Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Geomorphology Study
Study Plan Section 6.5

Initial Study Report
Part C: Executive Summary and Section 7

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

Tetra Tech
Watershed GeoDynamics

June 2014

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EXECUTIVE SUMMARY

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Purpose	The purpose of the Geomorphology Study is to characterize the geomorphology of the Susitna River, and to evaluate the effects of the Project on the geomorphology and dynamics of the river by predicting the trend and magnitude of geomorphic response. This will inform the analysis of potential Project-induced impacts to aquatic and riparian habitats. The results of this study, along with results of the Fluvial Geomorphology Modeling below Watana Dam Study (ISR Study 6.6), will be used in combination with geomorphic principles and criteria/thresholds defining probable channel forms to predict the potential for alteration of channel morphology from Project operation.
Status	Significant efforts were conducted on 10 of the 11 study components in the Geomorphology Study in 2013. The exception, assessment of stream crossings along transmission lines and access alignments, was not initiated in 2013. Data collected included aerial photography along the entire river corridor from PRM 262 to PRM 3.3 (both 2012 and 2013), sediment transport data by the USGS, geomorphic mapping and assessments in the Focus Areas and large woody debris mapping and assessment. Analysis of historical and current aerial photography, mapping of aquatic macrohabitat types and geomorphic features from aerial photographs, analysis of sediment transport data and analysis of hydrologic information resulted in the filing of 7 Technical Memorandums (TMs) and one field report. Some of these analyses will be refined in 2014 and early 2015 as new data and results of analyses become available. Work that had been planned for 2013 but was moved to 2014 and 2015 is identified in the 2013 Variances Section.
Study Components	The Geomorphology Study is comprised of the following 11 study components: 1. Delineate Geomorphically Similar Reaches and Characterize the Geomorphology of the Susitna River 2. Bed Load and Suspended-Load Data Collection 3. Sediment Supply and Transport Middle and Lower Susitna River Segments 4. Assess Geomorphic Change Middle and Lower Susitna River Segments 5. Riverine Habitat versus Flow Relationship Middle Susitna River Segment 6. Reconnaissance-Level Assessment of Project Effects on Lower and Middle Susitna River Segments 7. Riverine Habitat Area versus Flow Lower Susitna River Segment

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	8. Reservoir Geomorphology 9. Large Woody Debris 10. Geomorphology of Stream Crossings along Transmission Lines and Access Alignments 11. Integration of Fluvial Geomorphology Modeling below Watana Dam with the Geomorphology Study
2013 Variances	AEA implemented the methods as described in the Study Plan with the exception of the following variances:
	The pebble count bed-material samples identified in the Study Plan (RSP Section 6.5.4.2.2) were not collected by the USGS in 2012. Since numerous bed-material samples are being collected throughout the Middle and Lower Susitna River Segments as part of the Fluvial Geomorphology Modeling below Watana Dam Study (ISR 6.6 Section 4.1.2.9), this will not affect the ability to meet study objectives (ISR 6.5 Section 4.2.3). In addition, the USGS did perform pebble counts in 2013 to characterize bed material at the sediment transport measurement sites.
	Due to logistical and safety issues, the bed load samples at Tsusena Creek identified in the Study Plan (RSP Section 6.5.4.2.2) were terminated after 2012, were not collected in 2013, and will not be collected by the USGS in the future. This will not affect the ability to meet study objectives as alternate means are available to determine the bed load passing the dam site for the without Project condition (ISR 6.5 Section 4.2.3).
	The initial sediment balance task in Study Plan (RSP section 6.5.4.3.2.1) calls for comparison of the total sediment load at the Sunshine and Susitna Station gages for an average, wet, and dry year between pre- and post-Project conditions (RSP Section 6.5.4.3.2). The total sediment load was actually determined for the entire 61 year extended record which provided a more comprehensive assessment of the sediment balance (ISR 6.5 Section 4.3.3).
	The Study Plan identifies the determination of effective discharge of the Susitna River at Gold Creek, Sunshine and Susitna Station (RSP Section 6.5.4.3.2.4). In addition to these locations the effective discharge was also calculated for the Susitna River at Susitna Station, the Chulitna River, the Talkeetna River and the Yentna River providing a more comprehensive analysis than originally planned (ISR 6.5 Section 4.3.3).
	It was the intent of the Study Plan (RSP Section 6.5.4.5.2.1) to obtain three sets of aerial photography in 2012 at the following approximate discharges: 23,000, 12,500, and 5,100 cfs. The decision was made to acquire aerials at a single target flow of approximately 12,500 cfs as AEA concluded that aerial

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	photography collected at specified discharges to develop macrohabitat versus flow relationships was not necessary for the meeting the objectives of the Study Plan as the combination of the 2-D hydraulic modeling, bathymetry and topography collected in the Focus Areas can provide direct determination of the area of the various macrohabitat types over the range of flows of interest (ISR 6.5 Section 4.5.3).
	The Study Plan indicates that the literature review of the downstream effects of dams will be completed in Q4 2013 (RSP Section 6.5.4.6.2.4). This task will be completed in 2014 to allow for integration with the Riparian IFS (Study 8.6) to produce a single, comprehensive document (ISR 6.5 Section 4.6.3).
	The Study Plan indicates the initial analysis of the modified braiding index (MBI) will be determined in Q3 2013 (RSP Section 6.5.4.6.2.3). This task will be performed in 2014 when information on bed-material gradation and channel aggradation/degradation are available from the 1-D Bed Evolution Model (ISR 6.5 Section 4.6.3).
	Hydrologic analysis of operational scenarios beyond the initial streamflow assessment is identified in the Study Plan for the Geomorphology Study (RSP Section 6.5.4.6.2.1); however, the analysis will be performed in the Fish and Aquatics IFS (Study 8.5 Section). The initial streamflow assessment was performed as part of the Geomorphology Study (ISR 6.5 Section 4.6.3).
	The Study Plan indicates the concurrent flow analysis will be conducted in Q4 2013 (RSP Section 6.5.4.6.2.1). This analysis had been intended to help inform the discussion on extending the modeling effort up the Chulitna and Talkeetna rivers; however, that decision to model these major tributaries was already made for other reasons. The concurrent flow analysis will now be performed in 2014 (ISR 6.5 Section 4.6.3)
	The Study Plan indicated that the assessment of reservoir erosion would take place in 2013 (RSP Section 6.5.4.8.2.3). Due to access considerations, the field work and analysis did not take place in 2013. This task will be performed in 2015. There are no other proposed changes to methods described in the Study Plan, and the study objectives will be met (ISR Study 6.5 Section 4.8.3).
	The first variance (ISR Study 6.5 Section 4.9.3) involving the LWD study component is related to the August 2013 high-flow event that provided the opportunity to assess LWD movement at several sample areas; this was an unanticipated event and was not included in the Study Plan (RSP Section 6.5.4.9.2). This event provided additional data on wood movement and helps

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	to meet study objectives.
	The second variance (ISR Study 6.5 Section 4.9.3) involving the LWD study component is related to the timing of the LWD field data collection effort. The Study Plan indicated that this data collection would occur in the summer of 2013 (RSP Section 6.5.4.9.2). Due to lack of access to CIRWG lands and weather issues, not all of the field work was completed in 2013. The remaining field work will be completed in 2014/2015. No additional modifications to the LWD Study Plan are proposed for 2014/2015 (Note: This variance is identified in the Part B Supplemental Information and (Errata)).
	The Study Plan indicated that the field assessment of stream crossings would take place in 2013 (RSP Section 6.5.4.10.2). Due to access considerations, the field work did not take place in 2013. This task is planned for 2015. There are no other changes to methods described in the Study Plan anticipated, and the study objectives will be met (ISR Study 6.5 Section 4.10.3).
Steps to Complete the Study	AEA's plan for completing this study are included in ISR 6.5 Section 7.2 with 2014 activities listed in Section 7.2.1 and 2015 activities in Section 7.2.2. Major activities are summarized below: <u>Planned 2014 Activities</u> Continue characterization of the Susitna River geomorphology including refinement of the processes that form and maintain the features and surfaces in the Middle and Lower River. The role of ice processes is an important aspect of this effort (Section 7.2.1.1.3). • USGS will perform mainstem and major tributary sediment transport measurements (Section 7.2.1.3). • Update of sediment balance, bed-material mobilization and effective discharge calculation as 1-D Bed Evolution Model results from Study 6.6 become available (Section 7.2.1.3). • Update channel change analysis, complete floodplain turnover analysis and document them in a Technical Memorandum to be developed in 2014 (Section 7.2.1.4) • Update aquatic macrohabitat type mapping from current aerials based on coordination with Studies 9.9 and 8.5 (Section 7.2.1.5). Revised Technical Memorandum to be developed in 2014. • Develop literature review on downstream effects of dams (2014). Section 7.2.1.6). • Refinement of the reconnaissance level assessment of Project effects as 1-D modeling results for scenarios become available (Section

