the Tt QAO, who will initiate the corrective action system described above, document the nature of the problem, and ensure that the recommended corrective action is carried out. The Tt QAO has the authority to stop work on the project if problems affecting data quality require extensive effort to resolve and are identified.

The AEA PM and Tt Modeling Manager will be notified of major corrective actions and stop work orders.
Corrective actions might include the following:

- Re-emphasizing to staff the project objectives, the limitations in scope, the need to adhere to the agreed-upon schedule and procedures, and the need to document QC and QA activities
- Securing additional commitment of staff time to devote to the project
- Retaining outside consultants to review problems in specialized technical areas
- Changing procedures
- The Tt Modeling Manager may replace a staff member or subcontractor, as appropriate, if it is in the best interest of the project to do so.
- The Tt QC Officers are responsible for overseeing work as it is performed and periodically conducting checks during the data entry and analysis phases of the project. As data entries, calculations, or other activities are checked, the person performing the check will sign and date a hard copy of the material or complete a review form, as appropriate, and provide this documentation to the Tt Modeling Manager for inclusion in the project files. Field audits and technical system audits will not be conducted under this task order.

C 2.0 REPORTS TO MANAGEMENT

The Tetra Tech Project Manager and Modeling Manager will provide the AEA Assistant Director with a report describing the status of the project and the results of any intermediate assessments. The results of the study will be provided to the AEA Assistant Director in the final modeling report summarizing the results of this study after all modeling analyses have been completed. In addition, Tetra Tech will deliver the project files that will contain copies of all records and documents, including soft copy versions of the data and model input data sets. Tetra Tech will deliver the files to AEA at the end of the project.

The final modeling report will include results of technical reviews, model tests, data quality assessments of output data and audits, actual input and databases used, response actions to correct model development of implementation problems, and if applicable, pre- and post-software development.

D. DATA VALIDATION AND USABILITY

D 1.0 MODEL VALIDATION

Data review and validation services provide a method for determining the usability and limitations of data and provide a standardized data quality assessment. Verification of new model components or parameters (when applicable) improves the predictive capabilities of new models or modified existing models. Experienced professionals will be used in the data review, compilation, and evaluation phases of the study. Tetra Tech will be responsible for reviewing data entries, transmittals, and analyses for completeness and adherence to QA requirements. The data will be organized in a standard database on a microcomputer. A screening process that scans through the database and flags data that are outside typical ranges for a given parameter will be used. Values outside typical ranges will not be used to develop model calibration data sets or model kinetic parameters.

D 2.0 VERIFICATION AND VALIDATION METHODS

The Modeling QC Officer will review or oversee review of all data related to the project for completeness and correctness. Raw data received in hard copy format will be entered into the standard database. All entries will be compared to the original hard copy data sheets by the team personnel. Screening methods will be used to scan through the database and flag data that are outside typical ranges for a given parameter. Data will also be manipulated using specialized programs and Microsoft Excel 2007. Unless otherwise directed by the AEA Assistant Director, Tetra Tech anticipates that it will recalculate ten percent of the calculations to ensure that correct formula commands were entered into the program. If 5 percent of the data calculations are incorrect, all calculations will be rechecked after the correction is made to the database. Data quality will be assessed by comparing entered data to original data; performing the data and model evaluations; and comparing results with the measurement performance or acceptance criteria summarized in the Revised Study Plan to determine whether to accept, reject, or qualify the data. Results of the review and performance processes will be reported to the AEA Assistant Director.

General guidelines and procedures for model data performance and calibration are listed in Section 13.0. Verification will be performed by comparing new model parameters or components to theory. The model will be considered calibrated when it reproduces data within an acceptable level of accuracy determined in consultation with the AEA Assistant Director. The quantitative calibration measure calculations will be included in the final modeling report.

Model performance evaluates the model’s ability to appropriately simulate conditions under a data set or period that is independent from those used in the calibration. The calibration and performance process will be documented in the nutrients modeling report.

Because the goal is to be able to predict when point and nonpoint source loads produce water quality impairment on the basis of the ambient water quality criteria, model calibration and performance should strive to reduce errors (deviations between model predictions and observed measurement data) to zero.

D 3.0 COMPARING CALIBRATION/VALIDATION RESULTS TO DATA QUALITY INDICATORS

A set of parameters used in the calibrated model might not accurately represent field values, and the calibrated parameters might not represent the system under a different set of boundary conditions or hydrologic stresses. Therefore, a second model performance period helps establish greater confidence in the calibration and the predictive capabilities of the model. A site-specific model is considered *validated* if its accuracy and predictive capability have been proven to be within acceptable limits of error independently of the calibration data. In general, model performance is performed using a data set that differs from the calibration data set (i.e., low-flow data set for calibration versus higher-flow data set for verification). If only a single time series is available, the series can be split into two sub-series, one for calibration and another for performance. If the model parameters are changed during the performance, the exercise becomes a second calibration, and the first calibration needs to be repeated to account for any changes. Acceptable limits are those defined by the combined process of quantitative and qualitative examination of the model versus the data. There are not quantifiable limits because the Tetra Tech modelers may decide for a particular station that the statistics (quantitative) are more or less important that the graphical plots (qualitative). The limits used will be documented in the modeling report.

Model performance will be accomplished by calibration. A model calibration is the process of adjusting model inputs within acceptable limits until the resulting predictions give good correlation with observed data. Commonly, the calibration begins with the best estimates for model input on the basis of measurements and subsequent data analyses. Results from initial simulations are then used to improve the concepts of the system or to modify the values of the model input parameters. The success of a model calibration is largely dependent on the validity of the underlying model formulation.

D 4.0 RECONCILIATION WITH USER REQUIREMENTS

All data quality indicators will be calculated at the completion of the data analysis phase. Measurement quality requirements will be met and compared with the DQOs to confirm that the correct type, quality, and quantity of data are being used for model development in support of the Susitna – Watana Hydroelectric Project, Water Quality Modeling Study. The interpretation and presentation stage includes inspection of the form of the results, and the meaning and reasonableness of the computation results and post-simulation analysis.

The Tetra Tech Modeling QC Officers will perform internal reviews to assess departures from assumptions established in the planning phase of the modeling process. Tetra Tech, in consultation with the AEA Assistant Director, will determine how anomalies will be resolved.

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ATTACHMENT 5-3

MERCURY ASSESSMENT AND POTENTIAL FOR BIOACCUMULATION STUDY
SAMPLING AND ANALYSIS PLAN (SAP) / QUALITY ASSURANCE PROJECT PLAN (QAPP)

Sampling and Analysis Plan/Quality Assurance Project Plan

for the

Susitna – Watana Hydroelectric Project

Mercury Assessment and Potential for Bioaccumulation Study
Susitna River, Southcentral Alaska

FERC Project No. 14241

Alaska Energy Authority
Contract No. AEA-11-025

Prepared for:

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November 7, 2012
QAPP xxx, Revision 0

This quality assurance project plan (QAPP) has been prepared according to guidance provided in Alaska Department of Environmental Conservation and *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5, EPA/240/B-01/003, U.S. Environmental Protection Agency (EPA), Quality Assurance Division, Washington, DC, March 2001 [Reissued May 2006]) to ensure that environmental and related data collected, compiled, and/or generated for this project are complete, accurate, and of the type, quantity, and quality required for their intended use. Tetra Tech will conduct work in conformance with the quality assurance program described in the quality management plan for Tetra Tech's Fairfax Group and with the procedures detailed in this QAPP.

Approvals:

Betsy McGregor Assistant Director Alaska Energy Authority	Date	Paul Dworian Principal Manager URS Corporation	Date
Robert Plotnikoff Technical Lead Tetra Tech, Inc.	Date	Harry Gibbons Project Manager Tetra Tech, Inc.	Date
Jerry Diamond Toxicologist Tetra Tech, Inc.	Date	Susan Lanberg QA Officer Tetra Tech, Inc.	Date
William Loskutoff QA Manager URS Corporation	Date		

Contents

ACRONYMS AND ABBREVIATIONS

ADEC	Alaska Department of Environmental Conservation
AEA	Alaska Energy Authority
°C	degrees Celsius
cm	centimeters
DO	Dissolved oxygen
DQI	Data quality indicators
DQO	Data Quality Objectives
EPA	Environmental Protection Agency
g	grams
m	meter(s)
µS/cm	microSiemens per centimeter
mg/L	milligrams per liter
NPS	Nonpoint source
PDF	Portable Document Format
PM	Project Manager
QA	Quality assurance
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QAPP	Quality assurance project plan
QC	Quality control
QCO	Quality Control Officer
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard Operating Procedure
TMDL	Total Maximum Daily Load
TL	Technical Lead
Tt	Tetra Tech, Inc.

DISTRIBUTION

This document will be distributed to the following Alaska Energy Authority, URS Corporation, and Tetra Tech, Inc. staff members who are involved in this project, as well as to all responsible subcontractors.

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Mark Vania, URS Project Field Lead	907-261-9755 (phone) 907-562-1297 (fax) mark.vania@urs.com	URS Corporation 700 G Street, Suite 500 Anchorage, AK 99501
Tetra Tech, Inc. (Tt)		
Harry Gibbons Project Manager	206-728-9655 Ext. 107 (phone) 206-728-9670 (fax) harry.gibbons@tetratech.com	Tetra Tech, Inc. 1420 Fifth Avenue, Suite 550 Seattle, WA 98101
Robert Plotnikoff Technical Lead	206-728-9655 Ext. 124 (phone) 206-728-9670 (fax) robert.plotnikoff@tetratech.com	
Shannon Brattebo Tt Project Field Lead	509-232-4312 (phone) 509-744-9281(fax) shannon.brattebo@tetratech.com	Tetra Tech, Inc. 316 W. Boone Avenue, Suite 363 Spokane, WA 99201
Jerry Diamond	410-356-8993 (phone) jerry.diamond@tetratech.com	Tetra Tech, Inc. 400 Red Brook Blvd. Ste. 200 Owings Mills, MD 21117

A. PROJECT MANAGEMENT ELEMENTS

A 1.0 PROJECT/TASK ORGANIZATION

The Alaska Energy Authority (AEA) is preparing a License Application that will be submitted to the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project (Project). The Project is located on the Susitna River in the South-central region of Alaska. The Project's dam site will be located at River Mile (RM) 184. The results of this study and of other proposed studies will provide information needed to support the FERC's National Environmental Policy Act (NEPA) analysis for the Project license.

Construction and operation of the Project as described in the Pre-Application Document (PAD, AEA 2011) is expected to change some of the water quality characteristics of the resulting riverine portion of the drainage downstream of the dam site as well as the inundated area that will become the reservoir. This SAP/ QAPP outlines the objectives and methods for developing a monitoring program that will adequately characterize baseline methylmercury concentrations in the Susitna River within and downstream of the proposed Project area, as well as predict methylmercury impacts that may occur due to the dam's construction.

This Sampling and Analysis Plan (SAP)/Quality Assurance Project Plan (QAPP) is being prepared to document the quality assurance (QA) and quality control (QC) measures that will be observed to ensure the following objectives are met: data are consistent, correct, and complete, with no errors or omissions; QC sample results have been reviewed and are included; established criteria for QC results are met; measurement quality objectives have been met, or data qualifiers are properly assigned where necessary; and data specified in the sampling process design are obtained. Data collection methods will follow established state and federal (e.g., Alaska Department of Environmental Conservation and U.S. Environmental Protection Agency; EPA) guidelines.

The organizational aspects of a program provide the framework for conducting tasks. The organizational structure can also facilitate project performance and adherence to quality control (QC) procedures and quality assurance (QA) requirements. Key project roles are filled by those persons responsible for ensuring the collection of valid data and the routine assessment of the data for precision and accuracy, as well as the data users and the person(s) responsible for approving and accepting final products and deliverables. The key personnel involved in the Mercury Assessment Study of the Susitna River are listed in Table A1-1.

Table A1-1. Project/Task Organization and Responsibility Summary

Personnel	Responsibility	Address/E-Mail	Phone Number
Betsy McGregor	Responsible for project coordination with local, county, state, and federal government officials; and for reviewing drafts of the study plan, QAPP and summary data reports	Alaska Energy Authority 813 W Northern Lights Blvd. Anchorage, AK 99503 bmcgregor@aidea.org	907-771-3957
Paul Dworian	Responsible for directing daily project activities and tracking product delivery. Communicates with AEA Environmental Manager on project schedule and timing for product delivery.	URS Corporation 700 G Street, Suite 500 Anchorage, AK 99501 paul_dworian@urs.com	907-261-6735
Mark Vania	Responsible for field sampling assistance, quality assurance and quality control of field protocols.	URS Corporation 700 G Street, Suite 500 Anchorage, AK 99501 Mark.vania@urs.com	907-261-9755
Robert Plotnikoff	Responsible for preparing the project QAPP, coordinating and completing sampling activities, analyzing project data, and preparing the draft and final data reports. Serves as the principal project team contact for field staff for the duration of the study	Tetra Tech, Inc. 1420 5th Ave. Suite 550 Seattle, WA 98101 robert.plotnikoff@tetratech.com	206-728-9655
Harry Gibbons	Responsible for managing the project, overseeing preparation of the project QAPP, reviewing analysis of project data, and review of the draft and final data reports. Serves as the principal project team contact for the technical aspects of the study	Tetra Tech, Inc. 1420 5th Ave. Suite 550 Seattle, WA 98101 harry.gibbons@tetratech.com	206-728-9655
Shannon Brattebo,	Responsible for field sampling assistance, quality assurance and quality control of field protocols.	Tetra Tech, Inc. 316 W. Boone Avenue, Suite363 Spokane, WA 99201 shannon.brattebo@tetratech.com	509-232-4312

Personnel	Responsibility	Address/E-Mail	Phone Number
Jerry Diamond	Reviews QAPP and all Ecology quality assurance programs. Provides technical assistance on QA/QC issues during the implementation and assessment of the project.	Tetra Tech, Inc. 400 Red Brook Blvd. Ste. 200 Owings Mills, MD 21117 jerry.diamond@tetratech.com	410-356-8993

Additional technical staff will be responsible for conducting specific tasks during the project (e.g., performing field sampling and collecting surface water quality data) at the direction and discretion of the Project Manager (PM). The Project Manager will supervise the technical staff participating in the project, including implementing the QC program, completing assigned work on schedule with strict adherence to procedures established in the approved QAPP, and completing required documentation. The PM will direct the work of the field sampling team including collection, preparation, and shipment of samples and completion of field-sampling records. To perform the required work effectively and efficiently, the field-sampling team will include scientific staff with specialization and technical competence in field-sampling activities, as required to ensure the highest quality data are collected without incident. They must perform all work in adherence with the project work plan and QAPP, including maintenance of field sample documentation. Where applicable, custody procedures are required to ensure the integrity of the samples with respect to preventing contamination and maintaining proper sample identification during handling. Where field samples are collected the sampling team is responsible for the following:

- Receiving and inspecting the sample containers
- Receiving, inspecting, calibrating, and maintaining field instrumentation
- Completing, reviewing, and signing appropriate field records
- Assigning tracking numbers to each sample (sample identification numbers)
- Controlling and monitoring access to samples while in their custody
- Verifying the completeness and accuracy of chain-of-custody documentation
- Initiating shipment and verifying receipt of samples at their appropriate destinations
- Verifying the results of sample measurements collected for compliance with the requirements of the reference methods and this QAPP

Additional oversight will be provided by the QC Officers (QCO), who are responsible for performing evaluations to ensure that QC is maintained throughout the sampling process, that the data collected will be of optimal validity and usability, and that limitations of the data set are minimized as much as is possible given the challenges of the routine field investigation. The QCO is any senior technical staff assigned the responsibility of providing a second-level review of all documentation and records developed during the sample and data collection process. The QC evaluations will include double-checking work as it is completed and providing written documentation of these reviews (minimally initialing and dating documents as they are reviewed) to ensure that the standards set forth in the QAPP are met or exceeded. QCOs may be assigned at the task or subtask level allowing teams to efficiently divide work processes or tasks required and exchanging project documentation for review prior to departure from a sampling station. In this regard, QCOs ensure that all required data and information are recorded for each sampling station prior to physically leaving the collection site. Other QA/QC staff, such as technical reviewers and technical editors selected as needed, will provide peer review oversight on the content of work products and ensure that work products comply with the client's specifications.

