

Susitna-Watana Hydroelectric Project Document ARLIS Uniform Cover Page

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1.1. Fluvial Geomorphology Modeling below Watana Dam

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 each study proposal and the information to be obtained.

The overall goal of the study is to model the effects of the Project on the fluvial geomorphology of the Susitna River. The results of this study along, with results of the other geomorphology studies, will be used in combination with geomorphic principles and criteria/thresholds defining probable channel forms to predict the potential for alteration of channel morphology.

Specific objectives of this study are:

1. Model channel formation processes in the Susitna River downstream of the proposed Watana Dam site;
2. Estimate the potential for channel change for with-Project operations; and
3. Coordinate with other studies to provide channel output data.

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

To be completed by requesting organization. AEA anticipates resource agencies will request this study.

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

Fisheries and aquatic resources are owned by the State of Alaska, and the Project could potentially affect these public interest resources by affecting channel morphology and aquatic habitat.

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

Sediment transport issues downstream of Watana Dam are expected to stem from the influences of the regulated outflows and the deficit of sediment due to trapping in the reservoir. These issues are particularly important because fish resources have the greatest potential to be impacted by the Project, and most of the potential impacts would occur downstream of the Project (AEA 2010). The effect of altered flows on anadromous and resident fish habitats and their associated populations was the major focus of studies conducted in the 1980s (APA 1984). The major fish habitats are located in the Susitna River, side channels, side sloughs, upland sloughs, and tributary mouths (APA 1984).

Modeling of hydraulics of the Susitna River below the then proposed Project, a necessary step in developing a sediment transport model, was performed in the 1980s. One-dimensional HEC-2 hydraulic models were developed in the 1980s to support the calculation of water-surface profiles and channel hydraulics (Acres 1983). The models represented the reach between

Devils Canyon (Susitna RM 186.8) and Talkeetna (RM 99), excluding Devils Canyon (Susitna RM 162.1 to RM 150.2). The Aquatic Resources Data Gap Analysis (HDR 2011) indicates sediment transport modeling of a portion of the Susitna River was undertaken. Realizing the complexity of the sediment transport problem at the Chulitna River confluence, APA commissioned the Iowa Institute of Hydraulic Research to develop a quasi-steady, one-dimensional flow numerical model of sediment transport for the 14-mile reach of the Susitna River from the Chulitna confluence downstream to Sunshine Station (Holly 1985). The model was based on sediment transport data from 1981 and 1982, as the following years of data collection had not yet been completed. The topography was derived from 28 cross-sections (approximately 1 every ½ mile) measured by R&M and aerial photography (Ashton and R&M 1985). The model was still in development as of the writing of the report in 1985, and the companion report referenced in Holly (1985) was not found in the Susitna documentation.

The Aquatic Resources Data Gap Analysis (HDR 2011) indicates that channel equilibrium, an important macrohabitat variable, was not addressed in the APA Project instream flow study. The question of whether the existing channel morphology will remain the same, or at least be in “dynamic equilibrium”, once the proposed action has occurred is a significant question in an instream flow study. Instream flow versus habitat relationships developed for today’s river assumes that similar relationships will persist for the period of time the project is in place, within a reasonably defined range of variability. In the case of the proposed Project instream flow study the question is whether the river is currently in a state of equilibrium or disequilibrium. If it is in a state of disequilibrium, will the state be exacerbated or reversed as a result of the project? If it is exacerbated or reversed, the impact of the project cannot be assessed without estimating a post project channel configuration (Bovee et al. 1998). The same holds true if the river is currently in a state of equilibrium and shifts to disequilibrium for a significant period of time with the project in place.

The AEA Susitna Water Quality and Sediment Transport Data Gap Analysis Report (URS 2011) concluded: “Numerical modeling of the sediment transport dynamics would provide a basis for comparing the changes in channel morphology and aquatic habitat associated with the proposed Project and the proposed operations.” The Fluvial Geomorphology Modeling below Watana Dam Study addresses the need to develop a sediment transport model of the Susitna River.

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.