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	7.2.1.6). • Coordination with Water Quality Modeling Study 5.6 on reservoir sediment trapping efficiency and provide sediment outflows from Watana Dam for 1-D Bed Evolution Modeling in Study 6.6 (Section 7.2.1.8). • Complete digitizing of LWD from current and historical aerials in portions of the Middle and Upper Susitna River (Section 7.2.1.9). • Complete LWD field inventory in remaining Middle and Lower River sample areas (Section 7.2.1.9). • Continue activities associate with the integration of the Fluvial Geomorphology Modeling (Study 6.6) and the Geomorphology Study including review and interpretation of scenario runs from the 1-D Bed Evolution Model and refinement of conceptual geomorphic process models (Section 7.2.11). <u>Planned 2015 Activities</u> • The 2014 activities that were identified above as occurring in relation to evaluation of or dependent on results of modeling performed in Study 6.6 will continue into 2015 as 1-D and 2-D bed evolution model results from additional scenarios become available (Sections 7.2.2.3, 7.2.2.6, 7.2.2.8, and 7.2.2.11). • Development of a Technical Memorandum integrating the information compiled and produced by the Geomorphology Study (Section 7.2.2.1.3). • Completion of field data collection and analysis of potential for tributary delta formation in the reservoir fluctuation zone (Section 7.2.2.8). • Completion of field data collection and analysis for the reservoir erosion study (7.2.2.8). • Complete the analysis of the potential for increased bank erosion downstream of Watana Dam (Section 7.2.2.8). • Completion of LWD field data collection at the Upper River sample areas and LWD analysis for the Upper, Middle and Lower River (Section 7.2.2.9). • Completion of the field data collection and analysis of the geomorphology of stream crossings along the transmission line and access alignments (Section 7.2.2.10). Modifications to the Study Plan that are proposed for 2014 and 2015 are presented in Section 7.1.2 by study component. The majority of modifications

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	proposed for 2014/2015 involve schedule changes for activities that will be occurring later than identified in the Study 6.5 RSP. The modifications to methods are generally categorized as minor and several modifications result in more comprehensive analysis being performed that will enhance AEA's ability to meet Study Plan objectives. The one substantial modification involves the decision not to collect aerial photography at three separate target flows in the Middle River to develop aquatic macrohabitat area versus flow relationships. This was an approach pursued in the 1980s, but the combination of mapping and modeling performed in the current effort obviate the need for this information (Section 7.1.2.5). This modification was presented in a Technical Memorandum and at two Technical Workgroup Meetings.
Highlighted Results and Achievements	Significant work was completed in the 2013 and early 2014 in the Geomorphology Study. This included completion and subsequent filing of 8 Technical Memorandums (TMs) with FERC covering sediment balance, geomorphic reach delineation and characterization, reconnaissance-level assessment of potential Project effects, stream flow assessment, synthesis of 1980s aquatic habitat information in the Lower River, and mapping of 1980s and 2012 aquatic macrohabitats type and geomorphic features from aerial photography. This work was initiated in 2012. The information developed in these TMs was used to help inform, refine and plan continued implementation of the study. One of the significant results of the effort was the decision to extend the Fluvial Geomorphology Modeling below Watana Dam Study from PRM 79 (Sunshine) to PRM 30 (Susitna Station) (ISR 6.6 Sections 3.1 and 7.1.1). Comparison of aerial photography between the 1980s and present in the Middle Susitna River Segment showed little change in channel bank alignment over the three decade period with the largest changes being on the order of 50 feet or less and many bank locations experiencing 20 feet or less of change. In contrast, the Lower Susitna River Segment experienced much greater change with channel alignment shifting several hundred feet or more in some instances. In both segments, there was a general trend for vegetation to become established on portions of previously open gravel bars. The turnover analysis (Study 6.5 RSP Section 6.5.4.4) being completed in 2014 will provide further quantification and insight into this aspect of the Susitna River geomorphology. The USGS collected sediment transport measurements at four locations on the mainstem Susitna River and the three major tributaries in 2012 and 2013 (Study 6.5 RSP Section 6.5.4.2). A similar effort will be conducted in2014. The current sediment transport measurements provide a comparison with the extensive data set collected in the 1980s. This allows use of the historical data in the current study to create a robust sediment transport data set to support the 1-D and 2-D Bed Evolution modeling efforts in the Fluvial

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	Geomorphology Modeling below Watana Dam Study.

7. COMPLETING THE STUDY

7.1. Proposed Methodologies and Modifications

There are 11 study components to the Geomorphology Study. To complete this study, AEA will implement the methods described for each study components in the Study Plan except as described in Section 7.1.2. These activities include:

1. *Study Component: Delineate Geomorphically Similar (Homogeneous) Reaches and Characterize the Geomorphology of the Susitna River* - This study component (RSP Section 6.5.4.1) is comprised of three tasks: Identification and Development of Geomorphic Classification System (RSP Section 6.5.4.1.2.1), Geomorphic Reach Delineation (RSP Section 6.5.4.1.2.2), and Geomorphic Characterization of the Susitna River (RSP Section 6.5.4.1.2.3). The first task has been completed and was reported on in two technical memoranda (TM). This includes the May 2014 filing of the technical memorandum *Geomorphic Reach Delineation and Characterization, Upper, Middle and Lower Susitna River Segments* (Tetra Tech 2014a) which was an update to the 2012 Study Technical Memorandum, *Initial Geomorphic Reach Delineation and Characterization, Middle and Lower Susitna River Segments,* (Tetra Tech 2013a). The efforts to complete the remaining tasks involve updating the description and characterization of the geomorphic reaches and updating the conditions and processes that drive their behavior. This will be performed as information becomes available from field work and analyses being conducted in this and other studies including Fluvial Geomorphology Modeling (Study 6.6), Fish and Aquatics IFS (Study 8.5), Riparian IFS (Study 8.6), and Ice Processes (Study 7.6). There are no variances or proposed modifications to this study component.
2. *Study Component: Bed Load and Suspended-load Data Collection at Tsusena Creek, Gold Creek, and Sunshine Gage Stations on the Susitna River, Chulitna River near Talkeetna and the Talkeetna River near Talkeetna* - This study component (RSP Section 6.5.4.2) consists of data collection by the USGS to characterize sediment transport conditions in the Susitna River and its major tributaries within the Study Area. Two years of data collection have been performed and a third year will be conducted to complete the study. Continuation of a variance associated with the decision to not perform bed load collection at the Susitna River at Tsusena Creek is described as a study plan modification in Section 7.1.2.
3. *Study Component: Sediment Supply and Transport Middle and Lower Susitna River Segments* – This study component (RSP Section 6.5.4.3) consist of several tasks to characterize the sediment supply and transport conditions in the Susitna River between the Watana Dam site (PRM 187.1) and Susitna Station (PRM 29.9). This effort will provide the sediment input from the mainstem and major Susitna River tributaries for the bed evolution modeling efforts being performed in the Fluvial Geomorphology Modeling Study (RSP Section 6.6). Tasks include Middle and Lower Susitna River sediment balance (RSP Sections 6.5.4.3.2.1 and 6.5.4.3.2.2), characterization of bed material mobilization (RSP Section 6.5.4.3.2.3), and determination of effective discharge (RSP Section 6.5.4.3.2.4). There were two variances in this study component that will carry forward as study plan modifications related to assessment of sediment transport conditions. They involve use of the continuous flow record for total sediment load calculation rather than representative wet, average and

dry years; and calculation of effective discharge. In determining the average annual sediment load, the 61-year extended record was used rather than the wet, dry and average years. To correct an error in the wording, there was also a change in the effective discharge calculation procedure stated in the RSP (ISR Study 6.5 Section 4.3.3). These variances are further described in Section 7.1.2. In addition, the effective discharge was not initially calculated at Tsusena Creek because the 61-year extended record was not available for Tsusena Creek (ISR Study 6.5 Section 4.3.3). In completing the study, future calculation of total load will be performed for the representative years as well as the continuous record and synthesized flows for Tsusena Creek will be used to calculate effective discharge at this location for both pre- and post-Project conditions. Therefore, this variance will not carry forward as a modification into 2014 and 2015.

4. *Study Component: Assess Geomorphic Change Middle and Lower Susitna River Segments* – This study component compares existing, 1980s and 1950s geomorphic feature data mapped from analysis of aerial photography to characterize channel stability and change and the distribution of geomorphic features under unregulated flow conditions. Current (2012 and 2013) and historical (1950s and 1980s) aerial photographs have been acquired. Analysis of channel change between the 1980s and 2012 was performed and reported on in a TM in Q1 2013 (Tetra Tech 2013b). Analysis of channel change from the 1950s to the 1980s and a turnover analysis addressing the periods of 1950s to 1980s and 1980s to 2012 have been performed and will be reported on in a Technical Memorandum. The TM will be the final effort conducted under this study component. There are no variances or proposed study modifications for this study component.

5. *Study Component: Riverine Habitat versus Flow Relationship Middle Susitna River Segment* – This study component delineated current and 1980s riverine macrohabitat types and developed wetted habitat area data over a range of flows. The effort is broken into three tasks: acquisition and processing of aerial photography, digitization of riverine macrohabitat types, and riverine macrohabitat analysis. The majority of this effort was completed in 2012 and reported on in a Q1 2013 technical memorandum (Tetra Tech 2013c). Remaining work to complete the study involves coordination with the Fish and Aquatics IFS (Study 8.5) and Characterization and Mapping of Aquatic Habitat Study (Study 9.9). The study was implemented by AEA per the methods described in the Study Plan except aerial photography was acquired at a single target flow rather than the three flows identified in the RSP (ISR Study 6.5 Section 4.5.3). This variance is further described in Section 7.1.2.