Technical staff involved with the program will be responsible for reading and understanding this QAPP and complying with and adhering to its requirements in executing their assigned tasks relative to this project.

A 2.0 BACKGROUND

Construction and operation of the Project as described in the Pre-application Document (PAD, AEA 2011) is expected to change some of the water quality characteristics of the resulting riverine portion of the drainage downstream of the dam site as well as the inundated area that will become the reservoir.

Many studies have documented increased mercury concentrations in wildlife following the flooding of terrestrial areas to create hydroelectric reservoirs. The purpose of this study is to assess the potential for such an occurrence in the proposed Project area.

The study area includes the Susitna River within the proposed Watana Reservoir and downstream of the proposed Watana Dam. The study area begins at river mile 15.1 (Susitna River above Alexander Creek) and extends past the proposed dam site to river mile 233.4 (at Oshetna Creek, just above the upper extent of the proposed reservoir area). Tributaries to the Susitna River will be sampled and include those contributing large portions of the lower river flow such as the Talkeenta, Chulitna, Deshka, and Yentna river. Also included are smaller tributaries such as Gold, Portage, Tsusena, and Watana creeks, and the Oshetna River.

Soil and vegetation samples will be collected from the proposed inundation area. The proposed dam would be located at river mile 184. The dam would create a reservoir 42.5 miles long and 1 to 2 miles wide, with a normal reservoir surface area of approximately 23,546 acres and a normal maximum pool elevation of 2,050 feet. Piscivorous birds and mammals, and fish samples will be collected from a variety of drainages in the study area; however, the focus will be on the proposed inundation area for the dam to establish background concentrations of methylmercury in fish prior to site development.

Based on several studies, mercury that is found in newly formed reservoirs originates predominantly from inundation of organic soils. Receptors are and will be present in the Project inundation area (macroinvertebrates, fish, birds, etc.). Mercury methylation in reservoirs is a fairly well understood process, and numerous models exist to predict the occurrence and magnitude of the phenomena. Given these known factors, key questions that need to be answered by this study include the following:

1) Whether conditions within the reservoir will cause mercury methylation from this source.

2) The concentrations of methylmercury that might occur.

3) Whether a mechanism exists (fish and small invertebrates living in the methylation zone) to transfer that methylmercury to wildlife, resulting in detrimental impacts.

Based on these questions, specific objectives of this study are as follows:

- Summarize available and historic water quality information for the Susitna River basin, including data collection from the 1980s Alaska Power Authority (APA) Susitna Hydroelectric Project.

- Characterize the baseline mercury concentrations of the Susitna River and tributaries. This will include collection and analyses of vegetation, soil, water, sediment pore water, sediment, avian, terrestrial furbearers, and fish tissue samples for mercury.
- Utilize available geologic information to determine if a mineralogical source of mercury exists within the inundation area.
- Map mercury concentrations of soils and vegetation within the proposed inundation area. This information will be used to develop maps of where mercury methylation may occur.
- Use the water quality model to predict where in the reservoir conditions (pH, dissolved oxygen, turnover) are likely to be conducive to methylmercury formation.
- Use modeling to estimate methylmercury concentrations in fish.
- Assess potential pathways for methylmercury to migrate to the surrounding environment.
- Coordinate study results with other study areas, including fish, instream flow, and other piscivorous bird and mammal studies.

A 3.0 PROJECT/TASK DESCRIPTION

This section provides an overview of the staffing organization and schedule. The key personnel involved in the Mercury Assessment Study of the Susitna River are listed in Table A3-1.

Table A3-1. Project/Task Organization and Responsibility Summary

Personnel	Responsibility	Address/E-Mail	Phone Number
Betsy McGregor, Alaska Energy Authority	Responsible for project coordination with local, county, state, and federal government officials; and for reviewing drafts of the study plan, QAPP and summary data reports	Alaska Energy Authority 813 W Northern Lights Blvd Anchorage, AK 99503 bmcgregor@aidea.org	907-771-3957
Paul Dworian, URS	Responsible for directing daily project activities and tracking product delivery. Communicates with AEA Environmental Manager on project schedule and timing for product delivery.	URS Corporation 700 G Street, Suite 500 Anchorage, AK 99501 paul.dworian@urs.com	907-261-6735
Mark Vania, URS	Responsible for field sampling assistance, quality assurance and quality control of field protocols.	URS Corporation 700 G Street, Suite 500 Anchorage, AK 99501 mark.vania@urs.com	907-261-9755

Personnel	Responsibility	Address/E-Mail	Phone Number
Robert Plotnikoff, Tetra Tech, Inc.	Responsible for preparing the project QAPP, coordinating and completing sampling activities, analyzing project data, and preparing the draft and final data reports. Serves as the principal project team contact for field staff for the duration of the study	Tetra Tech, Inc. 1420 5th Ave. Suite 550 Seattle, WA 98101 robert.plotnikoff@tetratech.com	206-728-9655
Harry Gibbons Tetra Tech, Inc.	Responsible for managing the project, overseeing preparation of the project QAPP, reviewing analysis of project data, and review of the draft and final data reports. Serves as the principal project team contact for the technical aspects of the study	Tetra Tech, Inc. 1420 5th Ave. Suite 550 Seattle, WA 98101 harry.gibbons@tetratech.com	206-728-9655
Shannon Brattebo, Tetra Tech, Inc.	Responsible for field sampling assistance, quality assurance and quality control of field protocols.	Tetra Tech, Inc. 316 W. Boone Ave Suite 363 Spokane, WA 99201 shannon.brattebo@tetratech.com	509-232-4312
Gene Welch, Tetra Tech, Inc.	Reviews QAPP and all Ecology quality assurance programs. Provides technical assistance on QA/QC issues during the implementation and assessment of the project.	Tetra Tech, Inc. 1420 5th Ave. Suite 550 Seattle, WA 98101 gene.welch@tetratech.com	206-728-9655

The Mercury Assessment and Potential for Bioaccumulation Study for the Susitna River will begin in 2013 and continue through the beginning of 2015. The exact scheduling of the monthly and seasonal sampling will be coordinated between AEA and URS/Tt staff. Table 4-2 gives the projected schedule of activities and deliverables.

Table A3-2: Schedule for the Mercury Assessment and Potential for Bioaccumulation Study and Production of Associated Deliverables

Monitoring Activity	Timeline
QAPP/SAP Preparation and Review	January 2013 – March 2013
Water Quality Monitoring (monthly)	June 2013 - October 2013 (one sampling event in each of December 2013 and March 2014)
Soil and Vegetation Sampling (one survey)	August - September 2013
Sediment and Sediment Pore Water Sampling (one survey)	August - September 2013
Bird and Aquatic Furbearer Sampling	July - September 2013 and July - September 2014
Fish Tissue Sampling (one survey)	August - September 2012/2013

Monitoring Activity	Timeline
Data Analysis and Management	November 2013 – March 2014
Initial Study Report	February 2014
Updated Study Report	February 2015

A 4.0 DATA QUALITY OBJECTIVES AND CRITERIA

Measurement quality objectives (MQOs) are the performance or acceptance criteria for individual data quality indicators, including precision, bias, and sensitivity. The MQOs[1] for this project are presented in Table A4-1. Industry standard field methods will be used throughout this project to minimize measurement bias (systematic error) and to improve precision (to reduce random error). MQOs are listed for each of the parameters measured in water and from meteorological sites established in the upper river region of the Project area.

Table A4-1: Measurement Quality Objectives

Analyte	Precision (% RSD)	Bias (% deviation from true value)	Required Reporting Limit
WATER / PORE WATER			
Dissolved Oxygen	20	20	NA
Conductivity	20	20	NA
pH	20	20	NA
Temperature	20	20	NA
Mercury, Total and Methyl	15	20	0.002 up/L
SOIL/SEDIMENT/VEGETATION			
Mercury, Total	30	30	1 mg/kg
Total Organic Carbon (Sediment Only)	20	20	NA
Sediment Grain Size (Sediment Only)	NA	NA	NA
AVIAN/TERRESTRIAL FURBEARERS/FISH TISSUE			
Mercury, Total	10	10	0.03 mg/kg

NA Not applicable

Precision - Precision is defined as the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to subsequent (repeated) measurements. Precision is usually expressed as standard deviation, variance, or range, in either absolute or relative terms. Field sample replicates for assessment of precision will be analyzed at no less than a 5 percent frequency of the total number of samples. Laboratory replicates for assessment of precision will be analyzed at no less than a 5 percent frequency of the total number of samples submitted to the laboratory.

For sample results that exceed the reporting detection limit (RDL), the relative percent difference (RPD) will be less than or equal to 20 percent. No criteria are presented for duplicates that are below the RDL, as these data are provided for informational purposes only. When one or more of the results is below the RDL, professional judgment will be used in determining the compliance of the data to project requirements.

Representativeness - Sample representativeness is the degree to which data accurately and precisely represent a characteristic of a population. Representativeness will be addressed at two distinct points in the data collection process. During sample collection, the use of generally accepted sampling procedures applied in a consistent manner throughout the project will help ensure that samples are representative of conditions at the point where the sample was taken. During subsampling (sample aliquot removal) in the laboratory, samples will be inverted several times to ensure that the analytical subsample is well mixed and therefore representative of the sample container's contents.

Completeness - Completeness is a measure of the amount of valid data needed to meet the project's objectives. Completeness will be judged by the amount of valid data compared to the data expected. Valid data are those data in compliance with the data quality criteria as presented in this section, and in compliance within expected range of conditions and daily fluctuation patterns. While the goal for the criteria described above is 100 percent completeness, a level of 95 percent completeness will be considered acceptable. However, any time data are incomplete, decisions regarding re-sampling and/or re-analysis will be made. These decisions will take into account the project data quality objectives as presented above.

Comparability - Comparability is a measure of the confidence with which one dataset can be compared to another. This is a qualitative assessment and is addressed primarily by sampling design through use of comparable sampling procedures or, for monitoring programs, through consistent sampling of stations over time. In the laboratory, comparability is assured through the use of comparable analytical procedures and ensuring that project staff are trained in the proper application of the procedures. Within-study comparability will be assessed through analytical performance (quality control samples).

A 5.0 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

This QAPP and supporting materials will be distributed to all participants. The local Project Manager will conduct a procedural review before the field team is mobilized for sampling. The procedural review will include the requirements of the QAPP and referenced SOPs, as well as instrument manufacturers' operation and maintenance instructions. It will be performed concurrently with a check that all equipment and sampling gear are fully functional and ready for deployment. In addition, there will be discussions and demonstrations of sampling method(s) to be used and discussions regarding specific health and safety concerns. Each sampling team will consist of, at a minimum, one sample collector and a scientist familiar with QC requirements, which will ensure strict adherence to the project protocols, check all documentation for completeness and correctness, and verify that no transcription errors or omissions have been made in preparing sample custody records and other project documentation.

A 6.0 DOCUMENTATION AND RECORDS

Thorough documentation of all field sample collection is necessary for proper processing of data and, ultimately, for interpreting study results. Field sample collection will be documented in writing, on forms as well as on the following forms and labels:

- A field log notebook for general observations and notes
- A Field Data Record Form that contains information about observations and measurements made and samples collected at the site
- Checklists for each sampling event, sampling point, and sampling time.

The Technical Leads, and the appropriate PMs within subcontractor organizations will maintain files, as appropriate, as repositories for information and data used in preparing any reports and documents during the project and will supervise the use of materials in the project files. The following information will be included:

- Any reports and documents prepared
- Contract and Task Order information
- Project QAPP
- Results of technical reviews, data quality assessments, and audits
- Communications (memoranda; internal notes; telephone conversation records; letters; meeting minutes; and all written correspondence among the project team personnel, subcontractors, suppliers, or others)
- Maps, photographs, and drawings
- Studies, reports, documents, and newspaper articles pertaining to the project
- Special data compilations
- Spreadsheet data files: physical measurements, analytical chemistry data (hard copy and disk)

Copies of the field log books and physical characterization/water quality data sheets and sampling checklists will be supplied to the Field PMs at the close of each sampling event. These data will be used in conjunction with inspection checklists to compile the sampling event reports. Formal reports that are generated from the data will be subject to technical and editorial review before submission to Alaska Energy Authority and will be maintained at Tt's Seattle, Washington office in the central file (disk and hard copy). The data reports will include a summary of the types of data collected, sampling dates, and any problems or anomalies observed during sample collection.

If any change(s) in this QAPP are required during the study, a memo will be sent to each person on the distribution list describing the change(s), following approval by the appropriate persons. The memos will be attached to the QAPP. All written records relevant to the sampling and processing of samples will be maintained at Tt's Seattle, Washington office in the central file. Unless other arrangements are made, records will be maintained for a minimum of 5 years following expiration of the contract.

B. MEASUREMENT AND DATA ACQUISITION

B 1.0 SAMPLING DESIGN

This QAPP/SAP includes specific detail describing study design, sampling procedures, and determining quality of data collected that satisfy the study objectives. This QAPP/SAP is a required document when generating environmental data intended for use in making regulatory decisions. This document ensures that defensible and high quality data is generated in this study by establishing performance goals and a process for evaluation of each of the study elements.