Downstream of the proposed Watana Dam (Middle River and Lower River), Project operations have the potential to alter channel morphology and aquatic habitat as a result of changes to flow timing and magnitude, sediment supply and sediment transport capacity, and large woody debris (LWD) recruitment and transport. Changes in the channel morphology may alter the presence, physical characteristics and function of important riverine aquatic habitat types such as side channels and sloughs. Reduction in sediment supply has the potential to cause channel downcutting and coarsening of bed material. In contrast, reduction in peak flow magnitude and changes in timing can result in sediment deposition (also at tributary mouths). The regulated hydrology may affect access to aquatic habitats as well as sediment transport rates and timing that ultimately govern formation and maintenance of dynamic aquatic habitats. Analysis of the complex interaction of water and sediment with the channel and floodplain boundaries to evaluate potential Project effects requires development and application of a sediment transport model.

It was indicated in the AEA Susitna Water Quality and Sediment Transport Data Gap Analysis Report (URS 2011) that further quantification of the sediment supply and transport capacity would help identify the sensitivity of the channel morphology (and associated aquatic habitats) to the effects of the proposed Susitna-Watana Project. The report indicated information on sediment continuity could provide a basis for evaluating whether the Susitna River below the Chulitna confluence would be at risk of aggradation, and if so, whether the magnitude would alter aquatic habitats and hydraulic connectivity to these habitats. It also pointed out that side channels and sloughs are of particular importance to fisheries, and changes to the relationships between flow and stage at which the habitats are accessible could impact the fisheries. These relationships can be affected by not only distribution of flows, but also changes in the bed elevations due to sediment transport processes. Other impacts to the sediment transport regime could affect the cleaning of spawning gravels, hyporheic flows through redds, groundwater inflows, and hydraulic connectivity for out migration to the main channel.

The various components of this study will address the extent of the associated project effects and data needed for designing ~~any~~ ~~necessary~~ ~~necessary~~ PM&E measures ~~to minimize effects~~.

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.

The Fluvial Geomorphology Modeling below Watana Dam is divided into three study components: Bed Evolution Model Development, Coordination, and Calibration; Model Existing and with-Project Conditions; and Coordination on Model Output. Each of these components is explained further in the following subsections.

1.3.6.1. *Study Component G-2.1: Bed Evolution Model Development, Coordination and Calibration*

The goal of the Bed Evolution Model Development, Coordination and Calibration study component is to model channel formation processes in the Susitna River downstream of Watana Dam. The potential study area is the portion of the Susitna River from Watana Dam (RM 184) downstream to its mouth at the Cook Inlet (RM 0). The downstream limit of the modeling effort will be determined based on results of the General Geomorphology Study concerning the potential for the Project to affect channel morphology and in coordination with other studies and the agencies. As a minimum, the study area for this effort includes the entire Middle River from the Watana Dam site (RM 184) downstream to the three rivers confluence area (RM 98). The spatial extent of the Lower River modeling effort has not been determined. The 1D modeling will be continued downstream into the Lower River to at least Sunshine Station (RM 84) (see below for a discussion of the 1D and 2D modeling approach). The decision on whether to continue the 1D modeling further downstream in the Lower River and whether detailed 2D modeling sites will be included in the Lower River will be made based on an assessment of the potential for the Project to affect channel morphology in the Lower River. This assessment of potential project effects is being conducted in 2012 as part of the Geomorphology Study. The results of this 2012 effort will be presented to and reviewed by the stakeholders, AEA, and key members of other study teams (Instream Flow, Instream Flow Riparian, Ice Processes and Fish) to determine the spatial extent of fluvial geomorphology

modeling conducted in the Lower River. This will include determination of the downstream limit for the modeling.

Methods

The development of the bed evolution model is divided into three tasks: Development of a Bed Evolution Modeling Approach and Model, Coordination with other Studies on Processes Modeled, and Calibration/Validation of the Model.

Development of a Bed Evolution Model Approach and Model

Development of the bed evolution model for a dynamic system such as the Susitna is a complex undertaking that requires considerable investigation and coordination. The work in the Lower and Middle River contained in the General Morphology Study provides a considerable part of the required investigation. The results of the study will be combined with coordination with and information from the Reservoir Operations and Flow Routing Model Development, Instream Flow, Instream Flow Riparian, Ice Processes, and Fish studies to identify and develop models that properly reflect the dynamic nature of the Susitna River as well as provide other studies with the information on the changes in the channel and floodplain that will be necessary to perform their assessment of Project effects.