6. *Study Component: Reconnaissance-Level Assessment of Project Effects on Lower and Middle Susitna River Segments* – This study component (RSP Section 6.5.4.6) utilizes comparison of pre- and Post-Project flows and sediment transport conditions to estimate the potential for post-Project channel change in the Lower and Middle Susitna River Segments. Specific tasks under this study component include a stream flow assessment (RSP Section 6.5.4.6.2.1), a sediment transport assessment (RSP Section 6.5.4.6.2.2), the identification of geomorphic reach response through the integration of the stream flow and sediment transport assessments (RSP Section 6.5.4.6.2.3), and a literature review of downstream effects of dams (RSP Section 6.5.4.6.2.4). Much of this effort was completed in 2012 and 2013 and documented in three TMs (Tetra Tech 2013d, 2013e and 2013f). Future activities of this study component include performing the assessment of geomorphic response for the various alternative operating scenarios and development of a technical memorandum prepared jointly with the

Riparian IFS (Study 8.6) documenting the literature review on downstream effects of dams. There were two variances in this study component related to schedule. These variances are further described in Section 7.1.2.

7. *Study Component: Riverine Habitat Area versus Flow Lower Susitna River Segment* – An initial assessment of the potential for Project effects associated with changes in stage to alter riverine habitat in the Lower Susitna was completed under this study component (RSP Section 6.5.4.7). The results of the completed study component were presented in three TMs (Tetra Tech 2013c, 2013d and 2013g). No future activities are planned for this study component and there were no variances associated with completion of this study component.

8. *Study Component: Reservoir Geomorphology* – Characterization of changes resulting from conversion of the channel and portions of the Susitna River valley to a reservoir is the goal of this study component (RSP Section 6.5.4.8). The effort consists of four tasks: estimation of reservoir trap efficiency and sediment accumulation rates (RSP Section 6.5.4.8.2.1), estimation of the formation of tributary deltas in the reservoir fluctuation zone (RSP Section 6.5.4.8.2.2), assessment of reservoir erosion (RSP Section 6.5.4.8.2.3), and bank and boat wave erosion downstream of Watana Dam (RSP Section 6.5.4.8.2.4). Activities in all four of these tasks will be conducted to complete this study component. The study will be completed without variances or modifications to the Study Plan with the exception that the reservoir erosion field work and assessment was not initiated in 2013 (ISR Study 6.5 Section 4.8.3). This variance is further described in Section 7.1.2.

9. *Study Component: Large Woody Debris* – The potential for Project construction and operation to affect the input, transport, and storage of large woody debris (LWD) in the Susitna River is being assessed in this study component (RSP Section 6.5.4.9). Data development efforts to support the assessment of Project effects include inventory of LWD from aerial photography and inventory of LWD from field surveys (RSP Section 6.5.4.9.2). In order to complete this study component, these activities will all continue per the methods in the Study Plan with the exception that the August 22, 2013 high-flow event provided an opportunity to revisit sites inventoried earlier in the field season to check if previously inventoried wood had moved in the sample areas. This variance from the Study Plan provided additional information that was not included in the Study Plan and helps to meet the study objectives (Study 6.5 ISR Section 4.9.3). There is also a variance related to the schedule as the Study Plan indicated that the field effort would occur in the summer of 2013. The variances and the modifications going forward are further described in Section 7.12.

10. *Study Component: Geomorphology of Stream Crossings along Transmission Lines and Access Alignments* – This study component is being performed to characterize existing geomorphic conditions at the stream crossings along the access road/transmission line alignments and to determine potential geomorphic changes from construction, operation and maintenance of the roads and stream crossings (RSP Section 6.5.4.10). Completion of this study component requires activities in all aspects of the study which include analysis of mapping, aerial photography, crossing designs and road designs; field assessment of crossings; and analysis of potential Project effects. The study will be implemented without variances or modifications to the methods described in the Study Plan with the exception that the field work was not initiated in 2013 (ISR Section 4.10.3). The variance is described in Section 7.12.

11. *Study Component: Integration of the Fluvial Geomorphology Modeling below Watana Dam Study with the Geomorphology Study* – This study component consists of two-way integration between the Geomorphology Study and the Fluvial Geomorphology Modeling Study (Study 6.6). The Geomorphology Study will apply its results to help guide the development and application of the various modeling efforts. The Geomorphology Study will assist in interpreting the results of the Fluvial Geomorphology Modeling and Ice Processes (Study 7.6) studies in predicting the potential change to key geomorphic features that comprise the aquatic and riparian habitat. These activities will be ongoing through study completion. There are no variances or proposed modifications to this study component.

7.1.1. Decision Points from Study Plan

7.1.1.1. Study Component: Delineate Geomorphically Similar (Homogeneous) Reaches and Characterize the Geomorphology of the Susitna River

There are no decision points from the Study Plan for this study component.

7.1.1.2. Study Component: Bed- and Suspended-load Data Collection at Tsusena Creek, Gold Creek, and Sunshine Gage Stations on the Susitna River, Chulitna River near Talkeetna and the Talkeetna River near Talkeetna

When the decision was made to extend the 1-D bed evolution modeling from PRM 79 downstream to Susitna Station (PRM 29.9) it was decided to add the Susitna River at Susitna Station and the Yentna River near Susitna Station to the USGS bed load and suspended-load data collection effort. Adding the current sediment transport measurements for Susitna Station to the study provides for a check and potential modification of the 1980s sediment transport relationships that are important to the calibration and validation of the extended portion of the 1-D bed evolution model. The addition of the Yentna River sediment transport data collection effort similarly strengthens the ability to represent the overall sediment balance by quantifying a major sediment supply source near the downstream end of the model.

An overview of the decision to extend the 1-D bed evolution study limit downstream to PRM 29.9 is provided in ISR Study 6.6 Sections 3.1 and 7.1.1, and further documented in two TMs (R2 Resource Consultants [R2] 2013a and 2013b).

7.1.1.3. Study Component: Sediment Supply and Transport Middle and Lower Susitna River Segments

There are no decision points from the Study Plan for this study component.

7.1.1.4. Study Component: Assess Geomorphic Change Middle and Lower Susitna River Segments

The Study Plan (RSP Sections 6.5.4.4.2.1 and 6.5.5.5.2.2.) indicates a decision will be made on whether to acquire additional historical aerial photography for the Middle and Lower Susitna River Segments after completion of the analysis of aerial photography from the 1950s, 1980s and present. The analysis of channel change and the turnover analysis were just completed and the three sets of aerial photography provided an excellent history over the past 60 years. The set of

1950s aerial photography is the earliest high quality coverage available. In addition, the 2013 aerials that were flown to supplement the 2012 aerials document the river prior to, and after, the peak flow of ~90,000 cfs at Gold Creek which is one of the highest flows recorded in the period of record. These two sets of recent aerials provide an understanding of short-term channel change from a large event that was the intent of acquiring additional historical aerial photography. Finally, in the process of searching for the 1950s aerial photography no additional high quality aerial photography covering large portions of the study area were located.

7.1.1.5. Study Component: Riverine Habitat versus Flow Relationship Middle Susitna River Segment

There are no decision points from the Study Plan for this study component.

7.1.1.6. Study Component: Reconnaissance-Level Assessment of Project Effects on Lower and Middle Susitna River Segments

There are no decision points from the Study Plan for this study component.

7.1.1.7. Study Component: Riverine Habitat Area versus Flow Lower Susitna River Segment

The Study Plan (RSP 6.5 Section 6.5.4.7.2.5) calls for a decision to be made to obtain current aerial photography and historical aerial photography for two additional flows for the selected riverine habitat study sites in the Lower River. Based on the results of the analysis of channel change at the 5 selected study sites for the target flow of 36,600 cfs, the decision was made to not obtain additional aerials for the Lower River. The decision was based on the high level of channel change in the Lower River between the 1980s and the present and an evaluation that found 1980s riverine macrohabitat versus flow relationships used to represent current conditions had change appreciably. In addition, the Fish and Aquatics IFS (Study 8.5) is not pursuing macrohabitat versus flow relationships derived from aerial photography as an approach to characterize habitat in the Lower River that would require this information.

7.1.1.8. Study Component: Reservoir Geomorphology

The delta formation task in this study component (RSP 6.5 Section 6.5.4.8.2.2) calls for the selection of tributaries to study for potential delta formation in the proposed reservoir fluctuation zone (Elevation 1850 to 2050 feet, NAVD88). Because of the potential impacts of delta formation on fish movement into tributaries that drain directly to the proposed Watana Reservoir, tributaries were selected for study in coordination with the Study of Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries (Study 9.12) and the Study of Fish Distribution and Abundance in the Upper Susitna River (Study 9.5). Criteria for selection include:

1. Contributing drainage area, with greater drainage area being a positive factor influencing selection. Sediment production potential for development of a delta is greater for larger drainage areas.

2. The presence of anadromous (Chinook salmon) and resident fish species (burbot, Dolly Varden, round whitefish and artic grayling), with the presence being a positive factor influencing selection.
3. The presence of existing barriers eliminated due to inundation in the reservoir zone, with elimination of the barrier being a positive factor influencing selection.
4. The presence of barriers within a short distance (on the order of a mile) above the top of the reservoir fluctuation zone, with the presence being a negative factor in selection since only a short length of habitat would be accessible between the reservoir fluctuation zone and the barrier.

Through coordination between the Geomorphology Study, the Barriers Study (Study 9.12), and the Fish Distribution and Abundance Study (Study 9.5), a list of six tributaries was initially compiled for recommendation to Licensing Participants. The six recommended tributaries included: the Oshetna River, Goose Creek, Jay Creek, Kosina Creek, Watana Creek and Deadman Creek.

