Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Geomorphology Study
Study Plan Section 6.5

2014-2015 Study Implementation Report

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

Tetra Tech

Watershed GeoDynamics

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1. INTRODUCTION

The Geomorphology Study, Section 6.5 of the Revised Study Plan (RSP) approved by the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project, FERC Project No. 14241, focuses on characterization of 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.

A summary of the development of this study, together with the Alaska Energy Authority's (AEA) implementation of it through the 2013 study season, appears in Part A, Section 1 of the Initial Study Report (ISR) filed with FERC in June 2014. As required under FERC's regulations for the Integrated Licensing Process (ILP), the ISR describes AEA's "overall progress in implementing the study plan and schedule and the data collected, including an explanation of any variance from the study plan and schedule." (18 CFR 5.15(c)(1)).

Since filing the ISR in June 2014, AEA has continued to implement the FERC-approved plan for the Geomorphology Study, Section 6.5. For example:

- Characterization of the geomorphology of the Upper River Segment and on upstream to the Denali Highway Bridge (RSP Section 6.5.4.1.2.3 and ISR Section 7.2.1.1.3) based on the Upper River Reconnaissance
- Collection of 2014 bed and suspended-load sediment transport data by the USGS (RSP Section 6.5.4.2 and ISR Section 7.2.1.2)
- Aerial reconnaissance of the reservoir area tributaries (RSP Section 6.5.4.8.2.2 and ISR Section 7.2.1.8)
- Completion of large woody debris (LWD) sampling in the Middle and Lower Rivers (RSP Section 6.5.4.9 and ISR Section 7.2.1.9)
- AEA held the first ISR meeting for Studies 6.5 and 6.6 in October 15-17, 21-23, 2014 in Anchorage
- AEA has completed the following technical memorandum:
    - Susitna River Historical Cross Section Comparison (Tetra Tech 2014a)
    - Update of Sediment Transport Relationships and a Revised Sediment Balance for the Middle and Lower Susitna River Segments (Tetra Tech 2014b)
    - Mapping of Geomorphic Features and Turnover within the Middle and Lower Susitna River Segments from 1950s, 1980s, and Current Aerials (Tetra Tech 2014c)
    - Updated Mapping of Aquatic Macrohabitat Types in the Middle Susitna River Segment from 1980s and Current Aerials (Tetra Tech 2014d)
    - Assessment of the Potential for Changes in Sediment Delivery to Watana Reservoir Due to Glacial Surges (Tetra Tech 2014e)
    - Dam Effects on Downstream Channel and Floodplain Geomorphology and Riparian Plant Communities and Ecosystems – A Critical Literature Review (R2 Resource Consultants, Inc. and Tetra Tech 2014)

- Geomorphic Reach Delineation and Characterization, Upper, Middle and Lower Susitna River Segments – 2015 Update (Tetra Tech 2015a). (AEA notes that the geomorphic reach delineation technical memorandum was updated in 2015 to reflect the more detailed information gathered during the August 2014 field reconnaissance of the Upper River Segment and bed material samples collected in the 2014 winter and summer field seasons. The updated version of this technical memorandum Attachment 1 to this report.)

In furtherance of the next round of ISR meetings and FERC's SPD expected in 2016, this report describes AEA's overall progress in implementing the Geomorphology Study, Study 6.5, during calendar year 2014. Rather than a comprehensive reporting of all field work, data collection, and data analysis since the beginning of AEA's study program, this report is intended to supplement and update the information presented in Part A of the ISR for the Geomorphology Study, Study 6.5, through the end of calendar year 2014. It describes the methods and results of the 2014 effort, and includes a discussion of the results achieved.

2. STUDY OBJECTIVES

The overall goal 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 (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. This information will be used to assist in determining whether protection, mitigation, or enhancement measures may be needed, and if so, what those measures may be. More specific goals of the Geomorphology Study are as follows:

- Determine how the river system functions under existing conditions.
- Determine how the current system forms and maintains a range of aquatic and channel margin habitats.
- Identify the magnitudes of changes in the controlling variables and how these will affect existing channel morphology in the identified reaches downstream of the dam and in the areas upstream of the dam affected by the reservoir.
- In an integrated effort with the Fluvial Geomorphology Modeling below Watana Dam Study (Study 6.6), determine the likely changes to existing habitats through time and space.