Some of the important steps in the development of the modeling approach and model are:

- Develop an understanding of the system in terms of the dominant physical processes and governing physical conditions,
- Coordinate with other studies to obtain their understanding of the system,
- Coordinate with other studies to understand which physical features and processes are important to their studies,
- Review and understand available data,
- Identify an overall modeling approach that is consistent with the study goals and needs of the other studies as well as is consistent with constraints on information that is currently available or can practically be obtained,
- Identify a modeling approach that is consistent with the spatial and temporal scale of the area to be investigated,
- Determine the spatial limits of the modeling effort
- Determine the time scales for the various models
- Review potential models and select a model(s) that meets the needs and conditions previously determined,
- Identify data needs for the specific model and study area being investigated along with data gaps,
- Collect the required data to fill data gaps,
- Develop the model input,
- Identify information to be used to calibrate and validate the model,
- Perform initial runs and check basic information such as continuity for water and sediment, hydraulic conditions, magnitude of sediment transport, distributions of flows,
- Collaborate with other studies on initial model results,
- Refine model inputs,
- Perform calibration and validation efforts,
- Work with other studies to develop scenarios to evaluate including the definition for the existing condition,
- Coordinate with other studies on model results and format they will need,
- Perform runs of scenarios and distribute output to other studies, and

- Refine and run additional scenarios as previous scenarios inform the development of new scenarios.

General Modeling Approach: Many computer programs are available for performing movable boundary sediment-transport simulations. The choice of an appropriate model for this study depends on a number of items, including 1) the level of detail required to meet the overall project objective, 2) the class, type, and regime of flows that are expected to be modeled, and 3) the availability of necessary data for model development and calibration purposes. It would be unrealistic in terms of the data required, effort required for model development, and computational time required for model execution to model the entire system with a 2D sediment transport model. Considering the very broad physical expanse of the overall Susitna River system, a simplified approach to assess the general hydraulic and sediment-transport characteristics of the various subreaches that make up the overall study area will involve development and application of one-dimensional (1D) computer models and/or simplified relationships. To evaluate the hydraulic and sediment-transport characteristics on a smaller, more local scale, where the physical processes are complex and [fraught with have more](#) uncertainty, more sophisticated multi-dimensional [e.g., two-dimensional (2D)] modeling will be necessary. A variety of candidate models will be evaluated for application on the Susitna River. Potential candidate models for the 1D and 2D portions of the study are discussed below.

General Discussion of 1D Models: Most 1D movable boundary sediment-transport models are designed to simulate changes in the cross sectional geometry and river profile due to scour and deposition over relatively long periods of time. In general, the flow record of interest is discretized into a quasi-unsteady sequence of steady flows of variable discharge and duration. For each model time step and corresponding discharge, the water-surface profile is calculated using the step-backwater computational procedure to compute the energy slope, velocity, depth, and other hydraulic variables at each cross section in the network. The sediment-transport capacity is then calculated at each cross section based on input bed material information and the computed hydraulics, and the aggradation or degradation volume is computed by comparing the transport capacity with the upstream sediment supply (i.e., the supply from the next upstream cross section for locations not identified as an upstream boundary condition). The resulting aggradation/degradation volume is then applied over the cross-section control volume (i.e., the sub-channel concept), and the shape of the cross section is adjusted accordingly. Because the sediment-transport calculations are performed by size fraction, the models are capable of simulating bed material sorting and armoring. The computations then proceed to the next time step, and the calculations are repeated using the updated cross-sectional and bed material gradation.

1D sediment-transport models should not be applied to situations where 2- and 3-dimensional flow conditions control the sediment-transport characteristics. The models ignore secondary currents, transverse movement and variation, turbulence, and lateral diffusion; thus, the models cannot simulate such phenomena as point bar formation, pool-riffle formation, and plan form changes such as river meandering or local bank erosion. The models typically distribute the volume of aggradation or degradation across the entire wetted portion of the channel cross section after each time-step, so the effects of channel braiding are not directly considered. However, 1D models are useful in evaluating the general sediment-transport characteristics of a given reach, and are useful in providing boundary condition information to localized 2D models.

Potential 1D Models: 1D models that are considered for this study include the Corps of Engineers HEC-RAS (version 4.1; USACE, 2010), the Bureau of Reclamations SRH-1D (version 2.8; USBR, 2011), DHIs MIKE 11 (version 2011; DHI, 2011), and Mobile Boundary Hydraulics HEC-6T (version 5.13.22_08; MBH, 2008). A summary of each of these models, including potential benefits and limitations, are summarized in the following sections.