This study consists of six study components as listed below:

- Summarize available information for the Susitna River basin, including data collection from the 1980s APA Susitna Hydroelectric Project, and existing geologic information to determine if a mineralogical source of mercury exists within the inundation area.

- Collect and analyze background vegetation, soil, water, sediment, sediment pore water, and avian, terrestrial furbearer, and fish tissue samples for mercury. This will include mapping vegetation types and the lateral extent, thickness, and mercury concentrations of soils within the proposed inundation area. These data will be used to provide background concentrations for mercury, but will also help evaluate potential mitigation methods (soil and vegetation removal) should that become necessary.

- Use the water quality model to predict where in the reservoir conditions (pH, dissolved oxygen, turnover) are likely to be conducive to methylmercury formation (see Section 5.6 of Revised Study Plan).

- Utilize specialty models to predict potential fish methylmercury concentrations.

- Assess potential pathways for mercury movement from different areas of methylmercury formation to the surrounding environment.

- Prepare a technical report on analytical results, modeling, and mercury pathway assessment.

Data will be collected from multiple aquatic media including surface water, sediment, vegetation, piscivorous birds and mammals, and fish tissue. The work will be done as a single, comprehensive survey to determine the baseline concentrations of mercury in the watershed. Table B1-1 summarizes the parameters to be analyzed for this study according to media type and the frequency of collection.

Water quality and sediment samples will be collected at the sites identified in Table B1-2. The study area begins at RM 15.1 and extends past the proposed dam site to RM 233.4. Tributaries to the Susitna River will be sampled and include those contributing large portions of the lower river flow such as the Talkeetna, Chulitna, Deshka, and Yentna rivers. Also included are smaller tributaries such as Gold, Portage, Tsusena, and Watana creeks, and the Oshetna River. These sites were selected based on the following rationale:

- Adequate representation of locations throughout the Susitna River and tributaries above and below the proposed dam site for the purpose of a baseline mercury characterization.

- Location on tributaries where proposed access road crossing impacts might occur during and after construction (upstream/downstream sampling points on each crossing).

- Consultation with licensing participants including co-location with other study sites (e.g., instream flow, ice processes).

- Sites that are in the Susitna River mainstem, tributary, or slough locations, most of which were monitored in the 1980s.

Additional sample sites will be added at the Focus Areas (see below for further detail and Figures B1-1 through B1-10.

Soil and vegetation samples will be collected from the proposed inundation area. Avian, terrestrial furbearers, and fish samples will be collected from a variety of drainages in the study area; however, the focus will be on the proposed inundation area for the dam to establish background concentrations of methylmercury in fish prior to site development.

Water Quality Data Collection: Focus Areas on the Susitna River

A total of ten intensive study areas (Focus Areas) were presented and discussed with the TWG and are proposed for detailed study within the Middle Segment of the river. The proposed Focus Areas are intended to serve as specific geographic areas of the river that will be the subject of intensive investigation by multiple resource disciplines including water quality and mercury assessment. The Focus Areas were selected during an interdisciplinary resource meeting that involved a systematic review of aerial imagery within each of the Geomorphic Reaches (MR1 through MR8) for the entire Middle Segment of the river. Focus Areas were selected within MR1, MR2, MR5, MR6, MR7, and MR8. Focus Areas were not selected for MR3 or MR4 due to safety considerations related to Devils Canyon.

The areas selected were those deemed representative of the major features in the Geomorphic Reach and included mainstem habitat types of known biological significance (i.e., where fish have been observed based on previous and/or contemporary studies), as well as some locations (e.g, Slough 17) where previous sampling revealed few/ no fish. The areas included representative side channels, side sloughs, upland sloughs, and tributary mouths.

The Focus Area selections considered:

- All major habitat types (main channel, side channel, side slough, upland slough, tributary delta).
- At least one Focus Area per geomorphic reach (excepting reaches associated with Devils Canyon) will be included that are representative of other areas.
- A replicate sampling strategy will be used for measure habitat types within each Focus Area which many include random selection process.
- Areas that are known (based on existing and contemporary data) to be biologically important for salmon spawning/ rearing in mainstem and lateral habitats will be sampled (i.e., critical habitats) and
- Areas for which little or no fish use has been documented or for which information on fish use is lacking, will also be sampled.

Maps of each FA with River Mile numbers included are shown below in Figures B1-1 through B1-10.

