* 1. Ice Processes in the Susitna River
	2. Requestor of proposed study

To be completed by the requesting entity.

* 1. Responses to study request criteria (18 CFR 5.9(b))
		1. Describe the goals and objectives of the study and the information to be obtained
* Document ice processes in the Susitna River.
* Model ice processes in the Susitna River downstream of the proposed Watana Dam Site in order to estimate the potential for changes for a range of project operations.
* Provide ice processes data to fisheries, in-stream flow, geomorphology, and riparian studies.
* Assist Water Quality Modeling Study with reservoir ice predictions.

	+ 1. If applicable, explain the relevant resource management goals of the agencies and Alaska Native entities with jurisdiction over the resource to be studied.

To be completed by the requesting entity.

* + 1. If the requester is a not resource agency, explain any relevant public interest considerations in regard to the proposed study.

If applicable, to be completed by the requesting entity.

* + 1. Describe existing information concerning the subject of the study proposal, and the need for additional information.

*Ice Process Documentation*

* Ice processes were documented between the mouth of the Susitna River (RM 0) and the dam site (RM 180) between 1980 and 1985. Both freeze-up and breakup progression were monitored using aerial reconnaissance. Locations of ice bridges during freeze-up and ice jams during breakup were recorded each season. One winter, a time-lapse camera was installed in Devil Canyon in order to observe ice processes through the narrow, turbulent rapids.
* Additional ice data were collected to calibrate a model. These included ice thicknesses, top of ice elevations, air and water temperatures, slush ice porosity, and frazil density.

* Other entities (National Weather Service, USGS, Army Corps of Engineers) have also collected ice thickness, breakup, and freeze-up data in various locations on the river, although these data were not collected for the purpose of understanding the potential effects of the dam. These data are available upon request from the agencies.

***Ice Process Modeling***

* Freeze-up and melt-out processes in the Middle River (between Gold Creek and Talkeetna) were modeled using ICECAL, a numerical model developed by CRREL. The model utilized the outputs from a temperature model developed for the river (SNTEMP), and empirical data on frazil production and ice-cover progression derived from observations. Both the Watana-only and Watana-Devil Canyon operations were modeled for a range of meteorological conditions. The results of the model included predictions of the extent of ice cover for cold, average, and warm winters, the timing of ice cover progression for this range, and the inundated area below the ice cover for selected cross-sections.

***Need for Additional Information***

* Additional documentation of ice processes is needed to verify that locations of ice bridges, leads, ice jams, and timing of ice cover progression are similar to conditions observed in the 1980s. Ice bridging, leads, and ice jams are all influenced by channel geometry, and, in some cases, tributary mouth locations. In some cases, this geometry may have changed. In addition, the location of early freeze-up season frazil production varied significantly between study years. An assessment is needed to determine the importance of the Upper and Middle Susitna River in frazil production for a range of meteorological conditions.
* The ICECAL Model only simulated conditions upstream of Talkeetna. Under the proposed operations scenario, winter discharges would be higher than the natural range of variability downstream of the three-rivers confluence in Talkeetna.
* The ICECAL Model did not simulate flow fluctuations with a time-period shorter than one week, whereas it is likely that daily flow fluctuations will be considered when determining project operations.
* Updated fish habitat and geomorphology studies are needed to assess where ice processes may be important. In addition, updated ice modeling is needed to assess where project effects on fish habitat, geomorphology and riparian vegetation may be concentrated.
* Details on reservoir ice processes for the current project configuration are not available.
	+ 1. Explain any nexus between project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements.

Project operations have the potential to directly influence ice formation and breakup in the following ways:

* Increased winter water temperature released from the reservoir will limit ice cover for some distance below the dam.
* The dam will restrict frazil ice produced in the upper basin from accumulating downstream. There is evidence that frazil ice from the upper river contributes to ice front progression on the lower river, thus the dam could slow ice cover progression in the lower river.
* Increased winter flows will result in a more extensive ice cover and winter water stages higher than the natural range of variability in the ice-covered reaches.
* Flow fluctuations in the winter have the potential to affect the stability of the winter ice cover.
* Lower spring snowmelt flows will reduce the severity of breakup on the Middle River. Higher water temperature releases from the reservoir may cause ice to thin and melt in place earlier.
* The reservoir area will behave differently than the narrow channel in the winter.

