INTRODUCTION
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 Southcentral 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) will affect flow and sediment transport and delivery in the Susitna River downstream of the proposed dam site. Project operations may alter sediment transport conditions, and thereby potentially alter channel morphology downstream of the dam site, within the proposed reservoir, and in the channel immediately upstream of the reservoir. Because sediment transport is inherently variable in both space and time, collection of new sediment transport data to fill gaps and supplement existing data will be very useful to improving the accuracy of empirical sediment rating curves developed by the USGS from data collected in the 1980s.

STUDY OBJECTIVE
The study objective of the study is to collect and analyze suspended and bedload data at several locations in the River to determine the following:

- Bedload sediment rating curves.
- Suspended sediment rating curves.
- Particle size distribution curve for bedload sampled in transport.
- Particle size distribution curve for suspended sediment in transport.
- Monthly and annual bed and suspended sediment loads.
- Identification of the flow that corresponds with the reference sediment transport.
- Quantification of the sediment transport capacity at the effective discharge.

EXISTING INFORMATION
The data gap analysis for Water Quality and Sediment Transport (Tetra Tech/URS, Arctic Hydrologic Consultants 2011) identified studies for which bedload and suspended load data were collected in the 1980s. The data gap analysis found that there are no existing sediment rating
curves for the location where the Susitna River would enter Watana Reservoir. The most upstream 1980s measurement site (with both bedload and suspended load data) is the Gold Creek USGS gaging station (RM150), for which only three bedload measurements were obtained (at approximately 9,000, 25,000, and 40,000 cfs). Considering that annual peak discharges over the period of record for this measurement location range from a low of 25,000 to a high of 90,000 cfs, and the 2-year discharge at Gold Creek is 44,800 cfs, the bedload data collected in the 1980s should be supplemented at the higher flows (greater than approximately 40,000 cfs) to improve the USGS sediment rating curves (USGS, 1987) and associated bedload particle sizes in transport.

There are several 1980s sediment measurement locations downstream from the Gold Creek site on the Susitna River, including bedload samples collected at station 15292100 Susitna River near Talkeetna (RM ~100) about 5 miles above the three rivers confluence at discharges up to 46,000 cfs. Similar to the situation for the Gold Creek gaging location, inspection of the data indicates that there are very few measurements taken when flows were sufficiently high to obtain more useful data for quantifying sediment loads using an empirical sediment rating curve. An initial review of the flow range for bedload measurements for Susitna River at Sunshine (15292780) and at Susitna Station (15294350) indicate that measurements occurred at flows ranging from 1,600 cfs to 115,000 cfs, but these flows do not appear to equal the lowest peak annual flood recorded at either of those locations. There are other historical bedload and suspended load measurement sites on the Susitna River and on the tributaries.

STUDY AREA
The study area includes three sediment data collection sites that include: (1) Susitna River at Tsusena Creek (RM 182), which defines sediment load to the Watana Reservoir, (2) Susitna River at Gold Creek (RM 136), which defines sediment loads below the proposed dam site, about mid-way through the Middle River reach, and (3) Susitna River at Sunshine (RM 82), which is about 10 miles downstream of the three rivers confluence. Thus, the Sunshine site is a good location for measurement of the combined sediment input to the Lower River reach from the Talkeetna, Middle Susitna, and Chulitna Rivers.

METHODS
It is recognized that deployment of bedload and suspended samplers in the Susitna River is extremely difficult and potentially hazardous due to the depth, velocities, and floating debris that will be encountered. Boat and/or cable-way sampling platforms will be required. Additionally, construction of a cableway is likely to be necessary at the Tsusena site to perform bedload and suspended load sampling. Bedload sampling equipment may need to be customized for Susitna River conditions.

At each site a bedload, suspended load, and discharge measurement (unless there is ongoing daily gaging data collected near the site) will be made. Bedload (Helley-Smith) and suspended load measurement procedures would follow one of the standard sampling protocols that have long been used by the USGS (Guy and Norman, 1970). USGS equal-width increment procedures would most likely be used (Edwards and Glysson, 1999). Ideally, the Helley-Smith sampling at the higher discharges would be performed using a 6-inch sampler so that
the coarser, cobble size material is included. The 1980s measurements were performed using a 3-inch sampler which would have excluded cobble size material that may have been in transport. Measurements with a 6-inch sampler present a potentially greater safety issue whether sampling from a boat or cableway, and must therefore be cautiously tested.