In order to achieve the study goals, there are 11 study objectives:

1. Geomorphically characterize the Project-affected river channels and floodplain including:
    - Delineate the Susitna River into geomorphically similar reaches.

- Characterize and map relic geomorphic forms from past glaciation and debris flow events.
- Characterize and map the geology of the Susitna River, identifying controlling features of channel and floodplain geomorphology.
- Identify and describe the primary geomorphic processes that create, influence, and maintain mapped geomorphic features.

2. Collect sediment transport data to supplement historical data to support the characterization of Susitna River sediment supply and transport.
3. Determine sediment supply and transport in Middle and Lower Susitna River Segments.
4. Assess geomorphic stability/change in the Middle and Lower Susitna River Segments.
5. Characterize the surface area versus flow relationships for riverine macrohabitat types (1980s main channel, side channel, side sloughs, upland sloughs, tributaries and tributary mouths) over a range of flows in the Middle Susitna River Segment.
6. Conduct a reconnaissance-level geomorphic assessment of potential Project effects on the Lower and Middle Susitna River Segments considering Project-related changes to stream flow and sediment supply and a conceptual framework for geomorphic reach response.
7. Conduct a phased characterization of the surface area versus flow relationships for riverine macrohabitat types in the Lower Susitna River Segment including:
    - Delineation of aquatic macrohabitat per 1980s definitions for selected sites.
    - Comparison of 1980s versus existing macrohabitat areas at selected sites.
    - Estimate potential change in macrohabitat areas based on initial estimates of change in stage from Project operations.
    - Optional – If Focus Areas are extended into the Lower Susitna River Segment, perform analysis of macrohabitat wetted area versus flow relationships for additional sites and flows.
8. Characterize the proposed Watana Reservoir geomorphology and changes resulting from conversion of the channel/valley to a reservoir.
9. Assess large woody debris transport and recruitment, their influence on geomorphic forms and, in conjunction with the Fluvial Geomorphology Modeling below Watana Dam Study, effects related to the Project.
10. Characterize geomorphic conditions at stream crossings along access road/transmission line alignments.
11. Integration with the Fluvial Geomorphology Modeling below Watana Dam Study to develop estimates of Project effects on the creation and maintenance of the geomorphic features that comprise important aquatic and riparian macrohabitats and other key habitat indicators, with particular focus on side channels, side sloughs, and upland sloughs.

3. STUDY AREA

The study area for the Geomorphology Study is the Susitna River from its confluence with the Maclaren River (PRM 261.3[RM 260]) downstream to the mouth at Cook Inlet (PRM 3.3[RM 0]). The study area has been divided into three large-scale river segments:

- Upper Susitna River Segment: Maclaren River confluence (PRM 261.3[RM 260]) downstream to the proposed Watana Dam site (PRM 187.1 [RM 184]).
- Middle Susitna River Segment: Proposed Watana Dam site (PRM 187.1 [RM 184]) downstream to the Three Rivers Confluence (PRM 102.4 [RM 98]).
- Lower Susitna River Segment: Three Rivers Confluence (PRM 102.4 [RM 98]) downstream to Cook Inlet (PRM 3.3 [RM 0]).

Each of the 11 study components that make up the Geomorphology Study has a component-specific study area often related to the three large-scale river segments identified above. The study area and river segments are shown on Figure 3-1. Identification of the study area that each study component addresses is provided in the discussion of each study component in RSP Section 6.5.4, Study Methods.

4. METHODS AND VARIANCES IN 2014

The implementation of the 11 Geomorphology Study components and variances in 2014 are presented in this section. The variances listed in this section are continuations of 2013 variances described in the ISR Part A and proposed as study plan modifications in ISR Part C Section 7.1.2. No new variances were identified in 2014.

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

This study component has been carried out in accordance with ISR Study 6.5 Section 4.1 and RSP Section 6.5.4.1. It consists 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).

2014 activities for this study component were performed under two of the three tasks. For the Identification and Development of Geomorphic Classification System task, no work was performed in 2014. As identified in ISR Study 6.5 Section 7.2.1.1.1, this task has been completed and is reported 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 2014f) 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).