- **HEC-RAS:** HEC-RAS, version 4.1.0 (USACE, 2010) is a publicly available software package developed by the Corps of Engineers to perform steady flow water surface profile computations, unsteady flow simulations, movable boundary sediment transport computations, and water quality analysis. HEC-RAS includes a Windows-based graphical user interface that provides functionality for file management, data entry and editing, river analyses, tabulation and graphical displays of input/output data, and reporting facilities. The sediment-transport module is capable of performing sediment-transport and movable boundary calculations resulting from scour and deposition over moderate time periods, and uses the same general computational procedures that were the basis of the HEC-6 (USACE, 1993). In HEC-RAS, the sediment transport potential by grain size fraction, which allows for simulation of hydraulic sorting and armoring. This model is designed to simulate long-term trends of scour and deposition in stream and river channels that could result from modifying the frequency and duration of the water discharge and stage, or modifying the channel geometry. Benefits of the HEC-RAS software include widespread industry acceptance, public availability, and ease of use. Potential limitations of the program include excessive computer run-times, file size output limitations, and the inherent problems associated with 1D modeling of aggradation and degradation that results in equal adjustment of the wetted portion of the bed.
- **SRH-1D:** The U.S. Bureau of Reclamation (USBR) Sedimentation and River Hydraulics Group has a long history of developing numerical models for sediment transport in rivers (Huang, et.al., 2006). SRH-1D (Huang and Greimann, 2011) is a mobile boundary hydraulic and sediment transport computer model for open channels, and is capable of simulating steady or unsteady flow conditions, internal boundary conditions, looped river networks, cohesive and non-cohesive sediment transport (Ruark, et. al., 2011), and lateral inflows.
- **MIKE 11:** Danish Hydraulic Institutes MIKE 11 is a proprietary software package developed for 1D dynamic modeling of rivers, watersheds, morphology, and water quality. The model has the ability to solve the complete nonlinear St. Venant equations for open channel flow, so the model can be applied to any flow regime. MIKE 11 provides the choice of diffusive and kinematic wave approximation, and performs simplified channel routing using either the Muskingum or Muskingum-Cunge methods. The program includes a module for non-cohesive sediment transport that is capable of simulating erosion and deposition of non-cohesive sediments. The benefits of MIKE 11 include its hydrodynamic capabilities, the user-friendly graphical interface and the reporting and presentation capabilities. Considering the relatively high cost of this software, the proprietary nature of this model is its primary limitation.
- **HEC-6T:** HEC-6T was written by William A. Thomas, previous Chief of Research Branch at the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC). Mr. Thomas planned, designed, wrote, and applied the first version of HEC-6, and HEC-6T is an enhancement of the original version. HEC-6T is a proprietary, DOS-based program that includes a Windows-based graphical user interface for input data manipulation and post-processing of simulation results. Limitations of this program include involve reduced capabilities for modeling numerous ineffective flow areas, and limited capabilities associated with the graphical user interface (input data development and graphical presentation of results). This software is relatively inexpensive, so the fact that it is proprietary is not a significant limitation.

Potential 2D Models: Potential 2D models include the Bureau of Reclamations SRH2-D (version 3; Lai, 2008; Greimann and Lai, 2008), the Corps of Engineers Adaptive Hydraulics (ADH version 3.3; USACE, 2010), the US Geological Surveys MD_SWMS (McDonald et. al., 2005), and DHIs MIKE 21 (version 2011; DHI, 2011).