A seventh tributary, Unnamed Tributary 194.8 was identified as a candidate for study without a clear basis for inclusion or exclusion. The selection criteria, the characteristics of the mapped tributaries in the reservoir fluctuation zone and the tributaries preliminarily recommended for study were presented to the stakeholders at the March 19, 2014 Fisheries Technical Meeting. As a result of absence of interest from the stakeholders regarding Unnamed Tributary 194.8 at the meeting, it was decided to exclude this tributary from further study. The basis for exclusion was the relatively small contributing drainage area, the absence of Chinook presence at the existing confluence, and the presence of only two of the selected resident fish species (i.e., Dolly Varden and artic grayling). Table 7.1-1 presents the characteristics of the candidate tributaries and identifies the six that were finally selected for further study.

7.1.1.9. Study Component: Large Woody Debris

There are no decision points from the Study Plan for this study component.

7.1.1.10. Study Component: Geomorphology of Stream Crossings along Transmission Lines and Access Alignments

There are no decision points from the Study Plan for this study component.

7.1.1.11. Study Component: Integration of the Fluvial Geomorphology Modeling below Watana Dam Study with the Geomorphology Study

There are no decision points from the Study Plan for this study component.

7.1.2. Modifications to Study Plan

7.1.2.1. Study Component: Delineate Geomorphically Similar (Homogeneous) Reaches and Characterize the Geomorphology of the Susitna River

No modifications to the Study Plan for this study component are needed to complete the study and meet Study Plan objectives.

7.1.2.2. Study Component: Bed- and Suspended-load Data Collection at Tsusena Creek, Gold Creek, and Sunshine Gage Stations on the Susitna River, Chulitna River near Talkeetna and the Talkeetna River near Talkeetna

One variance from 2013 associated with the methods for this study component (RSP Section 6.5.4.2.2) carries forward as a modification to the Study Plan for 2014 (Study 6.5 ISR Section 4.2.3). Due to logistical and safety issues, the bed load samples at Tsusena Creek were terminated after 2012, were not collected in 2013, and will not be collected in 2014. This will not affect the ability to meet study objectives as alternate means are available to determine the bed load passing the Watana dam site for the pre-Project condition. For post-Project conditions, the bed load passing the dam site will be zero as all bed load will be trapped in the reservoir. In terms of alternate means of determining the bed load transport at the dam site, there is only a 20 percent difference in the drainage area between the Tsusena Creek and Gold Creek gages, therefore the combination of the considerable bed load data collected at Gold Creek in the 1980s, 2012 and 2013 as well as planned for 2014 combined with estimates of tributary bed load contributions (see ISR Study 6.6 Section 4.1.2.6) will support estimation of Susitna River bed load at the Watana dam site for existing conditions. The data that was collected in 2012 on the Susitna River at Tsusena Creek will be used as a check on these calculations. As valid alternative means of estimating the bed load passing the Watana dam site for existing conditions are available, this modification does not affect AEA's ability to meet the objectives of this study component.

7.1.2.3. Study Component: Sediment Supply and Transport Middle and Lower Susitna River Segments

Two variances in the methods involving sediment transport related calculation were identified for this study component (see ISR 6.5 Section 4.3.3) that carry forward in 2014 and 2015 as modifications to the Study Plan. One variance involved the time period for calculating total sediment load and the resulting sediment balance and the other involved a calculation procedure for effective discharge.

The Study Plan calls for comparison of the total sediment load at the mainstem Susitna River gaging stations for an average, wet, and dry year between pre- and post-Project conditions considering warm and cool PDO (RSP Section 6.5.4.3.2). Because the 61-year daily flow record was available for both pre-Project and Maximum Load Following OS-1 conditions, the full record was used for this purpose in lieu of selecting specific three representative years (or six considering PDO) for the analysis. Sediment loads were compared on an average annual basis over all years, and the variability assessed by considering the range of annual loads from the 61-year record. This more comprehensive approach to assessing sediment loads provides a better assessment of the long-term Project influence on sediment transport than considering only the three "representative" years. If subsequently needed, the results for representative years can be extracted from the results for the 61 years. Going forward, annual sediment loads will be determined for the selected 50-year portion of the 61-year extended record (ISR Study 6.6 Appendix E). It is also noted that consideration of warm and cool PDO will not be considered in designating wet, average and dry years for the open-water period efforts conducted by the Geomorphology studies (Studies 6.5 and 6.6). This decision is documented in the Updated Geomorphology Modeling Approach TM (Tetra Tech 2014b). By determining total sediment

load and sediment balance based on the 50-year period rather than just three representative years, additional information to support meeting the study objectives is developed. The information for the representative years will be extracted from the 50-year analysis. Therefore, the proposed modification in the methods for 2014 and 2015 constitutes a more comprehensive approach and the ability of AEA to meet the study objectives is enhanced.

The second proposed modification involves the procedure to calculate effective discharge. In accordance with the relevant literature, equal arithmetic bins and not logarithmic bins, as incorrectly stated in the RSP (Section 6.5.4.3.2.4), were used in the effective discharge analysis (Biedenharn et al. 2000). This modification corrects the details of the procedure used to calculate effective discharge consistent with the literature and maintains AEA's ability to meet the objectives of the Study Plan.

7.1.2.4. Study Component: Assess Geomorphic Change Middle and Lower Susitna River Segments

No modifications to the Study Plan for this study component are needed to complete the study and meet Study Plan objectives.

7.1.2.5. Study Component: Riverine Habitat versus Flow Relationship Middle Susitna River Segment

There is one variance identified for this study component from 2013 (ISR Study 6.5 Section 4.5.3) that carries over as a modification in 2014 and 2015. It involves the collection of aerial photography in the Middle and Lower Susitna River Segments. In 2012 and again in 2013, aerial photography was acquired at a single target flow rather than the three flows identified in the RSP (Section 6.5.4.5.2.1). The Study Plan identified acquisition of three sets of aerial photography in 2012 approximately corresponding to the following discharges: 23,000, 12,500, and 5,100 cfs. Only one set of aerial photography was actually obtained with the flow for 50 percent of the Middle River at 12,900 cfs and 50 percent of the Middle River at 17,000 cfs. In 2013, it was decided to acquire additional aerial photographs for only the 12,500-cfs target discharge in the Middle River. Aerials were obtained for about 60 percent of the Middle River at 11,300 cfs and 40 percent at 6,200 cfs.

One goal of acquiring three sets of 2012 aerials was to compare the macrohabitat versus flow relationships from current conditions to 1980s information and determine if there is a difference in the habitat areas for current conditions from those mapped in the 1980s at similar flows. This goal was met by collection of the single set of aerial photography in 2012. Using the 2012 aerial photography, AEA concluded that the macrohabitat areas were appreciably different from those mapped in the 1980s (Tetra Tech 2013c). Subsequently, AEA also concluded that aerial photography collected at multiple specified discharges to develop macrohabitat versus flow relationships was not necessary for meeting the overall objectives of the Study Plan as the combination of the 2-D hydraulic modeling, bathymetry and topography collected in the Focus Areas will provide direct determination of the area of the various macrohabitat types over the range of flows of interest. Therefore, development of macrohabitat area versus flow relationships from aerial photographs collected at specified discharges as identified as a goal of this study component are not needed. This variance and the alternative approach were presented at both the

September 25, 2013 and December 2, 2013 Technical Work Group meetings. The objectives of the study will be met without collecting additional aerials at three flows as specified in the RSP (Section 6.5.4.5.2.1).

7.1.2.6. Study Component: Reconnaissance-Level Assessment of Project Effects on Lower and Middle Susitna River Segments

There are four variances identified for this study component from 2013 that will carry forward as modifications (see ISR Study 6.5 Section 4.6.3). Three of the variances involve the schedule and one the methods.

The literature review on the downstream effects of dams (RSP Section 6.5.4.6.2.4) will be completed in Q3 2014 rather than Q4 2013 so it can be coordinated and combined with the Riparian IFS (Study 8.6). Combining the literature review into a single document will strengthen the study coordination efforts and increase AEA's ability to meet the study objectives by further developing the linkages between these two studies and the physical and biological processes they are investigating.

Initial analysis of the modified braiding index (MBI) will be performed in 2014 rather than 2013 as identified in the RSP (Section 6.5.4.6.2.3). In 2014 detailed information on bed-material gradation (see ISR Study 6.6 Section 4.1.2.9.1) and channel aggradation/degradation trends will become available from the 1-D Bed Evolution Model (see ISR Study 6.6 Section 4.1.2.1). The 1-D Bed Evolution Model results will represent the initial pre-Project and the initial post-Project scenario runs. This information will allow for an effective application of the MBI and its inclusion in the information used to determine potential Project effects on the morphology of the Lower River and support the decision on potentially extending the downstream limit of the 1-D Bed Evolution Model below PRM 29.9 (ISR Study 6.6 Section 7.1.1). The reason for performing the MBI calculation prior to Q1 2013 was to support the decision on whether to extend the 1-D Bed Evolution Model below PRM 79. This decision to extend the model to PRM 29.9 was made based on other factors (R2 2013a; R2 2013b), with the primary factor from the Geomorphology Study viewpoint being the level of peak flow change from pre-Project to the post-Project condition, represented by maximum load-following OS-1. By performing the MBI determination in 2014, the results will be available to inform the decisions on whether to extend the 1-D Bed Evolution Model below PRM 29.9; therefore this change in schedule does not affect AEA's ability to meet the objectives of the Study Plan.

