# Susitna-Watana Hydroelectric Project Document
# ARLIS Uniform Cover Page

| | |
|---|---|
| **Title:**<br>Water quality modeling study | **SuWa 150** |

**Author(s) – Personal:**

**Author(s) – Corporate:**
Alaska Energy Authority

**AEA-identified category, if specified:**
Aquatic and fish resources study requests

**AEA-identified series, if specified:**

| | |
|---|---|
| **Series (ARLIS-assigned report number):**<br>Susitna-Watana Hydroelectric Project document number 150 | **Existing numbers on document:** |
| **Published by:**<br>[Anchorage] : Susitna-Watana Hydroelectric Project, [2012] | **Date published:**<br>5/15/12 |
| **Published for:** | **Date or date range of report:** |
| **Volume and/or Part numbers:** | **Final or Draft status, as indicated:** |
| **Document type:** | **Pagination:**<br>7 p. |
| **Related work(s):** | **Pages added/changed by ARLIS:** |
| **Notes:** | |

**All reports in the Susitna-Watana Hydroelectric Project Document series include an ARLIS-produced cover page and an ARLIS-assigned number for uniformity and citability. All reports are posted online at http://www.arlis.org/resources/susitna-watana/**

## 1.1. Water Quality Modeling Study

## 1.2. Requestor of Proposed Study

AEA anticipates resource agencies will request this study.

## 1.3. Responses to Study Request Criteria (18 CFR 5.9(b))

### 1.3.1. Describe the goals and objectives of the study proposal and the information to be obtained

The collective goal of the water quality studies is to assess the effects of the proposed Project on water quality in the Susitna River basin and to identify and develop protection, mitigation, and enhancement measures that can be implemented to minimize these effects.

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

- Build upon and use, as appropriate, the historical water quality modeling results/data for the Project.

- Evaluate the 1980s water temperature model results and determine the applicability of the past results to the currently proposed Project.

- Identify appropriate reservoir and river water temperature models.

- Model expected water quality conditions in the proposed Watana Reservoir, including (but not necessarily limited to) temperature, dissolved oxygen (DO), suspended sediment and turbidity, chlorophyll *a*, nutrients, metals, and ice formation and breakup (unless a separate ice dynamics model is used).

- Model expected water quality conditions in the Susitna River from the proposed Watana Dam downstream, including (but not necessarily limited to) temperature, suspended sediment and turbidity, and ice processes (in coordination with the Ice Processes Study).

### 1.3.2. If applicable, explain the relevant resource management goals of the agencies and Alaska Native groups with jurisdiction over the resource to be studied

To be completed by requesting organization.

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

Fisheries resources are owned by the State of Alaska, and the Project could potentially affect these public interest resources by affecting water quality.

### 1.3.4. Describe existing information concerning the subject of the study proposal, and the need for additional information

Historical water quality data available for the study area include water temperature data collected during the 1980s. Some of these data will be evaluated as part of the 2012 Water Temperature Modeling Results and Data Collection study in an effort to determine what data will be most appropriate to use for the 2013 - 2014 water quality studies.

A data gap analysis was conducted for water quality and sediment transport in 2011 (URS et al. 2011). A detailed summary of results of the analysis is included in the data gap analysis report (URS, 2011). A few of the broader conclusions about water quality conditions based on existing data have been summarized in the Pre-Application Document (PAD) (AEA 2011).

Several conclusions from the data gap analysis were developed and 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. These are as follows:

- Lower Susitna River from Cook Inlet to the confluence of the Susitna, Chulitna, and Talkeetna rivers (River Mile [RM] 0-99).

  o Large amounts of data were collected in this reach during the 1980s. Very little data are available that describe current water quality conditions.

  o Metals data are not available for the mouth of Chulitna River. The influence of major tributaries (Chulitna and Talkeetna rivers) on water quality conditions is unknown. There are no monitoring stations in receiving water at these mainstem locations.

  o Metals data are not available for the Skwentna or Yentna rivers.

  o Continuous temperature data are not available for the mainstem and sloughs potentially used for spawning and rearing habitat.