- **SRH-2D:** The Bureau of Reclamations SRH-2D (Lai, 2008) is a finite-volume, hydrodynamic model that computes water-surface elevations and horizontal velocity components by solving the depth-averaged St. Venant equations for free-surface flows in 2-D flow fields. SRH-2D is a well-tested 2-D model that can effectively simulate steady or unsteady flows, and is capable of modeling subcritical, transcritical and supercritical flow conditions. The model uses an unstructured arbitrarily-shaped mesh composed of triangular elements, quadrilateral elements, or a hybrid composition. SRH-2D incorporates very robust and stable numerical schemes with a seamless wetting-drying algorithm that results in minimal requirements by the user to adjust input parameters during the solution process. A potential limitation of this software is that the mobile bed sediment-transport module is currently unavailable to the public; however Tetra Tech has gained permission to use the sediment-transport module on a number of other projects. This version of the model (Greimann and Lai, 2008) includes the “Morphology” model, which calculates bed-load transport capacities at each model node using a selection of equations that include Parker (1990) and Wilcock and Crowe (2003) based on user defined bed material sediment gradations on a fixed-bed basis. It also includes a second model that uses these capacities in a dynamic simulation to perform sediment- routing calculations and associated bed adjustments. Based on guidance from the model developers and confirmed by Tt-MEI’s use of the model for other studies, the maximum practical model size is about 16,000 elements, which could be a potential limitation in applying the model to larger scale areas.
- **ADH:** The Corps of Engineers Coastal and Hydraulics Laboratory (Engineer Research Development Center) developed the Adaptive Hydraulics (ADH;) program to model saturated and unsaturated groundwater, overland flow, three-dimensional Navier-Stokes flow, and two- or three-dimensional shallow water open channel flow conditions. ADH is a depth-averaged, finite-element, hydrodynamic model that has the ability to compute water-surface elevations, horizontal velocity components, and sediment-transport characteristics (including simulations to predict aggradation and degradation) for sub- and supercritical free-surface flows in two-dimensional flow fields. The ADH mesh is composed of triangular elements with corner nodes that represent the geometry of the modeled reach, with the channel topography represented by bed elevations assigned to each node in the mesh. A particular advantage of the ADH mesh is the ability to increase the resolution of the mesh, and thereby the model accuracy, by decreasing the size of the elements during a simulation in order to better predict the hydraulic conditions in areas of high hydraulic variability. However, use of the adaptive mesh option may result in excessively long simulation run times (several days per run) that could be impractical for this study. Additionally, the inability of the model to capture shockwaves associated with wetting and drying, particularly along the mesh boundary, may also be a significant limitation of this program.
- **MD_SWMS:** The US Geological Surveys Multi-Dimensional Surface-Water Modeling System (MD_SWMS; McDonald et. al., 2005) is a pre- and post-processing application for computational models of surface-water hydraulics. The system provides a tool in the form of a graphical user interface (GUI) that allows the modeler to build and edit data sets of the systems computational surface water models. MD_SWMS also provides a

framework that links the GUI with the modeling applications. The GUI is an interactive 1-, 2- and 3-dimensional tool that can be used to build and visualize all aspects of computational surface-water applications, including grid building, development of boundary conditions, simulation execution, and post-processing of the simulation results. The package includes a number of different modeling applications, including STORM (System for Transport and River Modeling), a two-dimensional surface water flow code based on the shallow water equations. It uses a technique that blends some of the features of finite volumes and finite elements, multi-dimensional streamline upwinding methods, and provides steady and unsteady versions in the same package. It employs a dynamic wetting and drying algorithm that allows for the computation of flooding, and can model subcritical, supercritical, and transcritical flow regimes (including hydraulic jumps). The program includes advanced turbulence models, sediment-transport algorithms for cohesive and non-cohesive sediment mixtures, transport of suspended and dissolved substances, and an automatic mesh refinement tool to better predict the hydraulic conditions in areas of high hydraulic variability.

MD_SWMS has been successfully applied to a number of rivers in Alaska, including the Tanana River near Tok (Conaway and Moran, 2004) and the Copper River near Cordova (Brabets, 1997), and some of the modules are being validated using high resolution scour data from the Knik River near Palmer.

- **MIKE 21:** Developed by the Danish Hydraulic Institute (DHI), MIKE 21 is a proprietary modeling system for 2-D free-surface flows that can be applied in rivers, lakes, coastal environments and seas. It has the ability to simulate sediment-transport and associated erosion and deposition patterns. The software includes a Windows-based graphical user interface as well as pre- and post-processing modules for use in data preparation, analysis of simulation results, and reporting modules that have graphical presentation capabilities. MIKE 21 has the ability to model a range of 2D mesh types that include Single Grid, Multiple Grid, Flexible Mesh, and Curvilinear Grid. Considering the relatively high cost of this software, the proprietary nature of this model is its primary limitation.