For the second task, the Geomorphic Reach Delineation task (ISR Study 6.5 Section 7.2.1.1.2) the 2014 bed material samples collected in Study 6.6 were used to update the bed material sizes representing each reach and the cross section survey data were used to update the representative channel slopes for several reaches. Characterization of the Upper Susitna River Segment was refined based on results of the Upper River Geomorphic Reach reconnaissance conducted in August 2014. These efforts resulted in the revised technical memorandum *Geomorphic Reach Delineation and Characterization, Upper, Middle and Lower Susitna River Segments – 2015 Update* provided in Attachment 1.

Activities in 2014 for the third task, the Geomorphic Characterization of the Susitna River (ISR Study 6.5 Section 7.2.1.1.3), include:

(1) 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);
(2) Integration of ice-modeling efforts (ice jam backwater and/or dam break surge) with geomorphic surfaces and system dynamics (Study 7.6);
(3) Further investigation of 7 extended Geomorphic Assessment Areas (GAAs) to ground-truth aerial/LiDAR based mapping;
(4) Integration of data from riparian investigations (Study 8.6) including vegetation mapping and aging to better define age constraints in FAs;
(5) Analysis of the spatial distribution of geomorphic surfaces and channel types within different aged components of the FAs;
(6) Integration of turnover analysis results with FA dynamics;
(7) Additional geomorphic characterization of the Upper and Lower Susitna River Segments;
(8) Development of similar level geomorphic characterization of the Upper River reaches; and
(9) Investigation of sources of sand that is the volumetrically significant fraction of the sediment load for construction of geomorphic surfaces in the Middle River.

During the Upper River reconnaissance opportunistic water quality parameters were collected. This included water depth, water temperature, conductivity, turbidity, and reduction potential (ORP). The parameters were sampled with a YSI 556MPS water quality meter and MicroTPW turbidity meter. This activity was not part of the FERC-approved Study Plan.

In addition to these characterization efforts, the technical memorandum *Susitna River Historical Cross Section Comparison* (Tetra Tech. 2014a) was filed on September 17, 2014. This technical memorandum provides a comparison of cross sections that were surveyed in the 1980s with those surveyed in 2012 and 2013. This information has been used by the Fluvial Geomorphology Modeling Study (6.6) to help in the validation of the 1-D bed evolution model in the Middle Susitna River segment. This effort was part of the third task of this study component.

4.1.1. Variance from Study Plan

There was one variance in 2014 to the Study Plan for this study component. This involved the collection of opportunistic water quality samples while performing the Upper River reconnaissance. This variance will enhance AEA’s ability to meet objectives of the Water Quality Baseline Study (5.5) and Fish Distribution and Abundance in the Upper Susitna River (9.5) by providing additional water quality data.

4.2. 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

In accordance with RSP 6.5.4.2, this study component consists of data collection by the USGS to characterize sediment transport conditions in the Susitna River and its major tributaries within the Study Area. In 2014, USGS continued data collection at all of the 2013 sites. This effort was performed per methods described in ISR Study 6.5 Section 4.2. This study component is complete.

4.2.1. Variance from Study Plan

As described in ISR Part A Section 4.2.3, collection of bedload samples from the Tsusena Creek gage site were terminated after 2012 due to logistical and safety concerns. This variance was proposed as a modification to the study (ISR Part C Section 7.1.2.2) and was implemented in 2014 as a variance to the Study Plan. This variance did not affect AEA’s ability to meet the objectives of this study component.

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

This study component (RSP Section 6.5.4.3) consists 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 provided the sediment input from the mainstem and major Susitna River tributaries for the bed evolution modeling efforts 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).

The 2014 activities for this study component included performing a more detailed pre-Project sediment balance for the Middle Susitna River Segment than presented in an earlier technical memorandum (Tetra Tech 2013a). This activity was performed with methods identified in ISR Part A Section 4.3 and further discussed in the technical memorandum filed September 17, 2014 (Tetra Tech 2014b).

Although not identified in the Study Plan, the availability of helicopter flight time provided the opportunity for the Geomorphology Study (6.5) to collect video of the Susitna River to support identification of mass wasting and sediment supply within the channel for both the Middle and Lower Susitna River segments. The videos are a mechanism to characterize tributaries and their contributing watersheds in terms of bed rock controls, lateral sediment sources, and potential sediment sinks. This data will support a more detailed pre-Project sediment balance for the Middle and Lower Susitna River segments.