- Middle Susitna River and tributaries from the confluence of the Susitna, Chulitna, and Talkeetna rivers to the mouth of Devils Canyon (RM 99-150).

  o Sources for metals detected at high concentrations in the Susitna River mainstem (1 location). Improvements to sampling would include consideration for increasing spatial coverage of sampling points to provide adequate representation of conditions.

  o Current data reflect large spatial data gaps between the upper river and the mid- to lower portion of the river.

  o Continuous temperature data are not available for the mainstem, tributaries, and sloughs potentially used for spawning and rearing.

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

  o Temperature data are not available above and below most tributaries on the mainstem Susitna River.

  o Overall, very limited surface water data are available for this reach.

  o Metals monitoring data do not exist or are limited.

  o Analysis of sediments for metals immediately below the proposed Project; sediments may become transportable once the Project begins operation.

  o Monitoring of mainstem and sloughs (ambient conditions and metals) needed for determining bioaccumulation potential of fishes.

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

---

- o Surface water and sediment analysis for metals not available for mainstem, only for one tributary.
- o 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.
- o Continuous temperature data are not available for the mainstem, tributaries, and sloughs potentially used for spawning and rearing.

**1.3.5. 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**

This study addresses some aspects of the following issues identified in the PAD (AEA 2011), for which existing information appears to be insufficient:

"WQ3: Water Quality Modeling Study" - Addresses potential effect of Project operations on temperature, turbidity, total dissolved/suspended solids, dissolved oxygen, pH, metals, and chemical/nutrient characteristics of the mainstem river downstream from the proposed Watana Dam Site (RM 184).

The Project's operations will modify the flow and water temperature regimes in the Susitna River downstream of the proposed reservoir. Reservoir operation and storage levels will affect water temperature in the reservoir and influence outflow water temperatures. Alteration of the baseline water temperature regime of the Susitna River is expected to modify baseline river ice conditions (which may affect channel morphology and riparian vegetation) and the suitability and productivity of aquatic habitats.

The results of the 2013–2014 water quality studies will be used as a basis to assess the effects of the proposed Project on water quality in the Susitna River basin and to identify and develop any necessary protection, mitigation, and enhancement measures related to water quality (including temperature), ice formation, and aquatic habitat in the reservoir and in Project-affected river reaches downstream of the dam.

**1.3.6. 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**

*1.3.6.1.    Water Quality Modeling Study*

To fully evaluate the effects of the proposed Project on conditions in the Susitna River, predictive models are necessary.

A memo will be prepared that lists potential water quality models, identifies key considerations for the selection of appropriate models, and recommends a modeling platform. In coordination with stakeholders, a final modeling platform will be selected and implemented. It is anticipated that a model with capabilities similar to the Environmental Fluid Dynamics Code (EFDC) will be implemented for the reservoir modeling and river modeling.

Reservoir modeling will focus on the length of the river from the expected upstream extent of reservoir inundation to the proposed dam location. It will involve first running the initial reservoir condition. This initial condition represents conditions in the absence of the dam. Subsequently, the model will simulate the proposed reservoir condition, i.e., with the dam in place.

Downstream of the proposed dam location a river model will be developed to evaluate the downstream effects of the proposed Project. 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 likely will extend to shortly downstream of the confluence of the Susitna, Talkeetna, and Chulitna rivers (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 to develop a model for predicting water quality conditions under various Project operation scenarios.

Several factors will be used to select a water quality model, which 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 United States Environmental Protection Agency and other public regulatory agencies.

- The model will be available for current and future use and remain available for the life of the Project and beyond (including upgraded versions).

### 1.3.6.2.    *Reservoir*

A multi-dimensional model will be used to address the spatial and temporal variability of hydrodynamics, temperature, and water quality processes within the reservoir. The model will be able to simulate flow circulation in the reservoir both horizontally and vertically, represent the initiation and completion of temperature stratification due to seasonal cycles, and represent the impact of different flow regimes and dam operations on internal temperature dynamics. In addition to hydrodynamics and temperature, the model will be able to simulate key water quality processes including the fate and transport of organic and inorganic nutrients, nutrient-algae-temperature interactions, total suspended solids (TSS), turbidity, and metals.

To develop the dynamic reservoir model, the following data need to be collected:

- Bathymetry information for the current river channel.

- Topographic information to represent the proposed reservoir.