Coordination with other Studies on Processes Modeled

As previously discussed, it is envisioned that a combination of 1D and 2D sediment transport models will be utilized for the Susitna River bed evolution model. This is due to the potential size and complexity of the system to be modeled. Therefore the current vision of the modeling approach is to utilize a 2D model in areas to be studied in detail and to link these detailed study areas with a 1D model. The 1D model would run the entire length of the study area, whereas the 2D model would be applied to specific detailed study areas representative of important riverine habitat and geomorphic conditions. Because of this modeling approach, it is extremely important to coordinate with other studies since results from the detailed 2D model will only be available at specified locations. The study areas would be locations that were also identified by the Instream Flow, Instream Flow Riparian, Ice Processes and Fish studies as areas to perform detailed efforts in areas that are representative of specific conditions identified in each study's stratification of the river. It is anticipated that on the order of four to six such locations for application of the 2D model would be identified with each representing a length of river on the order of one to several miles.

The time scale for the model execution is also an item that needs to be determined in collaboration with the other studies and stakeholders. For example, the 1D model may be executed on a daily basis for periods when releases from the Project are nearly constant; however, if load following scenarios are modeled, then it may be necessary to reduce the

modeling time step to shorter period such as an hourly. The 1D model could be executed for a continuous period of decades representing the potential length of a FERC license. On the other hand, the computational requirements for the 2D model are such that executing the model for a period of many years would not be feasible. Because of the nature of the 2D model formulation, the time increment that the model runs is typically on the order of seconds; however, results are reported at longer time intervals such as hours, days or months.

Close coordination between the study leads and key study team members will be required throughout the model development process. It is important that all the studies have an understanding of the abilities and limitations of the models, the information that will be provided by the model, and the selection of the detailed study areas. This will be accomplished through frequent informal communication and technical workgroup meetings. It is also recommend that the study leads and other key participants spend time together in the field to develop a practical understanding of each study's needs.

Model Calibration and Validation

Calibration and validation of the models will be a stepwise process. First the hydraulic components of the models will be calibrated by adjusting roughness and loss coefficients. Calibration will start with the 1D model and progress to the 2D model. The 1D model will be calibrated for water surface elevations for known discharges. There will be at least 10 level loggers to provide stage information and three mainstem USGS gages to provide stage and discharge information. The 2D model will also be calibrated to reproduce the water surface elevations; additionally, the model will need to have the local hydraulics calibrated. This will be accomplished by using depth and velocity data collected by the Instream Flow Study at the same detailed sites that the bed evolution model is being applied. Depending on the range of conditions as well as the spatial coverage of the depth and velocity data collected by the Instream Flow Study, additional data may be needed for calibration of the hydraulic portion of the 2D model. Specific calibration criteria will be established for both the 1D and 2D models.

The sediment transport portions of both the 1D and 2D model will be first calibrated based on the measured sediment transport data and the associated sediment rating curves for both bed load and suspended load. The bed load component of transport is dominant in terms of the channel forming processes, but the suspend load may be important in evaluating the changes to other features including the side channels, sloughs and floodplain. The sediment transport components will also be validated based on evaluation of the system response for specified runs versus the responses that have been documented through the assessment of geomorphology performed in the General Geomorphology Study. The potential to utilize 1980s transect and current 2012 transect data in the calibration process will be investigated.

Information Required

The following available existing information will be needed to conduct this study:

- Historical and current aerial photographs;
- Historical channel cross sections;
- LiDAR to develop above water topography and extend surveyed transects across the floodplain;
- Flow records for USGS gages on the mainstem and tributaries; and
- Historical bed material sampling results.

The following additional information will need to be obtained to conduct this study:

- Current channel transacts at a density sufficient to develop a 1D sediment transport model;
- Detailed below water bathymetry in sections of the channel in which 2D modeling may be applied;
- Extended flow records for mainstem gages and major tributaries;
- Estimation of flows for ungaged tributaries that will be accounted for in the water and sediment inflow and the potential development of tributary fans is to be evaluated;
- Sampling of surface and subsurface bed material in the main channel and various side channel and slough features;
- Sampling of bed material and channel cross sections on tributaries for which sediment supply and fan formation are to be accounted for;
- Information describing the influence of ice processes on channel and floodplain morphology;
- Information describing the influence of riparian vegetation on channel and floodplain morphology;
- Information developed in the General Geomorphology Study on channel changes that have occurred between the 1980s and the present;
- Information developed in the General Geomorphology Study on the physical processes most important to accurately modeling the Susitna River below Watana Dam; and
- Coordination with the Instream Flow, Instream Flow Riparian, Ice Processes, and Fish studies to identify river segments for detailed modeling (2D).