The concurrent flow and stage analysis at Three Rivers Confluence area identified in the Stream Flow Assessment (RSP Section 6.5.4.6.2.1) was not conducted in Q4 2013. The primary purpose of this analysis was to determine the necessity of extending the Mainstem Flow Routing Model up the Talkeetna and Chulitna Rivers to evaluate the potential for Project induced changes in Susitna River flows and stages to alter the flow patterns during peak flows on the Talkeetna and Chulitna Rivers. However, one of the recommendations in the Fluvial Geomorphology Modeling Approach (Tetra Tech 2013h) was to include the Chulitna and Talkeetna rivers as modeled river reaches in the 1-D Bed Evolution Model so as to allow direct evaluation of potential Project effects on hydraulic and sediment transport conditions in the lower portions of these two tributaries. The decision to extend the 1-D Bed Evolution Model up the Chulitna and Talkeetna rivers has already been made. The concurrent flow and stage analysis will contribute to

interpretation of the 1-D Bed Evolution Model results in the Three Rivers Confluence Area and will be performed in 2014. The change in schedule did not impact AEA's decision on the modeling approach for the Three Rivers Confluence area; therefore this change in schedule does not affect AEA's ability to meet the objectives of the Study Plan.

The final variance that represents a modification to the Study plan for 2014 and 2015 involves the hydrologic analysis of alternative operating scenarios identified in the RSP (Section 6.5.4.6.2.1). Going forward, for future project scenarios, the hydrologic analyses of peak flows and flow duration will not be conducted as part the Geomorphology Study but instead these analyses will be conducted as part of the Fish and Aquatics IFS (Study 8.5 RSP Section 8.5.4.4.1.3). This modification does not affect the objectives of this study component as the technical work will be conducted, just under a different study. The objectives of the Stream Flow study component will be met by incorporating hydrologic information developed in the Fish and Aquatics IFS (Study 8.5).

7.1.2.7. Study Component: Riverine Habitat Area versus Flow Lower Susitna River Segment

This study component has been complete per the Study Plan and the objectives met with no variances.

7.1.2.8. Study Component: Reservoir Geomorphology

One variance was identified for this study component (see ISR Study 6.5 Section 4.8.3) from 2013 that will carry forward as a Study Plan modification. The RSP (Section 6.5.4.8.2.3) indicated that the field effort would occur in the summer of 2013. Due to lack of access to CIRWG lands that represent much of the reservoir inundation zone, the field effort was delayed and will occur in 2015. Study Plan objectives will be met as this data can be collected and the assessment performed in a single year.

7.1.2.9. Study Component: Large Woody Debris

Two variances (See ISR Study 6.5 Section 4.9.3) were identified for this study component from 2013 that will carry forward as Study Plan modifications. The first is that the August 2013 high-flow event provided the opportunity to assess LWD movement at several sample areas; this was an unanticipated event and was not included in the Study Plan. This event allowed the LWD crew to re-visit several previously inventoried LWD sample areas in the Middle River in September 2013. This provided the opportunity to check if previously inventoried wood had moved at these sample areas. In addition, the aerial photography collected in 2013 will also provide a means of assessing LWD movement as the result of the high spring runoff and August rain event. The addition of the assessment of LWD movement, and possibly recruitment, due to high flow events was not included in the original Study Plan and will strengthen AEA's ability to meet the objectives of this study component in terms of the understanding of LWD transport and recruitment. The second modification is that the Study Plan indicated that the field effort would occur in the summer of 2013. Due to lack of access to CIRWG lands and weather issues, not all of the field work was completed in 2013. The remaining field work will be completed in 2014/2015.

7.1.2.10. Study Component: Geomorphology of Stream Crossings along Transmission Lines and Access Alignments

One variance was identified for this study component from 2013 (ISR 6.5 Section 4.10.3) that will carry forward as a Study Plan modification. The RSP (Section 6.5.4.10.2) indicated that the field effort would occur in the summer of 2013. Due to lack of access to CIRWG lands (i.e. the majority of the Gold Creek Corridor and portions of the Chulitna Corridor) the field effort was delayed and will occur in 2015. Study Plan objectives will be met as this data can be collected and the assessment performed in a single year. As described in the ISR overview and depicted in Figure 1, following the release of the Draft ISR in February 2014, AEA added a new north-south transmission and access corridor alignment from the dam site to the Denali Highway (Figure 7.1-1). This alignment is referred to as the Denali East Option. For clarity, the north-south alignment study to date (and historically referred to as the Denali Corridor) is now referred to as the Denali West Option. Hence, all references in ISR Part A to the "Denali Corridor" are referring to the newly designated Denali West Option.

7.1.2.11. Study Component: Integration of the Fluvial Geomorphology Modeling below Watana Dam Study with the Geomorphology Study

No modifications to the Study Plan for this study component are needed to complete the study and meet Study Plan objectives.

7.2. Schedule

In general, the schedule for completing the FERC-approved Study Plan is dependent upon several factors, including Project funding levels authorized by the Alaska State Legislature, availability of required data inputs from one individual study to another, unexpected weather delays, the short duration of the summer field season in Alaska, and other events outside the reasonable control of AEA. For these reasons, the Study Plan implementation schedule is subject to change, although at this time AEA expects to complete the FERC-approved Study Plan through the filing of the Updated Study Report by February 1, 2016, in accordance with the ILP schedule issued by FERC on January 28, 2014.

7.2.1. 2014 Activities

7.2.1.1. Study Component: Delineate Geomorphically Similar (Homogeneous) Reaches and Characterize the Geomorphology of the Susitna River

A significant portion of the effort associated with this study component was completed in 2012 and 2013. The 2012 and early 2013 effort was reported in a technical memorandum (Tetra Tech 2013a) and included the completion of the first task, development of the geomorphic reach classification system, and much of the second task, the geomorphic delineation. The third task, the geomorphic characterization of the Susitna River, has also seen considerable work effort performed in 2013 with the effort being documented in ISR 6.5 (Sections 4.1.2.3 and 5.1.3). The primary effort remaining is the completion of the third task, geomorphic characterization of the Susitna River.

7.2.1.1.1. Identification and Development of Geomorphic Classification System

This task has been completed and no further study efforts are planned.

7.2.1.1.2. Geomorphic Reach Delineation

The Geomorphic Reach delineations have been finalized for all geomorphic reaches in the Study Area. However, as field data collection efforts continue and various analyses are performed, the morphometric parameters will be updated in 2014 to reflect the additional information gathered. The primary items that will to be updated are:

- Bed-material samples will be collected in 2014 and bed-material sizes updated in all three Susitna River segments based on the field effort (ISR Study 6.6 Section 7.2.1.1.9.1).
- The profiles in the Middle and Lower Susitna River Segments will be updated based on survey data collected in 2014 as part of the Fish and Aquatics IFS (Study 8.5).

7.2.1.1.3. Geomorphic Characterization of the Susitna River

There are two primary subtasks for which work will be performed in 2014 as part of the geomorphic characterization of the Susitna River.

Surficial Geology

- The bedrock and lateral constraint mapping may be updated based on observations during the 2014 field season within MR-1, MR-2, and MR-3.

Geomorphic Surfaces and Processes

- The following activities will be undertaken in 2014 as information becomes available to further characterize geomorphic surfaces and processes.
  - Correlation of geomorphic surfaces with water-surface elevations determined from hydraulics generated by the 1-D and/or 2-D Bed Evolution models (Study 6.6)
  - Integration of ice-modeling efforts (ice jam backwater and/or dam break surge) with geomorphic surfaces and system dynamics (Study 7.6)
  - Further investigation of 7 extended Geomorphic Assessment Areas (GAAs) to ground-truth aerial/LiDAR-based mapping
  - Integration of data from riparian investigations (Study 8.6) including vegetation mapping and aging to better define age constraints in FAs.
  - Analysis of the spatial distribution of geomorphic surfaces and channel types within different aged components of the FAs.
  - Integration of turnover analysis results with FA dynamics.
  - Additional geomorphic characterization of the Upper and Lower Susitna River Segments.

— Development of similar level geomorphic characterization of the Upper River reaches.

— Investigation of sources of sand that is the volumetrically significant fraction of the sediment load for construction of geomorphic surfaces in the Middle River.

7.2.1.2. Study Component: Bed- and Suspended-load Data Collection at Tsusena Creek, Gold Creek, and Sunshine Gage Stations on the Susitna River, Chulitna River near Talkeetna and the Talkeetna River near Talkeetna

The USGS will continue to perform suspended-sediment and bed-load measurements and to the extent that conditions allow, bed-material samples in 2014. Measurements will be continued at all sites measured in 2013, which include the Susitna River above Tsusena Creek, near Talkeetna, at Sunshine and at Susitna Station; the Chulitna River below Canyon; the Talkeetna River near Talkeetna; and the Yentna River near Susitna Station.

7.2.1.3. Study Component: Sediment Supply and Transport Middle and Lower Susitna River Segments

As indicated in ISR 6.5 Section 6.3.1, additional USGS sediment measurements in the Middle Susitna River collected in 2014 will be used to assess the applicability of the 1980s sediment transport relationships and if necessary, to adjust the relationships. The initial analyses documented in the ISR will be updated to include additional operational scenarios as the associated post-Project flows become available. More specific tasks to be performed for each of the efforts are discussed below.