Indirect effects of increased winter stages and decreased breakup stages include the following:

* Sediment transport during the winter may increase with increased flows, as well as turbidity.
* Wetted perimeter will increase in the winter, and sloughs and side channels that are not currently connected to the mainstem under winter flow conditions may become inundated by mainstem flow. This could increase flow velocities and decrease temperatures compared to winter conditions in sloughs that are currently fed by seeps.
* There is some evidence that ice jams are partially responsible for creating and maintaining sloughs and some side channels in the Middle River. If ice-jam stages are generally lower post-Project because of delayed snowmelt peaks, slough habitats may experience less scour.

Utilizing the results of ice processes studies, modifications to Project operations to decrease the likelihood of adverse effects owing to altered ice processes can be evaluated. Operational modifications could include different reservoir release elevations to regulate temperature of flow releases, limitations on load-following flow fluctuations during the winter, and limitations on maximum winter flows.

* + 1. Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge.

Proposed study methods include the following:

* Aerial reconnaissance and GPS mapping of ice features, including ice jams, ice bridges, frazil accumulations, and open leads during the breakup and freeze-up periods, Spring 2012-Spring 2014.
* Time-lapse camera monitoring of breakup and freeze-up at selected locations corresponding to key fish habitat, in coordination with the fisheries studies.
* Field data collection for an updated modeling effort extending downstream of Talkeetna, including ice thickness and elevation measurements, Spring 2012-Spring 2014.
* Development and calibration of ice-process routines to augment the river temperature model, in coordination with the ice-processes studies. These routines would provide the ability to model ice cover progression and decay, ice cover extent and thickness, and the effects of flow fluctuation on ice cover development and stability between Sunshine Station and the dam site.
* Review and summary of existing cold-regions hydropower projects and the effects of their operations on ice-covered rivers.

Ice processes field observation standards follow those of EM-1110-2-1612, Ice Engineering, developed by the Army Corps of Engineers. Modeling of ice-cover progression is still a relatively underdeveloped field. Existing models will be reviewed for applicability to the Susitna River, and if needed, adapted to best describe the physics of a relatively wide, shallow river.

Describe 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.

Level of effort for field work will depend on the data needs of the chosen model, and related disciplines such as fisheries and geomorphology. Below is a rough estimate of costs associated with field documentation and model development in 2013-2014, which are the major components of the ice study.

* Documentation of ice observations is anticipated to cost $800,000-$1.3 million for the Spring 2013-Spring 2014 seasons (two breakup and one freeze-up, plus winter ice thickness and elevation surveys). This does not include costs for additional transect surveys to augment model geometry, if that data becomes necessary.
* Assuming a year-long modeling effort will be required, development and calibration of ice routines for the thermal and hydraulic model is anticipated to cost between $800,000 and $1.5 million. The cost will depend on the length of the modeled reach, and whether an existing ice model is purchased and used for both thermal and ice modeling, or new routines developed to dovetail with the thermal model.
	+ 1. Literature Cited

Arctic Environmental Information and Data Center. 1984, "Assessment of the Effects of the Proposed Susitna Hydroelectric Project on Instream Temperature and Fishery Resources in the Watana to Talkeetna Reach." Draft Report for Harza-Ebasco for Alaska Power Authority.

Harza-Ebasco, 1984, "Instream Ice Calibration of Computer Model. Document No. 1122. for Alaska Power Authority.

R&M Consultants, Inc ,1981. "Ice Observations. 1980-81." for Acres American for Alaska Power Authority.

R&M Consultants, Inc. 1982a. "Winter 1981-82, Ice Observations Report." for Acres American for Alaska Power Authority.

R&M Consultants, Inc., 1982b, "Hydraulic and Ice Studies." for Acres American for Alaska Power Authority.

R&M Consultants. Inc.,1983. "Susitna River Ice Study. 1982-83." For Harza-Ebasco for Alaska Power Authority.

R&M Consultants, Inc., 1984. "Susitna River Ice Study, 1983-84," Draft Report for Harza-Ebasco for Alaska Power Authority.

U.S. Army Corps of engineers, 2002, EM 1110-2-1612 Engineering and design, Ice Engineering. Department Of The Army. U.S. Army Corps of Engineers CECW-EH Washington, DC 20314-1000.