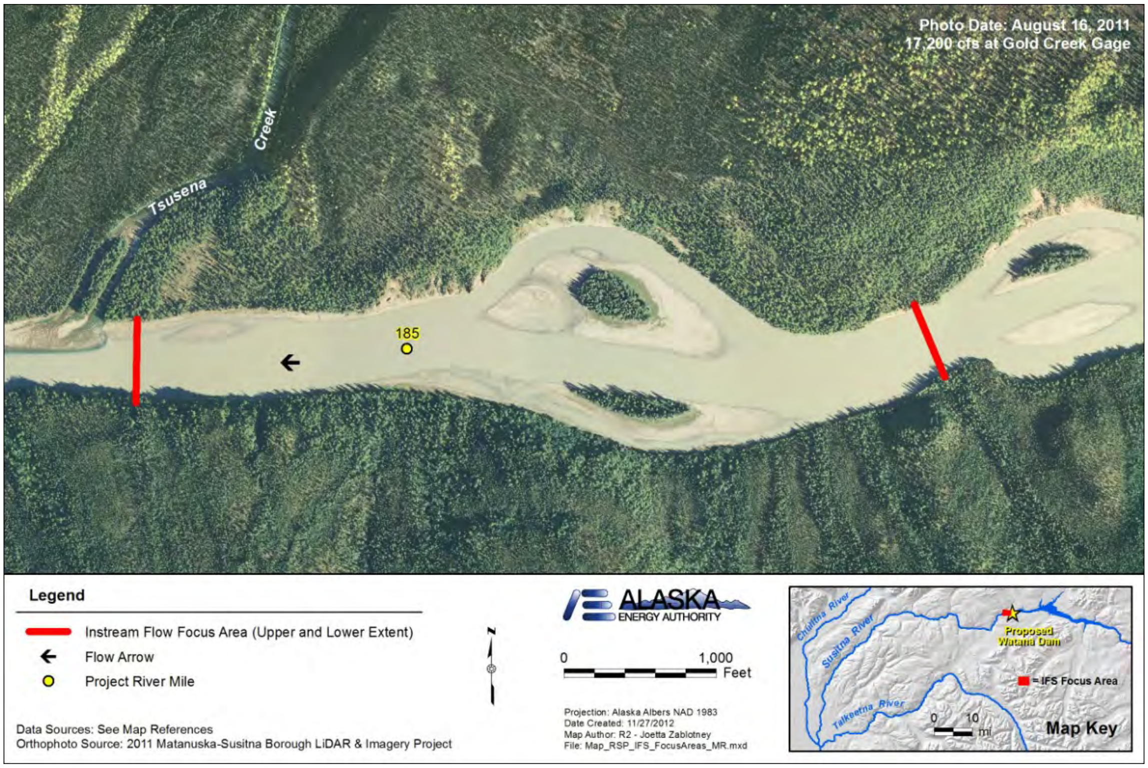

Figure B1-1. Map of Focus Area 1

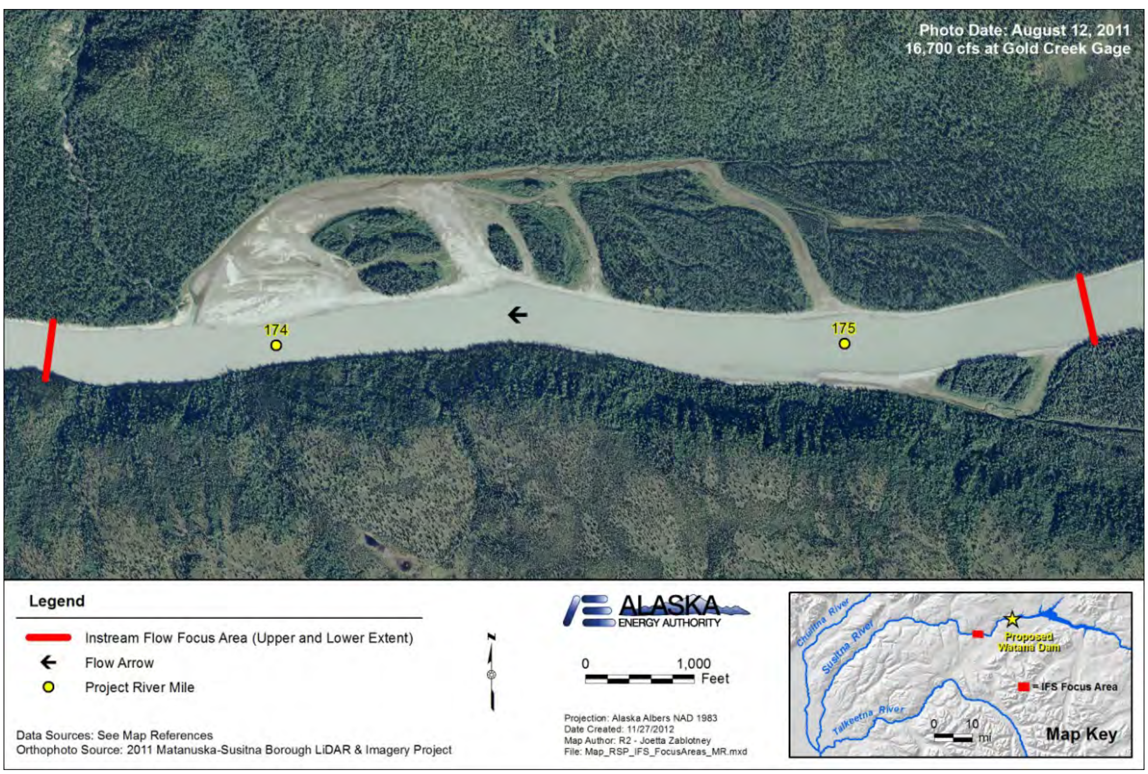

Figure B1-2. Map of Focus Area 2

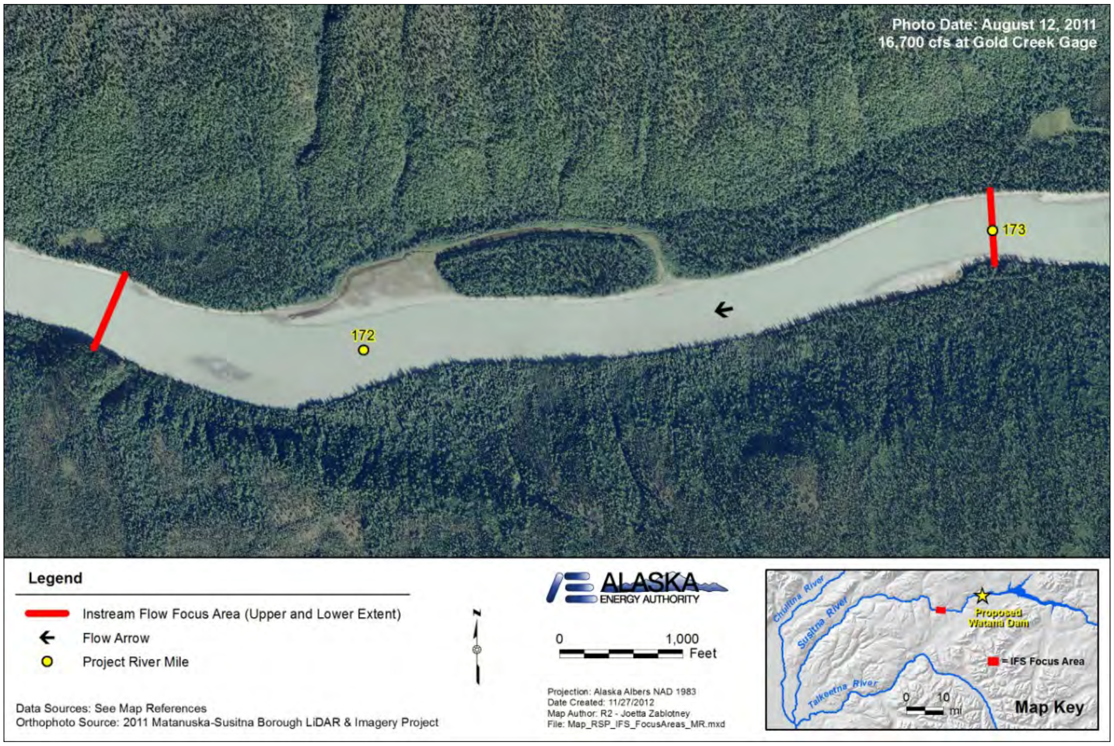

Figure B1-3. Map of Focus Area 3

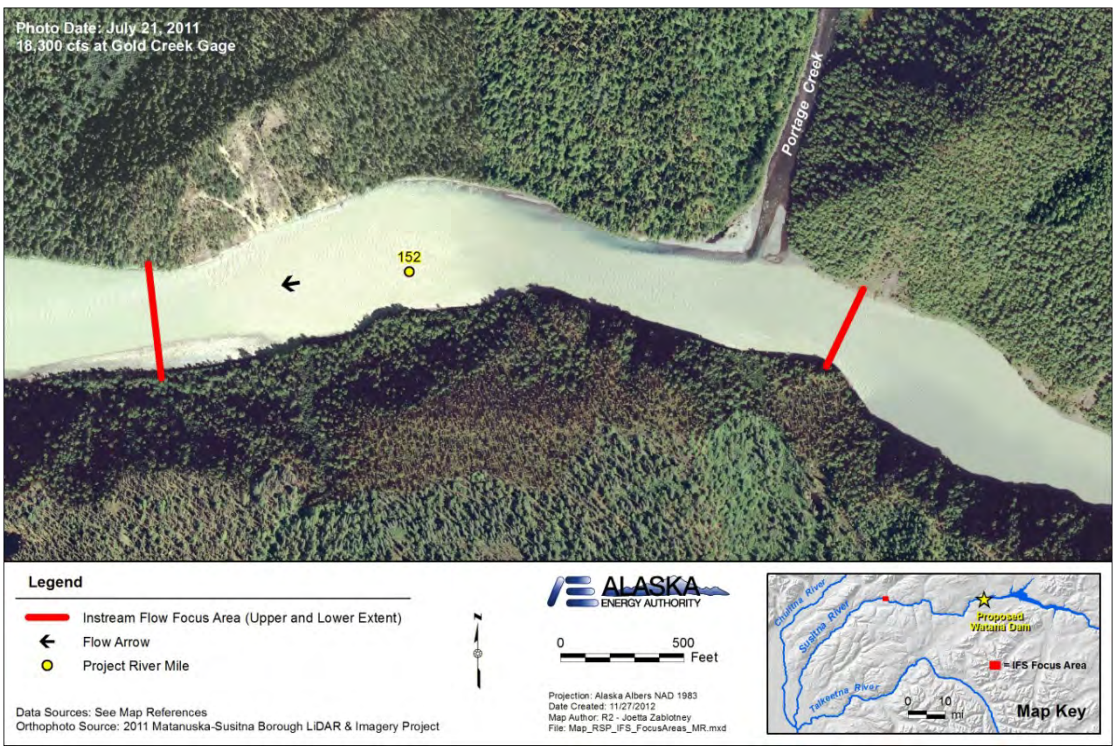

Figure B1-4. Map of Focus Area 4

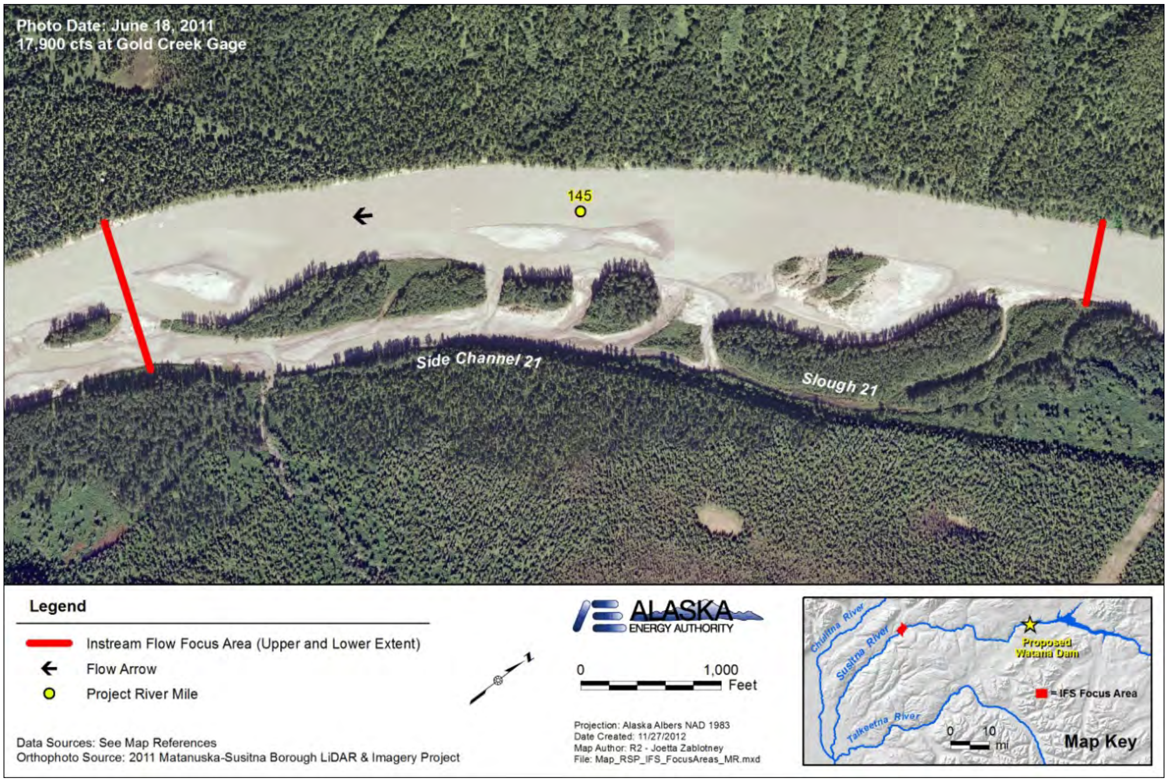

Figure B1-5. Map of Focus Area 5

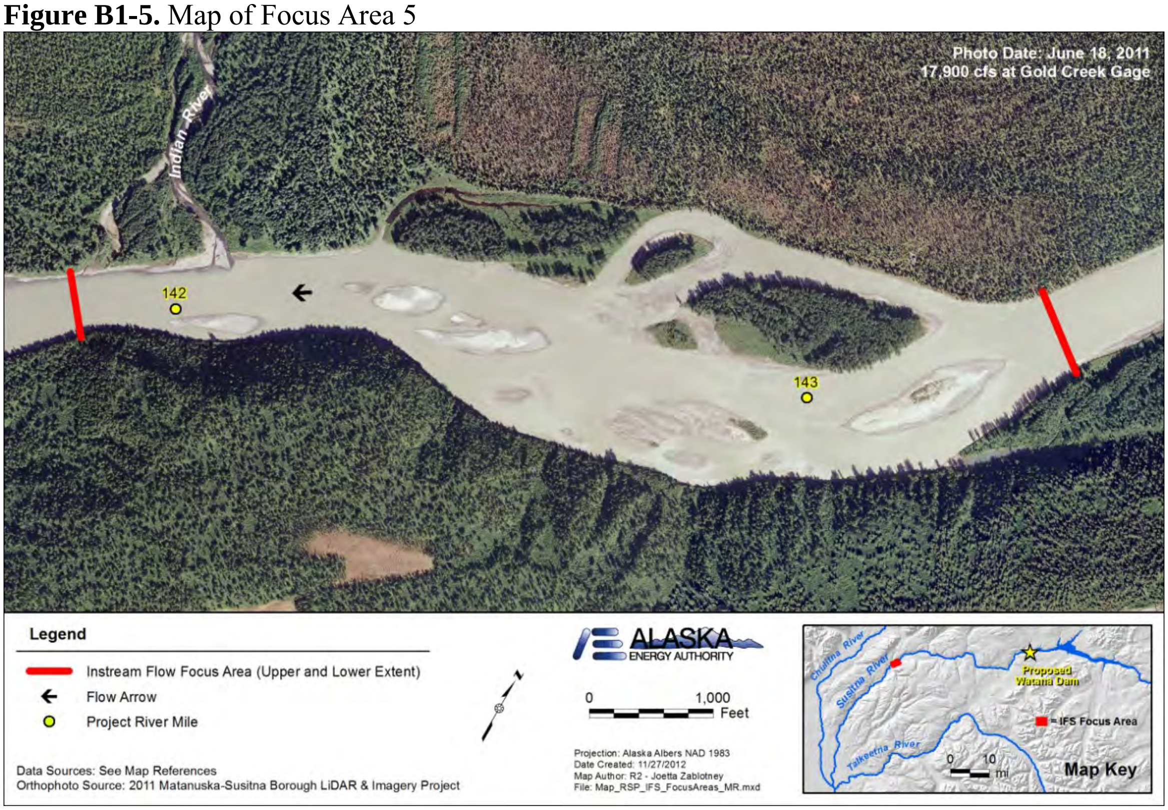

Figure B1-6. Map of Focus Area 6

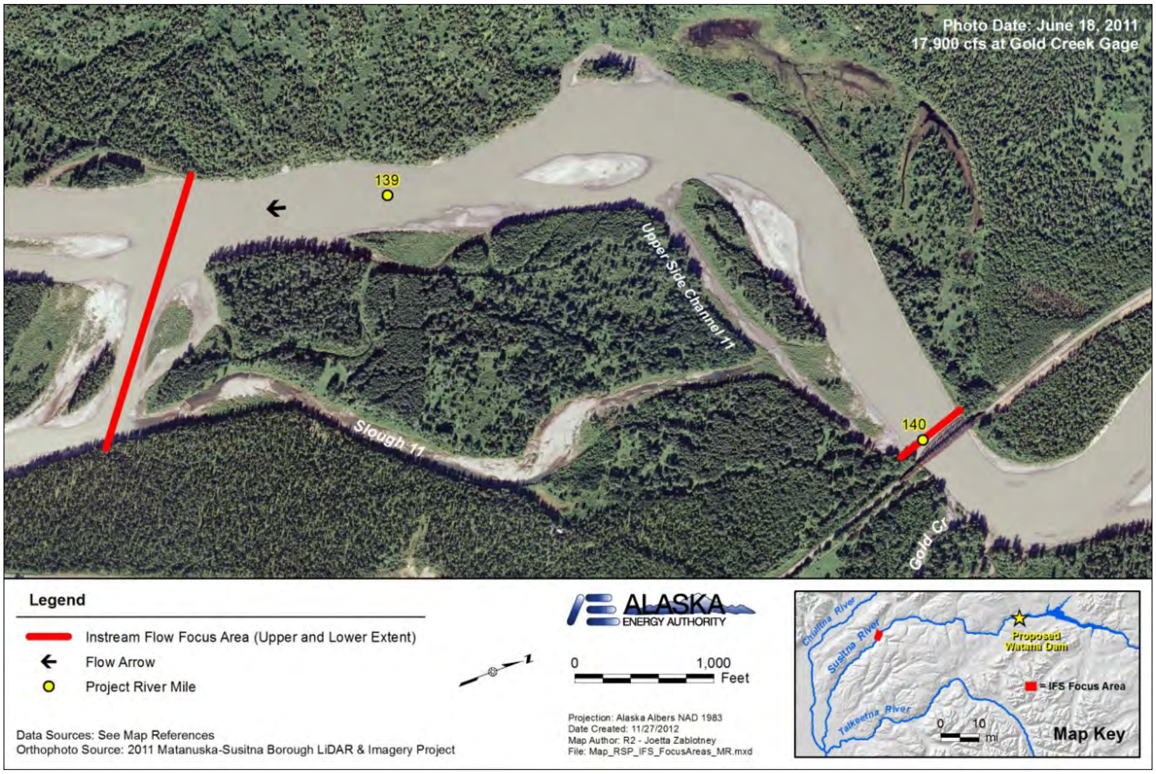

Figure B1-7. Map of Focus Area 7

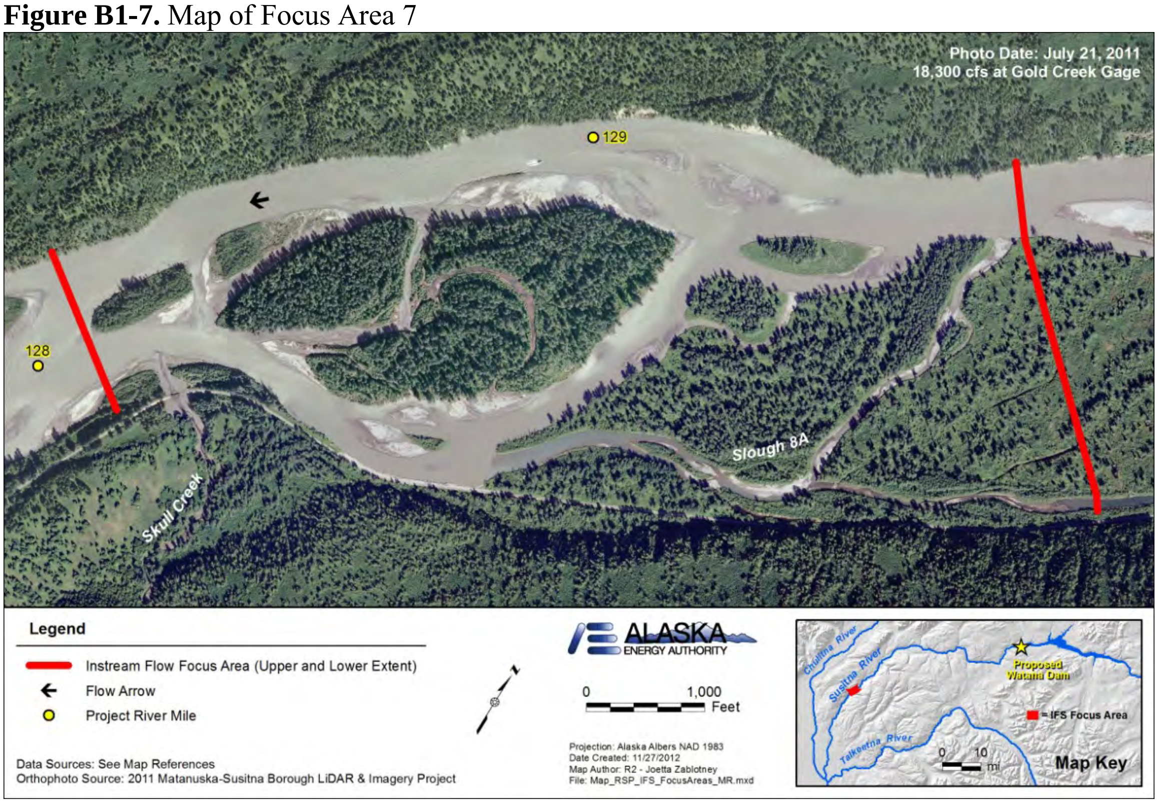

Figure B1-8. Map of Focus Area 8

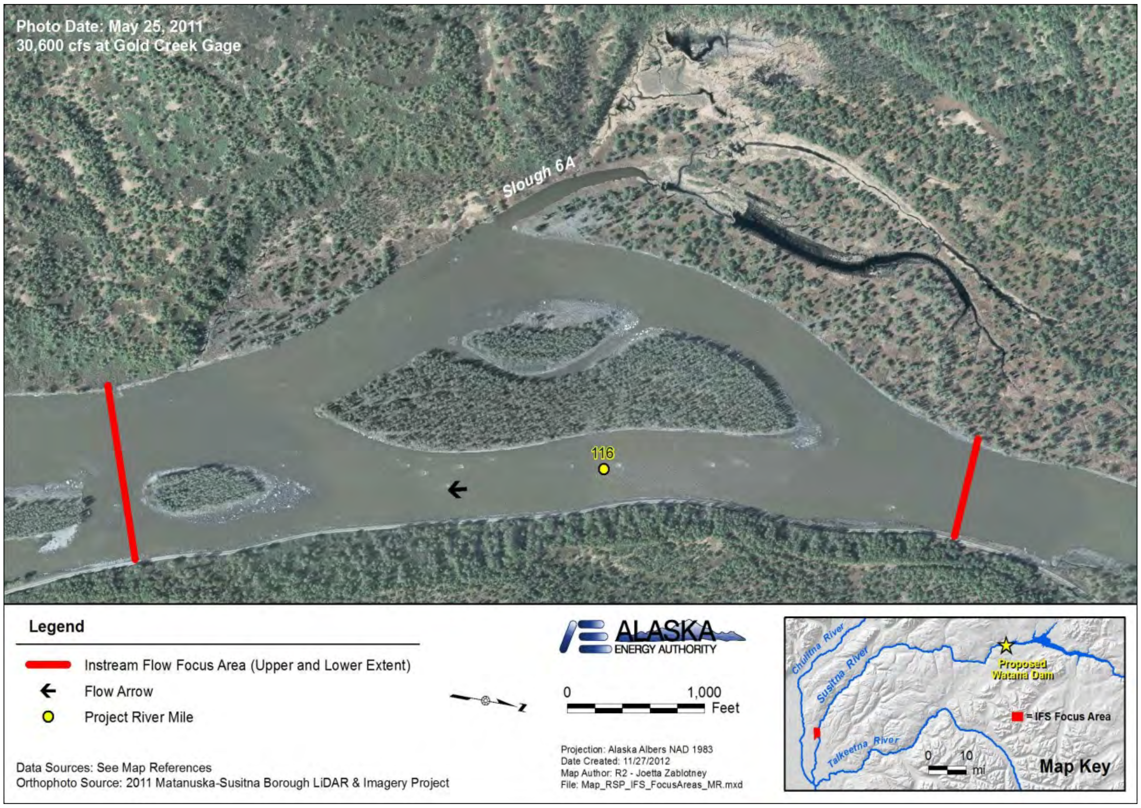

Figure B1-9. Map of Focus Area 9

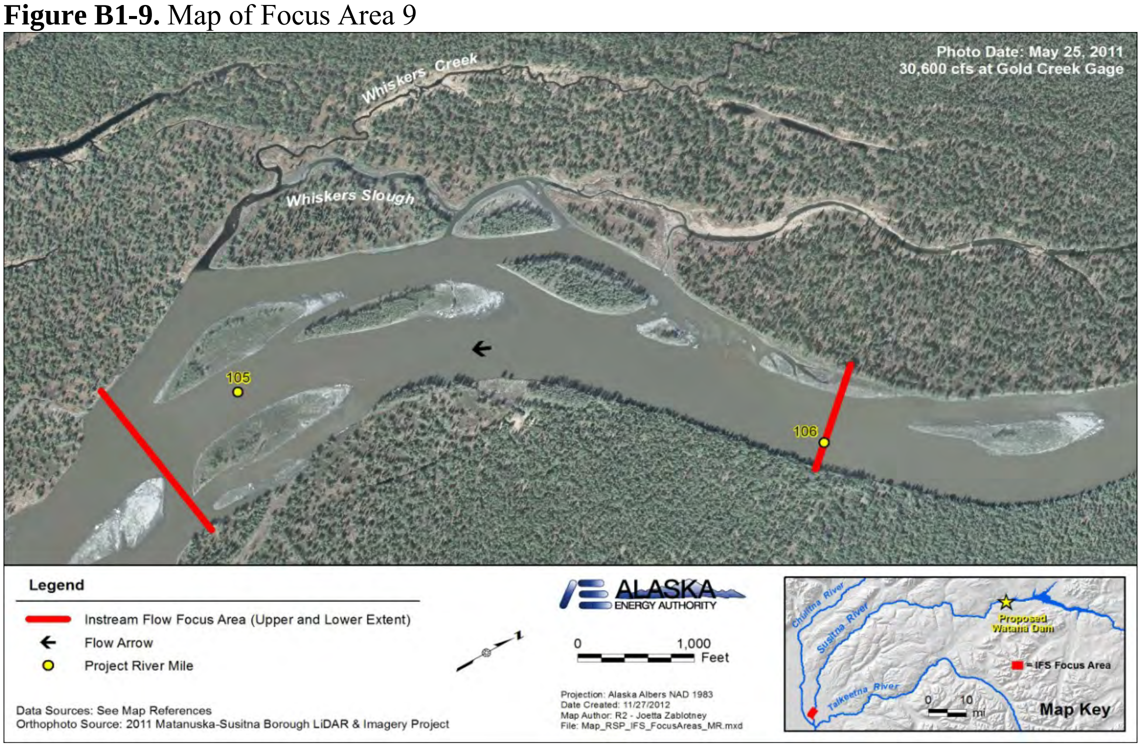

Figure B1-10. Map of Focus Area 10

Table B1-1. List of parameters and frequency of collection

Media	Analyses	Frequency of Collection	Holding Time
Surface Water, Sediment Pore Water	Total and methylmercury (EPA-7470A) Surface Water Only: Temperature, pH, DO, Conductivity, Redox Potential (Multi-parameter sonde)	Monthly	48 hours
Soil, Sediment	Total mercury (EPA 245.2/7470A) Sediment Only: Total Organic Carbon (EPA 415.1/9060) Sediment Grain Size (ASTM D422)	One Survey-summer	28 days
Avian and Terrestrial Furbearers	Total mercury (EPA-1631)	One Survey-late summer	7 days
Fish Tissue	Total and methylmercury (EPA-1631)	One Survey-late summer	7 days

Table B1-2. Proposed Susitna River Basin mercury assessment sites

Susitna River Mile	Description	Susitna River Slough ID	Latitude (decimal degrees)	Longitude (decimal degrees)
25.8	Susitna Station	NA	61.5454	-150.516
28.0	Yentna River	NA	61.589	-150.468
29.5	Susitna above Yentna	NA	61.5752	-150.248
40.6	Deshka River	NA	61.7098	-150.324
55.0	Susitna	NA	61.8589	-150.18
83.8	Susitna at Parks Highway East	NA	62.175	-150.174
97.2	Talkeetna River	NA	62.3418	-150.106
98.5	Chulitna River	NA	62.5574	-150.236
103.0	Talkeetna	NA	62.3943	-150.134
120.7	Curry Fishwheel Camp	NA	62.6178	-150.012
136.8	Gold Creek	NA	62.7676	-149.691
138.6	Indian River	NA	62.8009	-149.664
138.7	Susitna above Indian River	NA	62.7857	-149.651
148.8	Susitna above Portage Creek	NA	62.8286	-149.379
148.8	Portage Creek	NA	62.8317	-149.379
184.5	Susitna at Watana Dam site	NA	62.8226	-148.533
223.7	Susitna near Cantwell	NA	62.7052	147.538

B 2.0 SAMPLING METHODS

Below is a description of the sampling methods and techniques that will be used when collecting samples as part of the mercury assessment and potential for bioaccumulation study on the Susitna River. The sampling methods are broken out by media type.

Vegetation

The principal concern for the vegetation study is to determine the mass of organics and mercury concentrations in the reservoir area. Plant species differ in their ability to take up mercury. At the Red Devil and Cinnabar Creek mines, alders and willows concentrate mercury at levels as much as 20 times higher than those in the other species collected in this study (Baily and Gray 1997). The mechanism of mercury uptake and reason for variation in mercury uptake by species is unclear. Siegal et al. (1985, 1987) have suggested that some species are mercury accumulators, whereas other plant species release their absorbed mercury as mercury vapor and thus lower their total concentration of mercury. Overall, leaves and needles have been found to hold the greatest accumulations of mercury in Alaska plants (Baily and Gray 1997).

The degradation rate for organic materials in water seems to be a primary source of the spike in methylmercury concentrations after filling of a reservoir (Hydro-Quebec 2003). Only the green part of the vegetation (leaves of trees and shrubs as well as forest ground cover) and the top centimeters of humus decompose quickly. Tree branches, trunks and roots, as well as deeper humus, remain almost intact decades after flooding (Morrison and Thérien 1991). Previous studies by Hydro-Quebec have shown that woody debris, even if it contains mercury, is not a problem for mercury methylation because the decay rate is slow in cold water (Hydro-Quebec 2003).

Based on these studies, up to 50 samples of vegetation will be collected from various plants within the proposed inundation area. Studies are currently being completed on the distribution of types of species in the inundation zone, and this information is currently unavailable. The sampling will be biased toward total vegetative mass, that is to say species that are present in the inundation area at low frequency and size may not be sampled, because their contributions to mercury methylation will be low. Multiple samples (five to seven) will be collected at different locations for each species in the inundation area. Based on the available preliminary data, it is anticipated that a majority of the samples will consist of alder *(Alnus crispa),* willow *(Salix* sp.), white spruce *(Picea glauca),* cottonwood *(Populus balsamifera),* black spruce *(Picea mariana),* paper birch *(Betula papyrifera), and* dwarf birch*(Betula nana).* Leaves and needles will be collected and placed in appropriate sample containers. Vegetation samples will be shipped to the contract laboratory for total mercury analysis.

To collect vegetation samples the following equipment is needed: latex gloves, large Ziploc bags, sharpie pens and waterproof paper labels. Samples will be collected as follows:

- Samples of shrubs, and leaves or needles of trees should be collected by gathering the current year's growth (i.e., tips of coniferous trees and leaves).
- All vegetation samples should be collected by hand using disposable latex gloves.
- Samples will be placed in a single large Ziploc bag. Samples will consist of at least 10 grams of organic matter.
- Samples may be a composite of several identical species from the same area.
- Physical attributes such as species, location, exposed soil, herbaceous litter/mulch, woody litter, standing water, and rock type will be recorded in the field notes.
- All plant species collected will be assigned a stratum category (tall tree, stunted tree, shrub,

graminoid herbaceous, forb, etc.). The actual height for a representative species will be recorded.
- An estimation of percentage of cover will be made. Emergent and aquatic plants will be recorded at the immediate margin of water less than one foot deep.
- The outside of the bag will be labeled with a sharpie pen and place a waterproof paper label inside the bag.
- Samples will be refrigerated prior to shipping.
- The cooler will be sealed and transported to the laboratory with the appropriate chain-of custody (COC) forms which should accompany the shipment.
- Samples will be analyzed for total mercury using EPA Method 1631E. It is unnecessary to analyze these samples for methylmercury, given that these materials are considered as a source for methylmercury generation, and total mercy analyses includes both methylated and inorganic forms of mercury.

This sampling method is in accordance with USDA Natural Resources Conservation Service (NRCS) guidelines for vegetative sampling.