- Perform a more detailed pre-Project sediment balance for the Middle Susitna River Segment between the proposed Watana Dam site (PRM 187.1) and the Three Rivers Confluence (PRM 102.4) using the available data (the hydraulic and sediment transport modeling results for this portion of the study reach [Study 6.6]). This will involve the following steps:

  — Estimate the contributions to the sediment supply from mass wasting, bank erosion and tributaries in the Upper Susitna River Segment, and mass wasting, bank erosion and contributing tributaries downstream of the dam. The volume of sediment from bank erosion will be estimated by comparing channel locations and areas from the "turnover analysis" of the Assess Geomorphic Change Middle and Lower Susitna River Segments study component (ISR Study 6.5 Section 4.4) and comparison of cross sections surveyed in the 1980s with those from the 2012 surveys.

  — Use estimates of tributary sediment loading in the Middle River to be made as part of the Fluvial Geomorphology Modeling below Watana Dam Study (see ISR Study 6.6 Section 4.1.2.6) to refine the sediment balance.

  — Compare historical USGS sediment tributary data from Knott et al. (1986) with modeled loads from Indian River and Portage Creek. This information will be used to help select the appropriate sediment transport relationship for the tributaries and to adjust the relationship if necessary.

— Use suspended sediment-load measurements from the Susitna River at Tsusena gage in 2013 to refine the annual sediment supply to the Middle River.

- The characterization of bed-material mobilization will be updated in 2014 following the methods presented in ISR Study 6.5 Section 4.3.2.3. This will include expansion of the bed mobilization calculations to each of the Focus Areas and for the average hydraulic conditions and bed-material characteristics for each of the Middle and Lower River segment geomorphic reaches (LR-5 and LR-6 are not included).
- The effective discharge calculations will be updated using transport determination from the 1-D Bed Evolution Model (Study 6.6) for the pre-Project and OS-1 scenarios.

7.2.1.4. Study Component: Assess Geomorphic Change Middle and Lower Susitna River Segments

A large portion of the work in this study component was completed in 2012 and Q1 2013 and documented in the technical memorandum, *Mapping of Geomorphic Features within the Middle and Lower Susitna River Segments from 1980s and 2012 Aerials* (Tetra Tech 2013b). Additional efforts performed in 2013 included the acquisition and processing of archived 1950s aerial photography for the Middle and Lower River segments and acquisition and processing of 2013 aerials for the Lower, Middle and Upper River segments. As indicated in ISR Study 6.5 Section 6.4.1, the data currently available are adequate to support this study component and no additional data collection activities are planned for 2014.

Efforts planned for 2014 involve analysis of data previously collected, including:

- Complete the mapping of the geomorphic features in the Middle and Lower River segments from the 1950s aerial photography.
- Qualitatively assess channel change between 2012 and 2013 resulting from the large flows through side by side comparison of the 2012 and 2013 aerial photography and the overlay of the mapped 2012 geomorphic features on the 2013 aerial photography.
- Quantitatively assess the channel change between 2012 and 2013 in the Three Rivers Confluence area by delineation of the geomorphic features on the recently acquired 2013 aerial photographs in the Three Rivers Confluence area and comparing with the geomorphic features delineated for 2012 for the Talkeetna and Chulitna rivers and geomorphic reaches MR-8 and LR-1 of the Susitna River.
- Complete the turnover analysis in the Middle and Lower River segments to quantify the rate at which floodplain is converted to channels and channels are converted to floodplain over the period of 1950s to 1980s and 1980s to 2012.
- The current classification of the geomorphic features in the Middle River segments will be reviewed based on the 2013 aerial photography, the videography and line mapping from the Characterization and Mapping of Aquatic Habitats Study (Study 9.9), and field observations from 2013 studies and adjusted if necessary.

- Review the pairs of aerial photography to identify whether changes in a period may have been related to specific hydrology events. This will include the review of the 2012 and 2013 aerial photography identified in the second and third bullets above.
- Update the technical memorandum (Tetra Tech 2013b) to include the results of the five bulleted items above. The updated technical memorandum will be developed in 2014.

7.2.1.5. Study Component: Riverine Habitat versus Flow Relationship Middle Susitna River Segment

Most of the effort associated with this study component was conducted in 2012 and reported on in the technical memorandum *Mapping of Aquatic Macrohabitat Types at Selected Sites in the Middle and Lower Susitna River Segments from 1980s and 2012 Aerials* (Tetra Tech 2013c). Additional aerial photographs were collected in 2013 and described in ISR Study 6.5 Section 4.5.2.1.1.2. As indicated in ISR Study 6.5 Section 6.5.1, the data currently available are adequate to support this study component and no additional data collection activities are planned for 2014.

- In 2014, the mapping of the current (2012 and 2013) aquatic macrohabitat types will be expanded from the 50 percent performed to 100 percent of the Middle River segment. Similarly, mapping of the 1980s aquatic macrohabitat types will be expanded from 50 to 100 percent in the portion of the Middle River with suitable 1980s aerial photographs. This corresponds to PRM 102.4 to PRM 154.
- The additional mapping of aquatic macrohabitat type performed in 2014 will be used to update the habitat analysis presented in the 2012 study technical memorandum (Tetra Tech 2013f). The technical memorandum will be updated at the end of 2014.
- Coordination will occur with the Characterization and Mapping of Aquatic Habitats (Study 9.9) and Fish and Aquatics IFS (Study 8.5) to ensure that the macrohabitat types are mapped consistently across the three studies in the Middle River. This will be reflected in the updated TM to be developed in 2014.

7.2.1.6. Study Component: Reconnaissance-Level Assessment of Project Effects on Lower and Middle Susitna River Segments

The following tasks will be undertaken in 2014 under this study component.

- Refinement of the sediment transport assessment results for the pre-Project and OS-1 scenarios using updated sediment transport data/relationship and modeling results from the 1-D Bed Evolution Model. Updated information to be used in refining the sediment transport assessment is identified in ISR Study 6.5 Section 7.2.1.3.
- Determination of the modified braiding index (MBI) after information on bed-material gradation and channel aggradation/degradation trends becomes available from the 1-D Bed Evolution Model (ISR Study 6.6 Section 4.1.2.1).
- A technical memorandum on the downstream effects of dams will be completed and developed in collaboration with the Riparian Instream Flow Study (Study 8.6). If possible, observations from field studies will be included as comparison with the

compiled literature. The technical memorandum, documenting the results of the literature search and review will be developed in 2014.

7.2.1.7. Study Component: Riverine Habitat Area versus Flow Lower Susitna River Segment

No activities are planned for 2014 under this study component. The work for this study component was completed in 2013, which included the following tasks: Change in River Stage Assessment, Synthesis of 1980s Aquatic Habitat Information, Site Selection and Stability Analysis, and Aerial Photography Analysis.

7.2.1.8. Study Component: Reservoir Geomorphology

Efforts in three of the four tasks (reservoir trap efficiency and sediment accumulation rates, delta formation, and reservoir erosion) of this study component will occur in 2014. No significant work will be performed on the bank and boat-wave erosion downstream of Watana Dam task in 2014.

- Reservoir trap efficiency and sediment accumulation
  - Coordination with the Water Quality Modeling Study (Study 5.6) will occur on the initial simulation of trapping of fine sediment being performed using EFDC model. The Study 5.6 results will be checked against the sediment trapping estimates previously developed by the Geomorphology Study.
  - Trap efficiency estimates will be used to provide the Fluvial Geomorphology Modeling Study (Study 6.6) with sediment outflow from Watana Dam to serve as the upstream sediment supply to the 1-D Bed Evolution Model in the initial simulation of the OS-1 scenario.
- Delta Formation
  - An aerial reconnaissance of the selected tributaries to be evaluated in this task will be performed in order to refine and plan 2015 field data collection activities.
- Reservoir Erosion
  - Coordination will continue with the Geology and Soils Characterization Study (Study 4.5) and information developed in that study will be used to perform the initial office analysis of reservoir erosion/mass wasting potential.

7.2.1.9. Study Component: Large Woody Debris

Two major efforts will be performed in 2014 in this study component.

- Large woody debris will be digitized from either 2012 or 2013 aerial photographs for the mainstem Susitna River between the mouth (PRM 3.3) and PRM 75 and between PRM 143.6 and the Maclaren River (PRM 261.3). Wood will also be digitized from the 1983 and 1950 (if photo resolution is adequate) aerial photographs within the Middle and Upper River LWD sample areas.

- In 2014, the field inventory of LWD will take place in the remaining LWD sample areas in the Middle and Lower rivers following the field protocol used in 2013 (ISR Study 6.5 Appendix D.2).

7.2.1.10. Study Component: Geomorphology of Stream Crossings along Transmission Lines and Access Alignments

The primary efforts under this study component will be performed in 2015 including the field data collection efforts. In 2014, tasks will involve an aerial field reconnaissance to identify conditions along the corridors and refinement of the field data collection effort for 2015. These tasks, and the 2015 field work, will be coordinated with the Fish and Aquatic Resources (Study 9) and engineering planning efforts on the access corridor stream crossings.

7.2.1.11. Study Component: Integration of the Fluvial Geomorphology Modeling below Watana Dam Study with the Geomorphology Study

The integration of the Geomorphology Study with the Fluvial Geomorphology Modeling below Watana Dam Study will continue throughout 2014.

- Results of the initial pre-Project 1-D model run in the Middle River will be reviewed and interpreted in terms of the geomorphic response. This will include further refinement as necessary of the conceptual models describing the system.
- Results from the initial 1-D Bed Evolution Model run of post-Project OS-1 scenario will be reviewed and interpreted in terms of the geomorphic response.