1.3.6.2. Study Component G-2.2: Model Existing and with-Project Conditions

The goal of the Model Existing and with-Project Conditions is to provide a baseline and series of with-Project scenarios of future channel conditions for assessing channel change. The extent of the study area is the Susitna River downstream of Watana Dam and will be determined in study component G-2.1.

Methods

Through coordination with the technical work group, the time period and representative hydrologic conditions to apply the bed evolution model to will be determined. Prior to making this decision, the practical limitations as to model run-time will be developed and considered. Ideally, a continuous period of record could be used. Whether this is practical will not be determined until the actual model and study sites are selected. The hydrologic inputs for the various with-Project scenarios will be obtained from the Reservoir and Flow Routing Study and the model run for flows representative of each scenario.

The simulation period could take the form of modeling specific years or portions of the annual hydrographs from cases such as wet, average and dry years. Other scenarios might include rapid release of flows from an ice jam or larger flood events that are not contained in the period of the hydrologic record chosen for simulation. There may also be the desire to run sensitivity analysis.

Each run will go through a quality control process to ensure the appropriate data were used and model outputs are reasonable. Naming conventions for the model input and output files for the various scenario files will be applied so that files can be archived and retrieved in the future.

In addition to the actual model output and results, the model results will need to be interpreted and additional analysis possibly applied to identify the potential and assign a magnitude to certain types or channel changes. This is due to limitations in modeling certain processes directly.

Information Required

The following available existing information will be needed to conduct this study:

- Historical and current aerial photographs,
- Historical channel cross sections,
- LiDAR to develop above water topography and extend surveyed transects across the floodplain,
- Flow records for USGS gages on the mainstem and tributaries, and

The following additional information will need to be obtained to conduct this study:

- The calibrated/validated 1D and 2D models from the G-2.1 study component,
- Extended flow records for mainstem gages and major tributaries for the existing condition,
- The with-Project mainstem flows corresponding to the periods and locations the extended flow record is provided,
- Estimation of flows for ungaged tributaries that will be accounted for in the water and sediment inflow and the potential development of tributary fans is to be evaluated
- Information describing the influence of ice processes on channel and floodplain morphology including changes under with-Project conditions,
- Information describing the influence of riparian vegetation on channel and floodplain, and morphology under with-project conditions.

1.3.6.3. Study Component G-2.3: Coordination on Model Output

The goal of the Coordination on Model Output is to provide necessary output to the various studies that will require determination of channel change as. The extent of the study area is the Susitna River downstream of Watana Dam and will be determined in study component G-2.1.

Methods

Coordination with Instream Flow, Instream Flow Riparian, Ice Processes, Productivity, and Fish studies will be conducted to obtain lists of information they will need to reflect the results of the bed evolution modeling and predicted changes in channel conditions for the various Project scenarios. Because of the detailed spatial nature of the information produced by the 2D model, GIS will likely be an important tool for visually conveying model results and may also be useful in transferring the results of this study for use in the other studies.

It will take considerable coordination to develop the plan for transferring results so that they are most efficiently and effectively used by other studies. These details we need to be worked out as the overall modeling approach is developed in the technical working group.

Information Required

The following available existing information will be needed to conduct this study:

- Contact information for Program and Study Leads

The following additional information will need to be obtained to conduct this study:

- Study plans for other studies
- Locations of sites for other studies
- Lists of output required for other studies
- Output formats required for other studies
- Schedule dates for providing output

1.3.7. 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.

Specific details for the study components will be determined when Study Plans are further developed. Initial planning level estimates of the costs to perform the components of the Fluvial Geomorphology Modeling Study are provided in the table below along with the expected quarter the study components will be completed. The total effort for the Fluvial Geomorphology Modeling Study is estimated to cost between approximately \$1.0 million and \$1.6 million.

| Study Component | Estimated Cost Range | Estimated Completion |
|---|----------------------|----------------------|
| G-2.1 Model Development, Coordination and Calibration | \$750k to \$1,100k | Spring 2014 |
| G-2.2 Model Existing and with-Project Conditions | \$250k to \$400k | Fall 2014 |
| G-2.3 Coordination on Model Output | \$50k to \$100k | Fall 2014 |

1.3.8. Literature Cited

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