Soil

Studies have found that the primary source of mercury to new reservoirs was the inundated soils (Meister et al. 1979), especially the upper organic soil horizon, which often has higher mercury levels than the lower inorganic soil layers (Bodaly et al. 1984). Measuring the thickness and mercury content of these soils prior to inundation may allow predictions of possible mercury methylation, and assist with evaluating potential mitigation methods, if necessary.

To the extent possible, soil samples will be coincident with vegetative samples. The primary concern is to document the thickness and extent of organic rich soils, because these soils will have the highest concentrations of mercury and will provide most of the organic material resulting in the generation of methylmercury.

To collect soil the following general procedures should be followed:
- Samples will be collected using a soil probe with a window slot in the cylinder of the probe for easy sample recovery. The probe will be pushed till refusal.
- The soil layers encountered will be recorded using a tape measure and record depth (cm) in the field book.
- Each recovered soil profile will be catalogued, measured and photographed, along with each soil sample location. Data recorded from each collection point will include coordinates, slope, elevation, depth to water table, and depth to refusal. Soil properties such as soil horizons, texture, rock fragments, are recorded in the horizon data field. The soil will be classified in accordance with the Alaska Department of Transportation and Public Facilities Alaska Field Guide for Soil Classification.
- Soil samples will be collected from only the upper 5 to 7 inches of material. This is the zone of most active root development and is generally the primary zone of mercury accumulation in forest soils (Godbold, 1994). In addition, it is anticipated that soils will be poorly developed below about 6 inches, and are unlikely to have significant organic matter below that depth.
- Samples will consist of at least 10 grams of organic matter. Soil samples will be placed in 4 ounce plastic jars.
- Any large stones will be separated and discarded.
- Inorganic soils will be noted, but not sampled.
- Each sample will be handled using latex or vinyl disposable gloves.
- The field equipment will be cleaned with a mild soap solution and water between samples to

avoid cross-contamination.
- Samples will be frozen until delivery to the analytical laboratory under standard COC procedures.
- The samples will be analyzed for total mercury using EPA Method 1631E. It is unnecessary to analyze these samples for methylmercury, given that these materials are considered as a source for methylmercury generation, total mercy analyses includes both methylated and inorganic forms of mercury.

Water

The purpose of the water sampling is to collect baseline water quality information to support an assessment of the effects of the proposed Project operations on water quality in the Susitna River basin. Mercury in water will be tested monthly during the summer because it has been shown to vary in concentrations throughout the year (Frenzel 2000). Two sampling events will also be performed during the winter.

Water samples will be collected at the locations listed in Table B1-2. The proposed spacing of the sample locations follows accepted practice when segmenting large river systems for development of Total Maximum Daily Load (TMDL) water quality models. Water sampling during winter months will be focused on locations where flow data are currently collected, or were historically collected by USGS. Water samples will be analyzed for the parameters reported in Table B1-1.

Grab samples will be collected along a transect of the stream channel/water body, using methods consistent with Alaska and EPA protocols for sampling ambient water and trace metal water quality criteria. Mainstem areas of the river not immediately influenced by a tributary will be characterized with a single transect. Areas of the mainstem with an upstream tributary that may influence the nearshore zone or that are well-mixed with the mainstem will be characterized by collecting samples at two transect locations: in the tributary and in the mainstem upstream of the tributary confluence. Samples will be collected at 3 equi-distant locations along each transect (i.e. 25% from left bank, 50% from left bank, and 75% from left bank). Samples will be collected from a depth of 0.5 meters below the surface as well as 0.5 meters above the bottom. This will ensure that variations in concentrations, especially metals, are captured and adequately characterized throughout the study area.

These samples will be collected on approximately a monthly basis (four samples from June to September). The period for collecting surface water samples will begin at ice break-up and extend to beginning of ice formation on the river. Limited winter sampling (once in December, and again in March) will be conducted where existing or historic USGS sites are located.

Review of existing data (URS 2011) indicates that few exceedances occur with metals concentrations during the winter months. If the 2013 data sets suggest that mercury concentrations exceed criteria or thresholds, then an expanded 2014 water quality monitoring program will be conducted to characterize conditions on a monthly basis throughout the winter months.

Variation of water quality in a river cross-section is often significant and is most likely to occur because of incomplete mixing of upstream tributary inflows, point-source discharges, or variations in velocity and channel geometry. Water quality profiles at each location on each transect will be conducted for field water quality parameters (e.g., temperature, pH, dissolved oxygen, and conductivity) to determine the extent of vertical and lateral mixing.

Water quality samples will be collected using a davit/cable/winch system. A 50lb+ weight will be attached to the end of the cable to ensure that both the cable and sampling equipment remain vertical throughout the water column. Water quality grab samples are anticipated to be collected via a Kemmerer

Sampler, made out of Teflon for low level metals analysis, which will be attached to the davit cable. The sampler will be lowered into the water column via the winch until the desired sampling depth is reached. At that point the rope/cable attached to the sampler will be pulled tight and messenger sent down to close the sampler. Water from the sampler will be then be poured into the appropriate sample containers. If troubles are encountered while using the Kemmerer sampler due to high velocities in the Susitna River, a second sample collection method could be utilized where Tygon tubing is attached to the davit cable and water is pulled from the desired depth via a peristaltic pump. It is unknown at this time which sampling technique is better suited for conditions on the Susitna River and tributaries.