Monthly measurements would be made in May, June, July, August, and September 2012 because sediment delivery and transport rates vary greatly between months. Ideally, a measurement for each site should be targeted to fall near the 1.5-year peak discharge, since these are likely to be the flows that over the long-term would transport the most sediment and maintain the channel form (effective discharge). The objective for obtaining some measurements in this 1.5-year peak flow range is to ensure that full rather than partial bedload transport is measured.

Flood frequency curves will be prepared for the measurement sites using existing gaging records to determine the targeted 1.5-year flow. For sites with little or no gaging record (i.e., Tsusena) flood magnitude and frequency extension estimation techniques, such as the use of a regional flood frequency curve, may be necessary. In addition to targeting a measurement at the 1.5-year flow, sediment measurements will be obtained at lower discharges that will help to define the reference sediment transport (see discussion under Nexus between Project and Resource to be Studied). This will mean that some measurements may be taken when coarse bedload movement is initiated.

Certain hydraulic information will also be collected while in the process of collecting bedload and suspended load data that would likely be needed in a later study stage for any transport modeling. These data would include channel cross-section (or wetted top width), water slope, discharge, and sediment grain size of transported material.

**ANALYSIS**

Sediment-transport rating curves for suspended and bedload material would be separately prepared from the data for each station. Since sediment rating curves exist for Susitna River at Sunshine in the 1980s, the 2012 data should be combined with the historical data to define new sediment rating curves. Sediment discharge computations for the monthly suspended and bedload fractions and for the 2012 water year sampling period would be calculated.

Bed and suspended sediment samples would be analyzed for particle size. The suspended samples will be analyzed at phi-intervals down to the sand-silt break (0.063mm). Bedload samples will be sieved at phi-intervals from the largest sizes potentially captured (< 150 mm cobbles to the gravel/sand break (2mm). Particle size statistics, (including D$_{50}$ D$_{65}$, D$_{85}$) for the suspended and bedload fractions will be calculated for each sampling event.

**NEXUS BETWEEN PROJECT AND RESOURCE TO BE STUDIED AND HOW THE RESULTS WILL BE USED**

Project operations will reduce the bed and suspended sediment load downstream of the dam site, and will alter the transport capacity of the Susitna River. Depending on the extent to which sediment load and transport capacity are altered, there could be potential effects on channel morphology. The balance between sediment supply and transport rate controls potential
changes in bed scour and aggradation, bed particle size, channel dimensions, and the river planform including the erosion or build-up of bars, meanders, banks, and floodplains. Understanding existing sediment loads and transport capacity along with the particle sizes transported, both upstream and downstream of the proposed dam site, is essential for predicting potential geomorphic changes.

Assuming that sediment transport modeling will be used to predict changes in the sediment transport capacity under Project operations, obtaining some field measurements in 2012, and combining them with the data from the 1980s, will provide calibration of transport formulae, which will greatly increase the accuracy of transport estimates. There are two key sediment transport measurement points: (1) the flow corresponding to the reference bedload sediment transport (i.e., the discharge at which bedload sediment begins to move and (2) sediment transport at the effective discharge (i.e., corresponding to the channel maintenance flow). Data collection for this study should be performed for both flows at which bedload sediments begin transport and at flows approaching the effective discharge. This is also a critical input for any future modeling calibration.

The effective discharge is the flow that corresponds to the sediment transport which maintains the channel morphology. This is generally accepted to be approximately the 1.5-year peak flow in fully alluvial channels. Quantifying the sediment load at the effective discharge can be used to compare and validate the output of a sediment transport model. Additionally, the sediment load at the effective discharge can be compared between the Upper, Middle, and Lower River reaches to determine how sediment load and transport capacity changes longitudinally along the river and to thereby predict change in channel morphology under Project operations.