7.2.2. 2015 Activities

The following activities are planned for 2015. In addition, any planned 2014 activities that are delayed or only partially completed in 2014 will be completed in 2015.

7.2.2.1. Study Component: Delineate Geomorphically Similar (Homogeneous) Reaches and Characterize the Geomorphology of the Susitna River

The third task of this study component, Geomorphic Characterization of the Susitna River, will be completed in 2015.

7.2.2.1.1. Identification and Development of Geomorphic Classification System

This task has been completed and no further study efforts are planned.

7.2.2.1.2. Geomorphic Reach Delineation

This task will be completed in 2014 and no tasks are planned for 2015.

7.2.2.1.3. Geomorphic Characterization of the Susitna River

The remaining activities to complete this task per the Study Plan (RSP Section 6.5.4.1.2.3) will be performed in 2015. A comprehensive Technical Memorandum will be prepared presenting the results of the task. The technical memorandum will integrate the information compiled in this

study as well as relevant information from the Fluvial Geomorphology Modeling Study (Study 6.6), Fish and Aquatics IFS (Study 8.5), Riparian IFS (Study 8.6), Ice Processes Study (Study 7.6) and Groundwater Study (Study 7.5) to provide a thorough characterization of the key geomorphic processes that create and maintain the geomorphic features that form the Susitna River. The identified processes are conceptualized in the geomorphic models that describe the current (pre-Project) behavior of the Susitna River.

7.2.2.2. Study Component: Bed- and Suspended-load Data Collection at Tsusena Creek, Gold Creek, and Sunshine Gage Stations on the Susitna River, Chulitna River near Talkeetna and the Talkeetna River near Talkeetna

No data collection is planned for 2014 under this study component. The data collected by the USGS per RSP Section 6.5.4.2 is expected to be completed in 2015.

7.2.2.3. Study Component: Sediment Supply and Transport Middle and Lower Susitna River Segments

In 2015, this study component will support the Fluvial Geomorphology Modeling Study (Study 6.6) by performing calculations that help in evaluating and interpreting modeling as identified in RSP Section 6.5.4.3. 2015 activities include:

- Review USGS sediment transport data collected in 2014 and perform any final adjustments to sediment transport rating curves for the Susitna River mainstem sites (at Tsusena Creek, at Gold Creek, at Sunshine and at Susitna Station), the Chulitna River, the Talkeetna River, and the Yentna River.
- Effective discharge calculations will also be performed for each alternative operational scenario as the results of the 1-D Bed Evolution Model for post-Project scenarios become available.
- Perform assessments of sediment balance in the Middle and Lower Susitna River Segments for alternative operational scenarios as the results of the 1-D Bed Evolution Model for post-Project scenarios become available.
- Document bed mobilization characteristics associated with additional operational scenarios as the results of the 1-D Bed Evolution Model for post-Project scenarios become available.

7.2.2.4. Study Component: Assess Geomorphic Change Middle and Lower Susitna River Segments

This study component will be completed in 2014 per RSP Section 6.5.4.4 and no tasks are planned for 2015.

7.2.2.5. Study Component: Riverine Habitat versus Flow Relationship Middle Susitna River Segment

This study component will be completed in 2014 per RSP Section 6.5.4.5 and no tasks are planned for 2015.

7.2.2.6. Study Component: Reconnaissance-Level Assessment of Project Effects on Lower and Middle Susitna River Segments

In 2015, this study component will support the Fluvial Geomorphology Modeling Study (Study 6.6) by performing analysis that helps in evaluating and interpreting modeling results as identified in RSP Section 6.5.4.6. Planned 2015 activities include:

- A concurrent flow and stage analysis to help determine the potential for Project-induced changes in flows and stage on the Susitna River that may have the potential to alter the erosion patterns in the area of the town of Talkeetna. As part of this effort, aerial photography available prior to the high flow events in September 2012, June 2013 and August 2013 and aerial photography available after these high flows will be evaluated to determine the extent of erosion from the high flows.
- Application of the conceptual framework for the identification of geomorphic reach response (RSP Section 6.5.4.6.3) will be performed for each alternative operational scenario as the results of the 1-D Bed Evolution Model for post-Project scenarios become available.

7.2.2.7. Study Component: Riverine Habitat Area versus Flow Lower Susitna River Segment

This study component was completed in 2013 per RSP Section 6.5.4.7 and no tasks are planned for 2015.

7.2.2.8. Study Component: Reservoir Geomorphology

Activities in all 4 tasks associated with this study component will be performed in 2015 per the Study Plan (RSP Section 6.5.4.8.2).

- Reservoir trap efficiency and sediment accumulation
  - — Continued coordination with the Water Quality Modeling Study (Study 5.6) will occur on the simulation of trapping of fine sediment being performed using EFDC model for each alternative operational scenario as they become available. The Study 5.6 results will be checked against the sediment trapping estimates previously developed by the Geomorphology Study.
  - — The reviewed results of the Watana Dam sediment outflow from the Water Quality Modeling Study (Study 5.6) will be provided to the Fluvial Geomorphology Modeling Study (Study 6.6) to serve as the upstream sediment supply to the 1-D Bed Evolution Model of post-Project scenarios.
- Delta Formation
  - — Field data will be collected on the six tributaries selected for evaluation in this task (Oshetna River, Goose Creek, Jay Creek, Kosina Creek, Watana Creek and Deadman Creek).

— The analysis of the potential formation of tributary deltas will be evaluated per RSP Section 6.5.4.8.2.2 for the six selected tributaries.

- Reservoir Erosion

  — Field work for the Reservoir Geomorphology study component will take place in 2015 including collection of soil and geology data.

  — Perform reservoir erosion analysis per RSP Study 6.5 Section 6.5.4.8.2.3.

- Bank and Boat-wave Erosion Downstream of Watana Dam

  — This analysis will be performed in 2015 per RSP Study 6.5 Section 6.5.4.8.2.4, and will use data collected in the Fluvial Geomorphology Modeling below Watana Dam Study (ISR Study 6.6 Section 4.1.2.9).

7.2.2.9. Study Component: Large Woody Debris

Field data collection and analysis of all results will take place in 2015 and the study will be finalized per the Study Plan (RSP Section 6.5.4.9.2).

- Data from the aerial photograph and field inventories will be compiled and an evaluation of the interactions of LWD with aquatic habitat, geomorphological processes, ice processes, and riparian resources will be made.
- Field work at Upper River LWD inventory sites will take place in 2015 (sites from PRM 196 to PRM 260).

7.2.2.10. Study Component: Geomorphology of Stream Crossings along Transmission Lines and Access Alignments

This study component will be completed in 2015 per the Study Plan (RSP Section 6.5.4.10.2

- Field work along the transmission/access corridors will take place in 2015.
- Analysis of results will take place in 2015 and the study will be finalized.

7.2.2.11. Study Component: Integration of the Fluvial Geomorphology Modeling below Watana Dam Study with the Geomorphology Study

The integration of the Geomorphology Study with the Fluvial Geomorphology Modeling below Watana Dam Study will be completed in 2015 per RSP Section 6.5.4.11.

- Results of the final pre-Project model runs in the Middle River will be reviewed and interpreted in terms of the geomorphic response. This will include any refinement as necessary of the conceptual models describing the system.
- Results from the 1-D Bed Evolution Model runs of post-Project scenarios, as they become available, will be reviewed and interpreted in terms of the geomorphic response.

Results from the 2-D Bed Evolution Model runs of post-Project scenarios, as they become available, will be reviewed and interpreted in terms of the geomorphic response.

7.3. Conclusions

Significant progress has been made in 2012, 2013 and Q1 of 2014 in meeting the objectives of the Geomorphology Study. In 2013, the Geomorphology Study developed seven technical memorandums based on 2012 and early 2013 study efforts and one field report based on 2013 winter studies:

- Initial Geomorphic Reach Delineation and Characterization, Middle and Lower Susitna River Segments.
- Mapping of Geomorphic Features and Assessment of Channel Change in the Middle and Lower Susitna River Segments from 1980s and 2012 Aerials.
- Mapping of Aquatic Macrohabitat Types at Selected Sites in the Middle and Lower Susitna River Segments from 1980s and 2012 Aerials.
- Stream Flow Assessment.
- Development of Sediment Transport Relationships and an Initial Sediment Balance for the Middle and Lower Susitna River Segments.
- Reconnaissance Level Assessment of Potential Channel Change in the Lower Susitna River Segment.
- Synthesis of 1980s Aquatic Habitat Information.
- Field Assessment of Underwater Camera Pilot Test for Sediment Grain Size Distribution (Field Report – Included as Attachment A to Part A of the ISR).

In addition, the Geomorphology Study collaborated with and provided support to the Modeling Approach TMs submitted by the Fluvial Geomorphology Modeling Study (Study 6.6):

- Fluvial Geomorphology Modeling Approach (June 30, 2013).
- Updated Fluvial Geomorphology Modeling Approach (May 27, 2014).