Sediment and Sediment Pore Water

In general, all sediment samples will be taken from sheltered backwater areas, downstream of islands, and in similar riverine locations in which water currents are slowed, favoring accumulation of finer sediment along the channel bottom. Samples will be analyzed for mercury (Table B1-1). In addition, sediment size and total organic carbon (TOC) will be included to evaluate whether these parameters are predictors for elevated mercury concentrations. Samples will be collected just below and above the proposed dam site. Additional samples will be collected near the mouth of tributaries near the proposed dam site, including Fog, Deadman, Watana, Tsusena, Kosina, Jay, and Goose creeks, and the Oshetna River. The purpose of this sampling will be to determine where metals, if found in the water or sediment, originate in the drainage.

Mercury occurrence is typically associated with fine sediments, rather than with coarse-grained sandy sediment or rocky substrates. Therefore, the goal of the sampling will be to obtain sediments with at least 5 percent fines (i.e., particle size <63 µm, or passing through a #230 sieve).

Surficial sediment sampling will be conducted with a Van Veen sampler lowered from a boat by a power winch. This sampling device collects high-quality sediment samples from the top four to six inches of sediment. Three sediment samples will be collected at each of the sites sampled. These three samples will be collected and analyzed separately to characterize the presence of mercury and generate statistical summaries for site characterization. A photographic record of each sediment sample will be assembled from images of newly collected material.

Care will be taken to ensure the following:

- The sampler will not be overfilled with sediment.
- The overlying water is present when the sampler is retrieved.
- At least two inches of sediment depth is collected.
- There is no evidence of incomplete closure of the sampling device.

If a sediment sample does not meet all of the criteria listed above, it will be discarded and another sample will be collected.

Sediment interstitial water, or pore water, is defined as the water occupying the space between sediment particles. Interstitial waters will be collected from sites listed above and separated from sediments in the field house laboratory using a pump apparatus to draw pore water from each of the replicate samples. Filtering of samples will utilize a 0.45-µm pore size filter in both the lab apparatus and field apparatus. In some cases, pore water may be drawn from sediment samples in the field by using 100-milliliter (mL) syringes immersed in the dredge sample once a sediment sample is collected in a sample jar. These would be cases where sediment samples have slightly coarser particle sizes and pore water extraction in the field is possible. In other instances, where sediment samples have finer particle sizes requiring more time to draw samples for laboratory analysis, these samples will be transferred to the field laboratory for pore water extraction.

Birds and Aquatic Furbearers

The potential impacts of methylmercury on upper trophic level species can be influenced by a variety of factors including animal behavior and physiology (e.g., foraging behavior, diet composition) and physical/chemical properties of the receiving environment (e.g., organic carbon content, anaerobic conditions, sulfides, etc.). Fish, in particular, absorb methylmercury efficiently from dietary sources and store this material in organs and tissues (U.S. EPA, 1997). Because fish are the primary source of methylmercury migration into the terrestrial ecosystem, this evaluation focuses on the impact of methylmercury generated in the proposed reservoir on fish-eating (piscivorous) upper trophic species.

There are two significant challenges to the proposed sampling program. The first is that the populations of most piscivorous birds and aquatic furbearers are relatively small in the proposed study area. For that reason, sampling efforts are likely to collect few samples, or may be entirely unsuccessful for some species. From a statistical standpoint, low sample returns (< 5 samples), coupled with high variability in methylmercury concentrations, can result in inaccurate results and conclusions for this study. In addition, damaging relatively small populations of these species as part of this study is undesirable, and therefore non-destructive sampling methods are preferred.

The second challenge is that some species may be feeding in areas outside the area of project effects. Previous studies (Frenzel 2000, ADEC 2012) have shown that methylmercury concentrations may vary greatly between water bodies. Species that feed in more than one area may therefore be exposed to widely varying methylmercury dietary loads that are not specific to the inundation zone.

To compensate for these problems, the proposed study will:

1. Utilize data obtained in other studies on background concentrations of methylmercury in natural northern environments.

2. While methylmercury concentrates in the muscle and liver of various species, studies have found that it is also found in the feathers and the fur, where it does not degrade quickly (Thompson, 1996; Strom 2008). These types of samples can be collected without harvesting or even harassing the species being sampled.

For this study feathers will be collected from nests of raptors (principally bald eagles, given that ospreys are rare in the study area), loons, grebes, arctic terns, and kingfishers found during the wildlife surveys planned for 2013 and 2014. Feathers from raptors and water birds will only be collected after the nests have been vacated for the season, which typically occur in August. Kingfisher feathers will be collected from borrows during the planned survey of colonially nesting swallows. The feathers will be characterized by type, and species of bird sampled. To the extent possible the feathers will be segregated to those that came from adults or juveniles. It should be noted that samples may contain feathers from more than one individual. Samples will be placed in sealed plastic bags and labeled with the date, time, location, species sampled, and type of feather collected.

Nearly 100% of the mercury in feathers is in the form of methylmercury (Thompson and Furness, 1989) and represent body burdens at the time of feather growth (Scheuhammer, 1987). For this reason, the feathers collected will only be analyzed for total mercury. Feather mercury concentrations are also positively correlated with mercury concentrations in other tissues (Ohlendorf and Harrison, 1986, Spalding et al., 2000, Ackerman et al., 2007, Tsao et al., 2009).

Fur samples from river otters and mink will be sought from animals harvested by trappers in the study area; river otter furs must be presented to ADF&G for sealing, at which time fur samples can be obtained from animals known to have been harvested in or near the study area. In view of the low level of trapping expected to occur in the area, however, it is possible that this approach will yield few samples. If this approach does not yield fur samples in 2013, fur will be collected by placing hair-snag “traps” at or near the mouths of tributaries near the proposed dam site, including Fog, Deadman, Watana, Tsusena, Kosina, Jay, and Goose creeks, and the Oshetna River. It is possible that fur collected from snags may represent a mix of individuals or a particular species. The fur will be characterized by species. To the extent possible the fur will be segregated to those that came from adults or juveniles.

Samples will be placed in sealed plastic bags and labeled with the date, time, location, species sampled, and type of fur collected. Nearly 100% of the mercury in fur is in the form of methylmercury. For this reason, the fur collected will only be analyzed for total mercury.

Feather and fur samples will be kept cold until shipment to the analytical lab. In the laboratory all fur samples will be weighed and cut into small pieces and homogenized. The samples will be analyzed using EPA Method 1631 (US EPA, 2001).

There is no minimum size for the feather or fur samples, but smaller size samples will result in higher detection limits. For 500 mg of mass, the MDL is 0.03 mg/kg (wet-weight). This will be the goal for all samples.

Fish Tissue

Methylmercury is ubiquitous in the environment, and can be found in fish throughout Alaska. The primary concern of this study is not to catalogue this source of mercury in the environment; rather, it is to evaluate the potential for increasing mercury concentrations above background due to filling of the reservoir.

Methylmercury bioaccumulates, and the highest concentrations are typically in the muscle tissue of adult predatory fish. Targeting adult fish is a good way of monitoring methylmercury migration to the larger environment. While it may be possible for methylmercury generated by the reservoir to affect other species, there does not appear to be any pathway by which this could happen without also affecting fish.

Target fish species in the vicinity of the Susitna-Watana Reservoir will be Dolly Varden, arctic grayling, stickleback, long nose sucker, lake trout, whitefish species, burbot, and resident rainbow trout. If possible, filets will be sampled from seven adult individuals from each species. The larger number of samples from existing fish species will allow for some statistical control over the results.

Salmon will not be sampled. Preliminary data suggests that approximately 30 Chinook (king) salmon spawn in the Watana area. Collecting a sufficient number of samples from this resource would seriously deplete it. Instead, sampling data from ADEC will be used to evaluate mercury concentrations in this resource (ADEC 2012). It should be noted that most of the mercury in salmon is oceanic in origin.

There is a well-known positive correlation between fish size (length and weight) and mercury concentration in muscle tissue (Bodaly et al. 1984; Somers and Jackson 1993). Larger, older fish tend to have higher mercury concentrations. These fish will be the targets for sampling.

Body size targeted for collection will represent the non-anadromous phase of each species life cycle. For stickleback, whole fish samples will need to be used. Collection times for fish samples will occur in late

August and early September. Samples will be analyzed for methyl and total mercury (Tables B1-1). As previously stated, the study is prejudiced toward finding fish with the highest mercury concentrations that are drainage-specific.

Liver samples will also be collected from burbot and analyzed for mercury and methylmercury.

Field procedures will be consistent with those outlined in applicable Alaska State and/or EPA sampling protocols (USEPA 2000). Clean nylon nets and polyethylene gloves will be used during fish tissue collection. Species identification, measurement of total length (mm), and weight (g) will be recorded, along with sex and sexual. If possible, efforts will be made to determine the age of the fish, including an examination of otoliths and scales.

It is possible that adult fish of all species may not be present or available in the drainage. In this case, younger fish may be sampled. To eliminate the bias associated with differences in fish size, appropriate statistical procedures will be used to determine the mean mercury concentration for a specific fish size (Hydro Quebec 2003).

Water Sample Processing

Field equipment used for collection, measurement, and testing will be subject to a strict program of control, calibration, adjustment and maintenance. The Kemmerer sampler or tygon tubing/pump used to collect surface water samples will be routinely inspected to verify that it is working properly. The Van Veen grab sampler used to collected sediment sample will also be routinely inspected. Routine maintenance of all sample equipment will be conducted prior to each sampling event. Maintenance will include a visual inspection that all parts are present, attached correctly and devoid of any obvious contamination. The project manager will coordinate ordering replacement parts and repairing samplers. Spare sampling equipment will be available on-site in case of primary equipment failure.

QA/QC and Blank Samples and Frequency

Quality control activities in the field will consist of the following items:

- Adherence to documented procedures in this SAP and the companion QAPP;
- Cross-checking of field measurements and recording to ensure consistency and accuracy; and
- Comprehensive documentation of field observations, sample collection and sample identification information.

Multiple field quality control samples will be collected: one blind field duplicate sample will be collected for every ten sites sampled and sent to the laboratory to test for precision (e.g., repeatability) of analytical procedures. A trip blank will be submitted to the lab to ensure that equipment handling and transport procedures do not introduce contamination to transported project samples. Rinsate blanks will be collected at different periods throughout the program to assure that cross-contamination between samples does not occur.

B 3.0 SAMPLE DOCUMENTATION AND SHIPPING

Field Logbook and Field Log Forms

Thorough documentation of all field sample collection is necessary for proper processing of data and, ultimately, for interpreting study results. Field sample collection will be documented in writing, on forms, as well as on the following forms and labels:

- A field log notebook for general observations and notes

- A Field Data Record Form that contains information about observations and measurements made and samples collected at the site
- Checklists for each sampling event, sampling point, and sampling time.

Copies of the field log books and physical characterization/water quality/sediment data sheets and sampling checklists will be supplied to the Field Project Managers at the close of each sampling event. These data will be used in conjunction with inspection checklists to compile the sampling event reports. Formal reports that are generated from the data will be subject to technical and editorial review before submission to AEA, and will be maintained at Tt's Seattle, WA, office in the central file (disk and hard copy). The data reports will include a summary of the types of data collected, sampling dates, and any problems or anomalies observed during sample collection.

Samples will be documented and tracked on Field Data Record forms, Sample Identification labels, and Chain of Custody records. The Field Task Leaders (one for each team) will be responsible for ensuring that these forms are completed and reviewed for correctness and completeness by the designated field QC Officer. Tt will maintain copies of these forms in the project files. A sampling report will be prepared following each sampling event. Another person will manually check data entered into any spreadsheet or other format against the original source to ensure accurate data entry. If there is any indication that requirements for sample integrity or data quality have not been met (for samples or measurements collected by Tt), the Tt QAO will be notified immediately (with an accompanying explanation of the problems encountered).

Photographic Records

Recording of sampling locations will be documented with photographs using a conventional photo-point procedure. Photographs will be taken at each sampling location and the photograph number and the associated date, description of the photograph, site identification number and GPS coordinates will be recorded in the photographic log. The photos will be stored as digital images and maintained as files, as appropriate, in repositories for information and data used in preparing any reports and documents during the project. Digital photos will be submitted with an index for each set of photographs, identifying the project, site identification number and a description of the photograph.

B 4.0 SAMPLE HANDLING AND CUSTODY

Field Data Recording

In-situ field data measurements will be recorded immediately following collection, both, electronically (stored within Hydrolab Surveyor) and on a field data sheet for each station. Field data sheets will be printed on *Rite in the Rain* paper. Promptly following each sample event, scanned copies of field data sheets will be made and stored electronically.

Each sample bottle will have a waterproof sample identification label, tag, or permanent marker identification. All sample bottles will be labeled with an indelible marker before the time of collection. Sample labels will include station designation, date, time, collector's initials, and sample/analysis type. Special analyses to be performed and any pertinent remarks will also be recorded on the label.

Sample Packaging and Shipping Requirements

Samples for laboratory analysis will be collected in containers appropriate for the analytes of interest, filtered if necessary and will be properly preserved until delivery to the analytical laboratory. All samples will be immediately placed in coolers and packed with gel ice after sampling and will remain chilled to

4°C (±2°C) during transportation to the contract laboratory. All samples will be accompanied with completed chain-of-custody forms when shipped, and coolers will be sealed with signed and dated fiber tape for shipment. Tetra Tech maintains specific SOPs (Standard Operating Procedures) for sample chain of custody, sample shipping, and supporting sample documentation.

Chain of Custody

Chain of custody (COC) can be defined as a systematic procedure for tracking a sample or datum from its origin to its final use. Chain of custody procedures is necessary to ensure thorough documentation of handling for each sample, from field collection to data analysis. The purpose of this procedure is to minimize errors, maintain sample integrity, and protect the quality of data collected.

A data sample is considered to be under a person's custody if it is:

- In the individual's physical possession
- In the individual's sight
- Secured in a tamper-proof way by that person, or
- Secured by the person in an area that is restricted to authorized personnel.

Elements of chain-of-custody include:

- Sample identification
- Security seals and locks
- Security procedures
- Chain-of-custody record

The analytical laboratory will provide blank COCs with each bottle order and provide scanned copies of finished COCs with sample results.