Data collected under this study would be later used to calibrate a sediment transport model to predict changes in transport with Project operations in place. The difference in transport capacity between the empirical rating curves developed in this 2012 study in combination with the 1980s data, and the calibrated modeling, would quantify the effect of Project operations on sediment transport capacity. Additionally, bedload and suspended load contribution to Watana Reservoir would be used in a later study to calculate the rate of deposition in the reservoir.

Preliminary issues associated with bedload and sediment load identified in the PAD (AEA 2011), for which information appears to be insufficient, include:

- G1: Potential longevity of Watana Reservoir as a result of sediment entrapment based on present day particle sizes in transport.

- G2: Potential change in morphology at the upper end of the proposed reservoir resulting from sediment entrapment. Changes in the river morphology at the upper end of the reservoir may affect fish migration and habitat.

- G3: Potential effects of Project operations on mass wasting, shoreline erosion, tributary mouth migration, and stability within the reservoir inundation zone. These changes, to the extent they occur, would affect vegetation, fish and wildlife, and possibly, cultural resources.
• G5  Potential effects of reduced sediment load and changes to sediment transport as a result of Project operations within the Middle River. Streambed coarsening due to reduced sediment transport may alter river morphology, riparian conditions, and distribution and abundance of mainstem, side channels, and side sloughs that affect fish habitat.

• G6  Potential effect of Project operations on the stability of tributary mouths and access to the tributaries within the Middle River. Potential tributary mouth morphological changes may affect fish access to tributaries.

• G16 Potential effects of reduced sediment load and changes to sediment transport as a result of Project operations within the Lower River.

**PRODUCTS**
Study products to be delivered in 2012, at a minimum will include:

**Development of final 2012 study plan.** The 2012 component of the study will be finalized through consultation with AEA, the resource agencies and other licensing participants.

**Draft Technical Memoranda.** Draft technical memoranda will be prepared as necessary to provide information as needed for developing related 2013-2014 study plans. Preliminary memoranda topics are indicated below. In addition, each memo will summarize progress, identify data gaps, and indicate coordination efforts with other studies.

**Relational database.** A geospatially-referenced relational database of historic and current data used in the analysis will be prepared. This database will form the basis for additional data collection in 2013-2014. All data will be associated with location information collected using a Global Positioning System (GPS) receiver in unprojected geographic coordinates (latitude/longitude) and the WGS84 datum. Naming conventions of files and data fields, spatial resolution, and metadata descriptions must meet the ADNR standards established for the Susitna-Watana Hydroelectric Project.

**Data.** All original data collected in the field in 2012 will be QC’d and delivered to AEA. The data will be entered into the relational database described above, QC’d and delivered to AEA.

**Final 2012 Technical Memorandum.** A technical memorandum summarizing all of the 2012 results will be presented to resource agency personnel and other licensing participants, along with spatial data products. All map and spatial data products will be delivered in the two-dimensional Alaska Albers Conical Equal Area projection, and North American Datum of 1983 (NAD 83) horizontal datum consistent with ADNR standards. The technical memorandum will include:

- Bedload sediment rating curves.
- Suspended sediment rating curves.
- Particle size distribution curve for bedload sampled in transport.
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- Monthly and annual bed and suspended sediment loads.
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- Quantification of the sediment transport capacity at the effective discharge.

**Schedule**

This is a multi-year study that will be initiated in 2012. Monthly sediment sampling for May to September is prescribed at each study site. Data compilation and rating curve development will take place after the field data collection is completed. Sediment sampling at the Tsusena site would first require construction of a cableway, which would likely result in commencement of a sampling schedule much later than for the other sites, where a boat platform can be used to deploy sampling equipment. The following schedule is for milestones of the 2012 scope of work. This study identifies work that will be started in early 2012 and be completed according to the schedule outlined below.

- Final 2012 Bedload and Suspended Sediment Load Study Plan – March 20, 2012
- Draft Technical Memorandum – June 29, 2012
- Original QC’d Data - November 9, 2012
- QC’d Geospatially-referenced relational database – November 9, 2012

**References**