Substantial results from the Geomorphology Study representing additional work conducted in 2013 are presented in appendices included with Part A of this ISR including:

- Appendix A.1: Surficial Geology Mapping in the Lower and Middle Susitna River Segments
- Appendix A.2: Geomorphic Surface Mapping in 7 Focus Areas
- Appendix A.3: Rating Curves for 7 Focus Areas (water surface elevations)
- Appendix A.4: Recurrence Interval Plots for 7 Focus Area
- Appendix B: Initial Effective Discharge Analysis for the Mainstem Susitna River and Tributaries
- Appendix C: Compilation of References from Literature Search on the Downstream Effects of Dams
- Appendix D.1: Large Woody Debris Aerial Photograph Digitizing

- Appendix D.2: Large Woody Debris Field Inventory Protocol
- Appendix D.3: Large Woody Debris Study Area Maps

The most recent document developed by the Geomorphology Study is an update to the February 2013 technical memorandum on the delineation and characterization of geomorphic reaches:

- Geomorphic Reach Delineation and Characterization, Upper, Middle and Lower Susitna River Segments. (Updated May 2014).

The Geomorphology Study also supported the development of the Proof of Concept documented in the Updated Geomorphology Modeling Approach TM (Tetra Tech 2014b) and supported the Riparian IFS (Study 8.6) in the Riparian IFS Technical Team meetings held April 29 and 30, 2014. Each of these activities demonstrated the progress being made within each of the various studies involved and in integration of the studies to develop a comprehensive assessment of potential Project effects.

In summary, significant progress has been made in all 11 study components with Riverine Habitat Area versus Flow Lower Susitna River Segment (Study Component 7) completed in 2013. Two other study components will be completed in 2014: Assess Geomorphic Change Middle and Lower Susitna River Segments (Study Component 4) and Riverine Habitat versus Flow Relationship Middle Susitna River Segment (Study Component 5). Two other study components will essentially be completed in 2014 with the only remaining effort being reporting: Delineate Geomorphically Similar (Homogeneous) Reaches and Characterize the Geomorphology of the Susitna River (Study Component 1) and Bed Load and Suspended-load Data Collection at Tsusena Creek, Gold Creek, and Sunshine Gage Stations on the Susitna River, Chulitna River near Talkeetna and the Talkeetna River near Talkeetna (Study Component 2). There are three study components that will be primarily performed in 2015 due to earlier access issues and current funding: Reservoir Geomorphology (Study Component 8), Large Woody Debris (Study Component 9), and Geomorphology of Stream Crossings along Transmission Lines and Access Alignments (Study Component 10). All three of these studies represent efforts that can be performed in a single year and their delay does not impact AEA's ability to meet the Objectives of the Study Plan. Three study components will continue into 2015 as they participate in the evaluation of post-Project scenarios: Sediment Supply and Transport Middle and Lower Susitna River Segments (Study Component 3), Reconnaissance-Level Assessment of Project Effects on Lower and Middle Susitna River Segments (Study Component 6), and Integration of the Fluvial Geomorphology Modeling below Watana Dam Study with the Geomorphology Study (Study Component 11).

Given the combination of 2012, 2013 and early 2014 efforts, variances (see ISR Study 6.5 Section 4), and the plans for 2014 and 2015 with modifications (see Section 7.1.2), AEA will achieve the approved objectives (ISR Study 6.5 Section 2) for the Geomorphology Study.

7.4. Literature Cited

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7.5. Tables

Table 7.1-1. Selection of Tributaries to Study for Potential Delta Formation.

Tributary	PRM[1]	D.A. (mi²)	Bank[2]	2012/2013 Fish Distribution (Study 9.5)					Existing Fish Passage Barriers Eliminated by Reservoir[3]			Selected	Rationale for Not Selecting[7]
				Chinook	Burbot	Dolly Varden	Round Whitefish	Arctic Grayling	Type[4]	Trib. RM[5]	Elevation[6]		
Oshetna River	235.1	556.4	L	X		X	X	X				Y	
Goose Creek	232.8	106.5	L	X	X		X	X				Y	
Un. Tributary	228.5	46.9	R									N	TOB elev. at 2,375 feet
Un. Tributary	215.2	2.3	L									N	TOB elev. at 2,200 feet; small D.A.
Jay Creek	211.0	62.4	R		X	X	X	X				Y	
Kosina Creek	209.1	402.5	L	X	X	X	X	X				Y	
Un. Tributary	204.5	12.3	L						Cmpd.	0.4 & 0.6	1,830 & 1,925	N	Steep channel; small D.A
Un. Tributary	203.4	19.5	R									N	TOB elev. at 2,030 feet; small D.A.
Un. Tributary	198.4	1.8	L			X						N	Small D.A.
Un. Tributary	197.7	8.1	L						Falls	1.3	1,990	N	Steep channel; small D.A.
Watana Creek	196.9	176.4	R	X	X	X	X	X				Y	
Un. Tributary	194.8	23.2	R			X		X				N	Small D.A.
Un. Tributary	189.7	1.9	L						Chute	0.4	1,990	N	Small D.A.
Deadman Creek	189.4	175.4	R		X	X	X	X	Falls	0.6	1,760	Y	

Notes:

1 PRM = Project River Mile

2 Bank defines the location of the tributary confluence with the Susitna River, as viewed facing downstream on the Susitna River. L = left; R = right.

3 Identifies existing fish passage barriers potentially inundated by the proposed Watana Reservoir. Reservoir low pool elevation is 1,850 feet (NAVD88) with an upstream extent at PRM 222.5; reservoir maximum pool elevation is 2,050 feet (NAVD88) with an upstream extent at PRM 232.5.

4 Type of fish passage barrier, as identified in Study 9.12. Cmpd. = compound feature, such as a chute and falls.

5 Trib. RM = tributary river mile, with RM 0.0 at confluence with Susitna River, to locate existing fish passage barrier.

6 Elevation = elevation in feet (NAVD88) of the most upstream top of barrier (TOB) as estimated using 2011 MatSu LiDAR.

7 Primary basis for excluding tributary from further studies of potential delta formation.

7.6. Figures

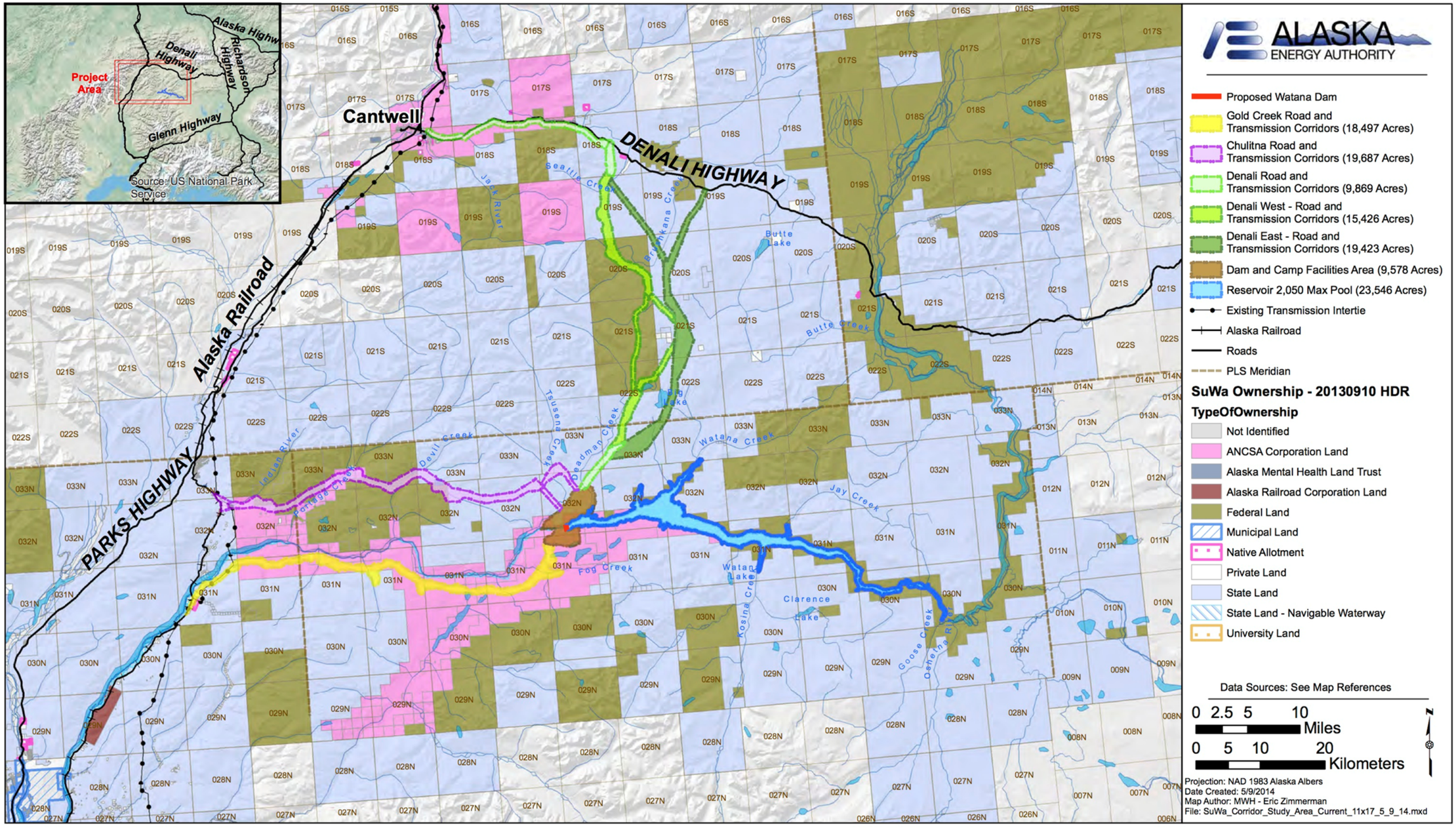

Figure 7.1-1: Updated Susitna-Watana access corridors.