B 5.0 ANALYTICAL METHODS

This study will employ both field measurements and collection of samples to be analyzed in the laboratory. Field and laboratory analytical procedures will follow U.S. EPA (1983, 1991) or APHA *et al*. (1998) methods. The expected detection or reporting limits for field parameters and laboratory analyses are listed in Table A4-1 along with the anticipated analytical method.

Field Sampling Decisions

Damage to equipment from wildlife, physical forces of the river, or equipment failure will be addressed using the following protocol. Field sampling decisions to deviate or modify field sampling locations or methods will only be made with the approval of the field crew chief. The field crew chief will document the decision on the field note sheets, and email a copy of the sheet or telephone the information to the study manager. If the field decision is large enough in scale to significantly affect the study's data, scope, schedule or budget, the field crew chief is authorized to stop work until further contact and coordination with the study manager can be performed.

Laboratory Operations Documentation

Laboratory data results will be recorded on laboratory data sheets, bench sheets and/or in laboratory logbooks for each sampling event. These records as well as control charts, logbook records of equipment maintenance records, calibration and quality control checks, such as preparation and use of standard solutions, inventory of supplies and consumables, check-in of equipment, equipment parts and chemicals will be kept on file at the laboratory.

Any procedural or equipment problems will be recorded in the field notebooks. Any deviation from this Sampling and Analysis Plan will also be noted in the field notebooks. Data results will include information on field and/or laboratory QA/QC problems and corrective actions.

Standard turnaround time for the analytical samples taken to the contract laboratory will be seven to ten working days and will not exceed twenty-two working days for reporting of data.

Chain-of-custody forms will be kept with the sample during transport and will accompany data results back to Tt and AEA. Training records and data review records will be kept on file at Tt and the contract laboratory and will be available on request. All sample analysis records and documents are kept at the contract laboratory and will be available to AEA for inspection at any time. In addition to any written report, data collected for the project will be provided electronically via a CD-ROM or e-mail ZIP file format.

All records will be retained by the contract laboratory for five years. All project records at Tt are retained permanently.

B 6.0 QUALITY CONTROL

Data quality is addressed, in part, by consistent performance of valid procedures in this SAP/QAPP. It is enhanced by the training and experience of project staff and documentation of project activities .This QAPP including its appendices will be distributed to all sampling personnel. A QC Officer (or equivalent) will ensure that samples are taken according to the established protocols and that all forms, checklists, and measurements are recorded and completed correctly during the sampling event.

Measurement performance criteria for data to be collected during this project are discussed in the following sections.

Precision

Precision is a measure of internal method consistency. It is demonstrated by the degree of mutual agreement between individual measurements or enumerated values of the same property of a sample, usually under demonstrated similar conditions. The usability assessment will include consideration of this condition in evaluating field measures from the entire measurement system. Although precision evaluation within 20 percent relative percent difference (RPD) are generally considered acceptable for water quality studies and analyses, no data validation or usability action will be taken for results in excess of the 20 percent limit (unless RPD is specified as acceptable when >20%). Instead, the results will be noted and compared with the balance of the parameters analyzed for a more comprehensive assessment before any negative assessment, disqualification, or exclusion of data.

This QC calculation also addresses uncertainty due to natural variation and sampling error. Precision is calculated from two duplicate samples by RPD as follows:

$$RPD = \frac{|C_1 - C_2|}{\overline{(C_1, C_2)}} \times 100\%$$

where C_1 = the first of the two values and C_2 = the second of the two if precision is to be calculated from three or more replicate samples (as is often the case in laboratory analytical work), the relative standard deviation (RSD) will be used and is calculated as

$$RSD = \frac{s}{\overline{\chi}}$$

where χ is the measured value of the replicate sample and *s* is the standard deviation and is determined by the following equation:

$$SD = \sqrt{\frac{\sum_{i=1}^{n}\left(\chi_i - \overline{\chi}\right)^2}{n-1}}$$

where χ_i is the measured value of the replicate, $\overline{\chi}$ is the mean of the measured values, and *n* is the number of replicates.

Accuracy

Accuracy is defined as the degree of agreement between an observed value and an accepted reference or true value. Accuracy is determined by using a combination of random error (precision) and systematic error (bias) due to sampling and analytical operations. Bias is the systematic distortion of a measurement process that causes errors in one direction so that the expected sample measurement is always greater or lesser to the same degree than the sample's true value. EPA now recommends that the term *accuracy* not be used and that *precision* and *bias* be used instead.

Because accuracy is the measurement of a parameter and comparison to a *truth*, and the true values of environmental physicochemical characteristics cannot be known, use of a surrogate is required. Accuracy of field measurements will be assumed to be determined through use of precision.

Accuracy of data entry into the project database will be controlled by double-checking all manual data entries.

Representativeness

Data representativeness is defined as the degree to which data accurately and precisely represents a characteristic of a population, parameter, and variations at a sampling point, a process condition, or an environmental condition. It therefore addresses the natural variability or the spatial and temporal heterogeneity of a population. The number of sampling points and their location within the study area were selected from a random draw to ensure that representative sample collection of each area of the watershed and each assessment characteristic occurs.

Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and entered into the data management system. To achieve this objective, every effort is made to avoid accidental or inadvertent sample or data loss. Accidents during sample transport or lab activities that cause the loss of the original samples will result in irreparable loss of data. Lack of data entry into the database will reduce the ability to perform analyses, integrate results, and prepare reports. Samples will be stored and transported in unbreakable (plastic) containers wherever possible. All sample processing (subsampling, sorting, identification, and enumeration) will occur in a controlled environment within the laboratory. Field personnel will assign a set of continuous identifiers to a batch of samples. Percent completeness (*%C*) for measurement parameters can be defined as follows:

$$\%C = \frac{V}{T} \times 100\%$$

where V = the number of measurements judged valid and T = the total number of measurements planned.

For this project, sampling will be considered complete when no less than 90 percent of the samples collected during a particular sampling event are judged valid.

Comparability

Two data sets are considered to be comparable when there is confidence that the two sets can be considered equivalent with respect to the measurement of a specific variable or group of variables. Comparability is dependent on the proper design of the sampling program and on adherence to accepted sampling techniques, and QA guidelines.

B 7.0 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Periodic regular inspection of equipment and instruments is needed to ensure the satisfactory performance of the systems. Equipment to be used during the sampling event is listed in the appropriate SOPs. Before any piece of sampling or measurement equipment is taken into the field, it will be inspected to ensure that the equipment is appropriate for the task to be performed, all necessary parts of the equipment are intact, and the equipment is in working order. In addition, the equipment will be visually inspected before its use. Broken equipment will be labeled “DO NOT USE” and returned to the Tt office to receive necessary repairs, or it will be disposed of. Backup field equipment will be available during all field activities in the event of equipment failure.

The objective of preventive maintenance is to ensure the availability and satisfactory performance of the measurement systems. All field measurement instruments will receive preventive maintenance in accordance with the manufacturer’s specifications.

B 8.0 INSTRUMENT CALIBRATION AND FREQUENCY

Calibrated field instruments will be used for in-field, instantaneous measurement of temperature, DO, conductivity, salinity, pH, and redox potential. Instruments will be calibrated in accordance with manufacturer’s specifications and as described in the measurement SOPs. The SOPs include pre- and post-calibration verification on each sampling date. Verification of pH measurement accuracy will be checked against standard solutions in the field and adjustments made to the meter prior to the next measurement, if necessary.

The calibration of temperature, DO, conductivity/salinity, and pH probes will be checked before and after each sampling event, or as deemed necessary by the multiprobe’s manufacturer, using certified standard solutions. Field calibrations will be recorded in the field sampling log book. Individual sensors will be considered to be operating correctly if the instrument reading is within 15 percent of the calibration standard value. If the two values are not within 15 percent of each other, the probe will be cleaned and recalibrated. If these two values are still not within 15 percent of each other following cleaning and recalibration, the probe itself will be replaced.

B 9.0 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Supplies and consumables are those items necessary to support the sampling and analysis operation. They include bottleware, calibration solutions, hoses, decontamination supplies, preservatives, and various types of water (e.g., potable, deionized, organic-free). Upon delivery of supplies, field crews will ensure that types and quantities of supplies received are consistent with what was ordered, and with what is indicated on the packing list and invoice for the material. If any discrepancies are found, the supplier will be contacted immediately.

While preparing for specific sampling events, the field sampling Task Leaders will be responsible for acquiring and inspecting materials and solutions that will be used for obtaining the samples for field measurements. Other materials must also meet specific requirements as indicated by the appropriate manufacturer; for example, only certified standard solutions will be used for the multiprobe calibration. Buffers and standards will be checked for expiration dates and appearance (correct color).

B 10.0 NONDIRECT MEASUREMENTS

Comparison of data collected during this field effort to historical data will be used for qualitative assessment only. Assessment of applicability for historical data is outside the scope of this document and is not addressed further in this data collection QAPP.

B 11.0 DATA MANAGEMENT

Samples will be documented and tracked on Field Data Record forms, Sample Identification labels, and Chain of Custody records. The Field Task Leaders (one for each team) will be responsible for ensuring that these forms are completed and reviewed for correctness and completeness by the designated field QC Officer. Tt will maintain copies of these forms in the project files. A sampling report will be prepared following each sampling event. Another person will manually check data entered into any spreadsheet or other format against the original source to ensure accurate data entry. If there is any indication that requirements for sample integrity or data quality have not been met (for samples or measurements collected by Tt), the Tt QAO will be notified immediately (with an accompanying explanation of the problems encountered).

Hard copy data packages will be paginated, fully validated raw data packages that include an analytical narrative with a signed certification of compliance with this QAPP and all method requirements; copies of Chain of Custody forms; sample inspection records; laboratory sample and QC results; calibration summaries; example calculations by parameter; and copies of all sample preparation, analysis, and standards logs adequate to reconstruct the entire analysis. The CD-ROM data will include a full copy of the paginated report scanned and stored in portable document format (PDF) for potential future submission to the client, if requested, and for long-term storage in the project files. Initially, the full raw data package will be submitted to the Tt QAO for assessment of compliance with the program goals and guidance.

All computer files associated with the project will be stored in a project subdirectory by Tt (subject to regular system backups) and will be copied to disk for archive for the 5 years subsequent to project completion. The data may eventually be stored using a State data management system specified Alaska Department of Environmental Conservation.

C. ASSESSMENTS AND OVERSIGHT

C 1.0 ASSESSMENT AND RESPONSE ACTIONS

The QA program under which this task order will operate includes technical system audits, with independent checks of the data obtained from sampling, analysis, and data-gathering activities. Tt will review the QA programs that subcontractors follow to ensure similar levels of QA and QC are attained. The essential steps in the QA program are as follows:

- Identify and define the problem
- Assign responsibility for investigating the problem
- Investigate and determine the cause of the problem
- Assign and accept responsibility for implementing appropriate corrective action
- Establish the effectiveness of and implement the corrective action
- Verify that the corrective action has eliminated the problem

Many of the technical problems that might occur can be solved on the spot by the staff members involved; for example, by modifying the technical approach, repairing instrumentation that is not working properly, or correcting errors or deficiencies in documentation. Immediate corrective actions form part of normal operating procedures and are noted in records for the project. Problems not solved this way require more formalized, long-term corrective action. If quality problems that require attention are identified, Tt or the subcontractor will determine whether attaining acceptable quality requires short- or long-term actions. If a failure in an analytical system occurs (e.g., performance requirements are not met), the appropriate QC Officer or subcontractor QA Manager will be responsible for corrective action and will immediately inform the Tt PM or QAO, as appropriate. Subsequent steps taken will depend on the nature and significance of the problem.

The Tt Technical Lead has primary responsibility for monitoring the activities of this project and identifying or confirming any quality problems. These problems will also be brought to the attention of the Tt QAO, who will initiate the corrective action system described above, document the nature of the problem, and ensure that the recommended corrective action is carried out. The Tt QAO has the authority to stop work on the project if problems affecting data quality require extensive effort to resolve and are identified.

The AEA PM and Tt Technical Lead will be notified of major corrective actions and stop work orders. Corrective actions might include the following:

- Re-emphasizing to staff the project objectives, the limitations in scope, the need to adhere to the agreed-upon schedule and procedures, and the need to document QC and QA activities
- Securing additional commitment of staff time to devote to the project
- Retaining outside consultants to review problems in specialized technical areas
- Changing procedures
- The Tt Technical Lead may replace a staff member or subcontractor, as appropriate, if it is in the best interest of the project to do so.
- The Tt QC Officers are responsible for overseeing work as it is performed and periodically conducting checks during the data entry and analysis phases of the project. As data entries, calculations, or other activities are checked, the person performing the check will sign and date a hard copy of the material or complete a review form, as appropriate, and provide this documentation to the Tt Technical Lead for inclusion in the project files. Field audits and technical system audits will not be conducted under this task order.

C 2.0 QA REPORTS TO MANAGEMENT

A draft data report will be prepared and forwarded to the AEA for data analysis completed during winter 2013.

The report will include the following:

- Description of the project purpose, goals, and objectives.
- Map(s) of the study area and sampling sites.
- Descriptions of field methods.
- Discussion of data quality and the significance of any problems encountered in the analyses.
- Summary tables of field data.
- Observations regarding significant or potentially significant findings.
- Recommendations based on project goals.

D. DATA VALIDATION AND USABILITY

D 1.0 DATA REVIEW, VERIFICATION, AND VALIDATION

Data validation and review services provide a method for determining the usability and limitations of data and provide a standardized data quality assessment. All Field Data forms will be reviewed by the Tt Technical Lead and Field Task Manager (assisted by the QAO, as needed) for completeness and correctness. Tt will be responsible for reviewing data entries and transmissions for completeness and adherence to QA requirements. Data quality will be assessed by comparing entered data to original data or by comparing results to the measurement performance criteria summarized in Section 4.0 to determine whether to accept, reject, or qualify the data. Results of the review and validation processes will be reported to the Technical Leads.

D 2.0 VERIFICATION AND VALIDATION METHODS

The Tt Technical Leads or designee will review all Field Data Record forms. The Tt QAO will review a minimum of 5 percent of the Field Data Record forms and other records. Any discrepancies in the records will be reconciled with the appropriate associated field personnel and will be reported to the Tt Technical Leads. The AEA PM will be consulted with deficiencies, observations, and findings, as well as with corrective action and technical directive recommendations for consideration and approval.

Data verification requires confirmation by examination or provision of objective evidence that the requirements of these specified QC acceptance criteria are met. Each step of the data collection and analysis process must be evaluated and its conformance to the protocols established in this QAPP verified, including:

- Sampling design
- Sample collection procedures
- Data analysis procedures
- Quality control
- Data format reduction and processing data

Validation involves detailed examination of the complete data package using professional judgment to determine whether the established procedures were followed. Validation will be done by the Study Lead.