- Upstream incoming flow rate (volumetric) at a daily frequency, inflow temperature (daily or hourly), inflow concentrations of dissolved oxygen (DO) (daily or hourly, Sonde data), chlorophyll *a* (bi-weekly), ammonia-N (bi-weekly), nitrate/nitrite (bi-weekly), total nitrogen (TN) (bi-weekly), dissolved total nitrogen (DTN) (bi-weekly), orthophosphate ($PO_4$) (bi-weekly), dissolved $PO_4$ ($DPO_4$) (bi-weekly), total phosphorous (TP) (bi-weekly), dissolved TP (bi-weekly), total organic carbon (TOC), dissolved organic carbon (DOC), turbidity (continuous at USGS sites and bi-weekly at additional locations required for calibrating the model), TSS (bi-weekly), and metals.

- Ice data (particularly the time period associated with ice cover).

- Major lateral incoming tributary flow rates (volumetric) at a daily frequency, inflow temperature (daily or hourly), inflow water quality in concentrations, and ice data (as noted above).

- Atmospheric boundary conditions near the reservoir area, including wind velocity and direction, air temperature, relative humidity, incident solar radiation, cloud cover, and precipitation data.

- Any information associated with groundwater impacts (e.g., key locations, estimated flow rate, temperature, DO, and nutrient concentrations).

Initial River Conditions

The model will first be run to represent conditions in the absence of the dam. This will provide a starting point for comparison of dam impacts. Existing data for the river will be used for calibration and validation of the model. Key calibration data include:

- Flow.

- Temperature.

- TP, TN, $NH_4$, $PO_4$, $NO_3$, TOC, and DO.

- TSS, turbidity, and metals.

Proposed Reservoir Condition

The model will then be configured to represent the presence of the dam and the reservoir. Configuration of this model will be dependent on engineering specifications for the dam and the inundated area. No monitoring data will initially be available for this configuration (given that the dam and reservoir do not yet exist); therefore, model parameter values from other representative modeling studies will be considered. A key consideration for reservoir modeling is ice dynamics. A description of ice processes from concurrent studies will be input to the reservoir model to account for the influence on temperature and other water quality parameters (e.g., pH, DO). The reservoir model will incorporate ice-associated model algorithms.

A series of scenarios will be run using the reservoir model to evaluate various management decisions associated with the proposed Project. The modeling will be conducted during summer and winter months to predict how Project operations affect water quality conditions. Modeling during winter months will inform the changes expected to occur in ice processes.

### 1.3.6.3.  River Downstream of Reservoir

A river model will be developed to evaluate the downstream effects of the proposed Project. The river model will be capable of representing conditions in both the absence and presence of the dam. 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). 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 fed into the downstream river model. This will enable the downstream impacts of the proposed Project on hydrodynamic, temperature, and water quality conditions to be directly evaluated.

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 to simulate water quality conditions for load following analysis. Organic carbon content from inflow sources will be used to correlate with mercury concentrations determined from the Water Quality Baseline Monitoring study and integrate with hypotheses from the toxics model that predict the potential for methylation of mercury in riverine and reservoir habitats.

Water temperature modeling and routing of fluctuating flows immediately prior to and during ice cover may be conducted with a separate thermodynamics-based ice processes model (e.g., CRISSP 1D).

### 1.3.6.4. *EFDC and Other Candidate Model Evaluation*

As noted above, EFDC, or a similar model, is a potential candidate for the modeling platform. Candidate models will be capable of simulating both rivers and reservoirs. Each must be a multi-dimensional dynamic model that includes hydrodynamics, water temperature, water quality, and sediment transport modules. 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 candidate model will have the ability to simulate an entire suite of water quality parameters. The water quality model will have 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 river downstream of the Project. This avoids the added complexity associated with transferring information among multiple models and increases the efficiency of model application.

## 1.3.7. Level of Effort and Cost

The cost and level of effort will be refined during the final study design. At this time, it is anticipated to be as follows:
- Planning ($50k)
- Model calibration/development ($400k)
- Workgroup Involvement ($150K)
- Model results/scenarios ($350k)
- Reporting ($200k)

## 1.3.8. Literature Cited

ADEC. 2005. Water Quality Assessment and Monitoring Program. Alaska Department of Environmental Conservation: Division of Water. Juneau, Alaska. 58p.

URS. 2011. AEA Susitna Water Quality and Sediment Transport Data Gap Analysis Report. *Prepared by* Tetra Tech, URS, and Arctic Hydrologic Consultants. Anchorage, Alaska. 62p.+Appendixes.