Tetra Tech and URS managers for the project will review all results to verify that methods and protocols specified in this QAPP were followed; that all instrument calibrations, quality control checks, and intermediate calculations were performed appropriately; and that the final reported data are consistent, correct, and complete, with no omissions or errors.

Evaluation criteria will include the acceptability of instrument calibrations and precision data and the appropriateness of assigned data qualifiers, if any.

The study lead will review the data packages and companion field notations to determine if the results met the MQOs for bias, precision, and accuracy for that sampling interval (monthly) and to ensure that all analyses specified on the "Chain of Custody" form were performed. Based on these assessments, the data will either be accepted, accepted with appropriate qualifications, or rejected.

After the field data have been reviewed and verified by the project manager, they will be independently reviewed by QA officer for errors before closing out the study. The initial data review will consist of a 10 percent random sampling of the project data. If any errors are discovered during the initial data review, a full independent review will be undertaken QA officer.

D 3.0 RECONCILIATION WITH USER REQUIREMENTS

As soon as possible following completion of the sample collection and analyses, Tt will assess the precision, accuracy, and completeness measures and compare them with the criteria discussed in Section A 4.0. This will be the final determination of whether the data collected are of the correct type, quantity, and quality to support their intended use for this project. Any problems encountered in meeting the performance criteria (or uncertainties and limitations in the use of the data) will be discussed with the project QA personnel and the AEA PM, and will be reconciled if possible.

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ATTACHMENT 5-4

GLOSSARY OF TERMS AND ACRONYMS – WATER QUALITY

Glossary of Terms and Acronyms
Water Quality

ADEC:	Alaska Department of Environmental Conservation.
Advection:	Advection is a transport mechanism of a substance by a fluid due to the fluid's bulk motion.
AEIDC:	Arctic Environmental Information and Data Center.
Anadromous fisheries:	Fish that migrate between the ocean and freshwater.
Anoxic:	Without oxygen.
APA:	Alaska Power Authority.
Aquatic:	Relating to water; living in or near water, or taking place in water.
AWQS:	Alaska Water Quality Standards (18 ACC 70.020(b)).
Benthic:	Living and feeding in the sediment at the bottom of a water body.
Bioabsorption:	Uptake of nutrients or contaminants by organisms.
Bioavailable:	The availability nutrients or contaminants for biological uptake.
Bioaccumulation:	The accumulation of contaminants in organisms over time.
Biomagnification:	The concentration of contaminants in higher trophic lives of the ecosystem over time.
BW:	Body weight of an animal.
Channel geometry:	Shape of a river or stream channel.
Chlorophyll-a:	A type of chlorophyll that is most common in photosynthetic organisms such as higher plants, red and green algae.
Coefficient:	Multiplicative factor in a mathematical equation.
Cohesive sediment:	Sediment particles composed primarily of clay-sized materials which stick together due to their surface ionic charges. Many pollutants, such as heavy metals, pesticides, and nutrients preferentially adsorb to cohesive sediments. In addition the sediments themselves are sometimes a water quality concern due to turbidity.
Cross-section:	A section formed by a plane cutting through an object, usually at right angles to an axis.
CWA:	Clean Water Act, the federal law that protects water quality in the United States.
D:	Daily intake. This is the amount of a contaminant that an organism is exposed to per day on a body weight basis.
Deciduous:	Trees or shrubs that lose their leaves seasonally.

Demethylation	Conversion of methylmercury to other forms of mercury.
Dissolved/particulate Partitioning:	Water quality parameters can be associated with solid, inorganic particles or appear as a dissolved form in surface water. This reference is typical for nutrients where parameters like phosphorus are either measured as a dissolved form in water or are part of a larger "clump" of material suspended in the water column. Partitioning is accomplished by filtering (typically 45µ pore size) to differentiate dissolved from particulate forms.
Divalent mercury:	Hg(I) and Hg(II) or Hg2+ are mercury compounds commonly found in nature, including mercuric sulphide (HgS), mercuric oxide (HgO) and mercuric chloride ($HgCl^2$). Some mercury salts, such as mercury chloride, form a vapor and can be transported in the air.
DOC:	Dissolved oxygen content.
Drawdown zone:	The area of the shoreline periodically submerged and exposed to air during operations of a reservoir.
EFDC:	Environmental Fluid Dynamics Code. A modeling program for water bodies.
EPA:	Environmental protection agency.
EPC:	Exposure point concentration. This is the amount of a contaminant per kilogram in a food source.
Eutrophication:	The ecosystem response to the addition of artificial or natural substances, such as nitrates and phosphates, to an aquatic system.
Evapotranspiration:	The sum of evaporation and plant transpiration from the Earth's land surface to atmosphere.
EWI:	Equal width increment method. A sampling device is lowered and raised at a uniform rate through equally-spaced vertical increments in a river cross-section. It is a flow-integrated sampling technique employed by USGS.
Field duplicates:	Field duplicates are identical field samples obtained from one location at the same time. They are treated as separate samples throughout the sample handling and analytical processes. These samples are used to assess total error (precision) associated with sample heterogeneity, sample methodology, and analytical procedures. This procedure is useful in determining total (sampling and analytical) error because it evaluates sample collection, sample preparation, and analytical procedures.
FLIR:	Forward Looking Infra-Red.

Flow mixing: Moving water exhibits different flow patterns (e.g., isolated roughness, wake interference, and quasi-smooth) and these patterns influence predictability of water quality conditions within a model. This term refers to a rate of mixing that is included among other rates like heat flux and heat transport when calibrating a surface water temperature model.

F_{site}: Fraction of the total food ingestion that is ingested from a particular site.

g: Grams.

Grid spacing: The surface area of the waterbody is partitioned into “grids” and defined as various shapes. The EFDC model (Environmental Fluid Dynamics Code) can auto-generate shapes described as “curvilinear-orthogonol grids” that serve as cells within which a water quality prediction is made. The center of each grid is the point water quality is predicted by the EFDC model.

Groundwater upwelling: Groundwater driven springs that occur within water bodies. These help to regulate temperature and create thermal refugia for fish.

Heat flux: Heat flux or thermal flux is the rate of heat energy transfer through a given surface.

Heat transport: Same definition as for “heat flux”.

Herbivores: Organisms that eat only plants.

Hg_p: Mercury concentration in piscivorous muscle tissue.

Hg_{np}: Mercury concentration in non-piscivorous muscle tissue.

HSC curves: Habitat suitability criteria (HSC) curves are a component of instream flow modeling that links to the hydraulic flow model to create a habitat-flow relationship. HSC curves consist of an X-Y graph, with the X axis representing a range of water velocity, water depth, and substrate characteristics, while the Y axis represents the probability of use for a given value. Separate HSC curves are typically developed for each species by life stage and for each parameter; i.e. separate curves are developed for velocity, depth, and substrate.

Humus: An upper soil horizon rich in organic material.

HQ: Hazard quotient. This is the ratio of the average anticipated concentration of a contaminant and the known concentration were adverse effects can occur.

Hydrodynamics: Turbulence in water accounted for by basic equations in a water quality model that predict motion and movement of dissolved and solid particles in a 3-dimensional matrix.

Ice Dynamics:	Processes involving formation and breakup of ice in riverine and reservoir settings and how these events influence surface water conditions.
IF:	Intake factor. This is how much of a particular food source is consumed per kilogram of body weight by an organism each day.
ILP:	Integrated licensing process.
Indicator species:	A species that is particularly susceptible to a potential contaminants, and is considered as a stand in for the impacts to larger groups of organisms.
Inorganic mercury:	Metallic mercury and divalent mercury.
Inundation area:	Area that will be flooded in creating a reservoir.
Isokinetic:	Refers to flow properties of water that moves through a sampling device that maintains consistency between surrounding riverine flow with that moving through the sampling device.
FERC:	Federal energy regulatory commission.
LAET:	Lowest Apparent Effects Threshold. This is the lowest concentration of a compound in that can be tolerated by the majority of benthic organisms.
LC50:	Lethal concentration 50. Also sometimes called the median lethal dose. This is the standard measure of the toxicity of a specific concentration of an element or compound. It will kill half the population of a specific test-animal in a specified period of time. The lower the number, the more toxic the material. LC50 values cannot be directly extrapolated from one species to another.
Macroinvertebrates:	Macroinvertebrates are organisms without backbones, which are visible to the eye without the aid of a microscope. Aquatic macroinvertebrates live in water of lakes, rivers, and streams. Examples of macroinvertebrates include fly larvae, beetles, dragonfly larvae, aquatic worms, snails, leeches etc.
Mainstem:	The main channel of a large river.
Matrix spikes:	Matrix spike are environmental samples that are spiked in the laboratory or in the field with a known concentration of a target analyte to verify percent recoveries. Matrix spike and matrix spike duplicate samples are primarily used to check matrix interferences. They can also be used to monitor laboratory performance.
Matrix spike duplicates:	A duplicate of the matrix spike analyzed to check precision of the matrix spike analyses.
Mercury:	Mercury (Hg) is an element that occurs naturally in the environment. It exists in several different chemical forms.
MET:	Meteorological station. Used for recording weather conditions.

Metallic mercury:	Also known as elemental mercury or Hg^0, it is mercury in its pure, un-combined form. It is a shiny, silver-white metal that is liquid at room temperature. At room temperature metallic mercury slowly evaporates, forming a vapor.
Methylmercury:	Also known as organic mercury, MeHg, or CH3Hg+, it is mercury combined with a methyl group. It is formed when mercury is combined with carbon and other elements by natural anaerobic organisms that live lakes, rivers, wetlands, sediments, soils and the open ocean. Methylmercury is not readily eliminated from organisms, and is biomagnified in aquatic food chains.
NELAP:	National Environmental Laboratory Accreditation Program.
NMFS:	National Marine Fisheries Service.
Omnivores:	Organisms that east both plants and animals.
Organometals:	Metals that easily bond with carbon. Common examples include mercury, iron, and copper.
Otoliths:	An otolith, also called statoconium or otoconium, is a structure in the saccule or utricle of the inner ear, specifically in the vestibular labyrinth of vertebrates. The layers on an otolith can be used to estimate the age of a fish.
pg/L:	picograms per liter.
P_i:	Total phosphorous from inflows (mg/yr.).
Pf:	Portion of the food consumed by an animal each day that contains a contaminant of concern.
P_r:	Concentration of total phosphorous in the reservoir at time t.
Peak increase factor:	Peak increase factor in fish of methylmercury over background concentrations.
Periphyton:	Periphyton are algae, cyanobacteria, heterotrophic microbes, and detritus that are attached to submerged surfaces in most aquatic ecosystems. It serves as an important food source for invertebrates and some fish. It can also absorb contaminants; removing them from the water column.
Phosphorus release model:	Decaying organic material releases phosphorous at a set rate.
Phosphorus cycle:	Movement of phosphorous through the environment.
Photodegradation:	Breakdown of a compound by light, usually sunlight.
Piscivorous:	Fish-eating.
Point/nonpoint sources:	Point sources are sources of water or contaminants that originate from a definitive place, for example a stream entering a reservoir. Nonpoint sources are from diffuse sources, for example rainfall or atmospheric deposition of dust.

Pore water:	Water that exists within the spaces of sediment.
Project:	The Susitna-Watana Dam project.
Q:	Mean annual flow.
QAPP:	Quality assurance project plan.
Radiant temperature:	Temperature of an object as measured using infrared radiation. This is just the surface temperature of an object.
Regression calculations:	A statistical method used to predict the behavior of a dependent variable. The result is an equation representing the relation between selected values of one variable (x) and observed values of the other (y). It allows the prediction of the most probable values of x based on the measured values of y.
Resident fisheries:	Non migrating fish.
Reservoir release temp.:	Temperature of water released from a reservoir.
Reservoir storage:	Amount of water stored in a reservoir.
Rinsate blanks:	Sample of water used to rinse field equipment to check if equipment was clean prior to sampling.
Riparian:	Relating to or living or located on the bank of a natural water body.
Riverine:	Located on or inhabiting the banks of a river.
RM:	River mile. Distance along the Susitna River, as measured from the mouth.
RSP:	Revised study plan.
SAP:	Sampling and analyses plan.
S_{max}:	Maximum surface area flooded by a reservoir.
Section 401:	Water Quality Certification process under the CWA.
Sediment:	Material deposited at the bottom of aquatic systems such as streams, rivers, and lakes.
Sediment diagenesis:	The sum of all the processes that bring about changes (e.g., composition and texture) in sediment. The processes may be physical, chemical, and/or biological in nature.
Sediment transport:	Movement of sediment in a water body.
Silica cycle:	Movement of silica through the environment.
Sloughs:	A side channel from a river. Commonly formed by migration of a river and its tributaries over time.
SNTEMP:	Modeling program used in the 1980s for the Susitna project.

Solar Degree Days:	The number of degree hours (heating and cooling) with respect to a standard reference temperature and totaled for the period of one day.
Speciated:	Determining the chemical form of various metals, for example chromium or mercury.
SPM:	Suspended particulate matter.
SQuiRT:	Screening Quick Reference Tables. These are thresholds developed by NOAA that are used as screening values for evaluation of toxics and potential effect to aquatic life in several media.
TDS:	Total dissolved solids.
Temperature Regime:	Spatial and temporal temperature patterns in the aquatic environment. Often used to refer to temperature patterns on a seasonal basis.
Thermal refugia:	Water temperatures have critical impacts on fish physiology, distribution, and behavior. At the limits of their thermal tolerance, fish may move to localized patches of colder or warmer water, known as thermal refugia. In Alaska this typically are areas of water bodies that stay relatively warm throughout the winter.
TIR:	Thermal infra-red.
TMDL:	Total maximum daily load.
TOC:	Total organic carbon.
TRV:	Toxicity reference value. This is the concentration of a contaminants where adverse ecological effects occur.
TSS:	Total suspended solids.
Transect measurements:	Measurements across a river, stream or other water body. Usually performed at right angles to flow.
Trophic level:	Relationship of different organisms in a food chain. For example, bacteria are grazed on by phytoplankton, which in are eaten by macroinvertebrates, which are fed on by fish. Each part of the food chain is considered to be a separate trophic level.
Turbidity:	The cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye.
TWG:	Technical Work Group.
µg/g:	Micrograms per gram. Also known as parts per million (ppm).
µm:	Micrometer.
USFWS:	U.S. Fish and Wildlife Service.
USGS:	U.S. Geological Survey.

V:	Reservoir volume in cubic meters.
Vertical stratification:	Vertical variations in a water body.
Water Quality Kinetics:	Transfer of water quality characteristics from one reach to another.
Zooplankton:	Heterotrophic organisms drifting in bodies of water.