4.3.1. Variance from Study Plan

Two variances in the methods related to sediment transport calculations were continued in 2014. These were also described as variances in 2013 (Study 6.5 ISR Part A Section 4.3.3) and were proposed as modifications to the Study Plan (see Study 6.5 ISR Part C Section 7.1.2.3). 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. These variances, as described in ISR Part C Section 7.1.2.3, were implemented in 2014. The entire available flow record (61 years) was used to evaluate sediment loads rather than only representative dry, average and wet years and equal arithmetic bins were used to evaluate effective discharge rather than logarithmic bins. These variances did not affect AEA's ability to meet the objectives of this study component.

A third variance involved collecting videos during reconnaissance trips on the Middle and Lower Susitna River. These videos help document conditions of tributaries and potential sources of sediment from mass wasting along the mainstem Susitna River. These opportunistically collected videos from aerial reconnaissance enhance AEA's ability to meet the objectives of this study component.

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

This study component compared 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 (RSP Section 6.5.4.4).

The 2014 activities for this study component included completing the mapping of geomorphic features in the Middle and Lower River segments from 1950s photography, assessing channel change between 2012 and 2013 aerial photography, completing the turnover analysis in the Middle and Lower River segments and revising the previously developed technical memorandum (Tetra Tech 2013g) (ISR Study 6.5, Part C, Section 7.2.1.4). The results are presented in September 26, 2014 filed technical memorandum *Mapping of Geomorphic Features and Turnover within the Middle and Lower Susitna River Segments from 1950s, 1980s, and Current Aerials* (Tetra Tech 2014c). These activities were performed with methods identified in ISR Study 6.5 Section 4.4 and are presented in further detail in the 2014 developed technical memorandum (Tetra Tech 2014c). This study component has been completed.

4.4.1. Variance from Study Plan

There were no variances in 2014 to the Study Plan for this study component.

4.5. 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 (RSP Section 6.5.4.5).

The 2014 activities for this study component included expanding the mapping of aquatic macrohabitat types to 100 percent of the Middle River Segment, coordinating with Study 9.9 and Study 8.5 to ensure consistent mapping, and updating the aquatic macrohabitat technical memorandum (Tetra Tech 2013f) (ISR Study 6.5, Part C, Section 7.2.1.5). The results are presented in September 26, 2014 *Updated Mapping of Aquatic Macrohabitat Types in the Middle Susitna River Segment from 1980s and Current Aerials* (Tetra Tech 2014d). These activities were performed with methods identified in ISR Study 6.5, Part A, Section 4.5 and further discussed in the 2014 developed technical memorandum (Tetra Tech 2014d). This study component has been completed.

4.5.1. Variance from Study Plan

There is one variance identified for this study component that was also described as a variance in ISR Study 6.5, Part A, Section 4.5.3 and was proposed as a modification in ISR Study 6.5, Part C, Section 7.1.2.5. 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. The actual aerial photography coverage of the Middle River obtained in 2012 was comprised of 50 percent at 12,900 cfs (PRM 143.6 to PRM 102.4) and 50 percent at 17,000 cfs (PRM 187.1 to PRM 143.6). 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 2013f). 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).

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

This study component 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 included a stream flow assessment (RSP 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).

The primary 2014 activities for this study component included refining the sediment transport assessment results for the pre-Project scenarios and completion of a technical memorandum on the downstream effects of dams in conjunction with Study 8.6 (ISR Study 6.5, Part C, Section 7.2.1.6). These activities were performed with methods identified in ISR Study 6.5, Part A, Section 4.6.2.2 and 4.6.2.4, respectively. The results of these activities are presented in *Dam Effects on Downstream Channel and Floodplain Geomorphology and Riparian Plant Communities and Ecosystems – A Critical Literature Review* (R2 and Tetra Tech 2014) filed November 14, 2014 and *Update of Sediment-Transport Relationships and a Revised Sediment Balance for the Middle and Lower Susitna River Segments* (Tetra Tech 2014b) filed September 17, 2014.

In support of the decision as to whether to continue the 1-D bed evolution model downstream of PRM 29.9, Project related changes in the magnitude of peak flows at Sunshine and Susitna station and changes in flow duration at Susitna Station were determined based on comparison of pre-Project and Max LF OS-1b flows. This effort is a continuation of the streamflow assessment identified in Study 6.5 ISR, Part A, Section 4.6.2.1. The annual peak flows to perform the frequency analysis and the daily flows to perform the flow duration analysis for the Max LF OS-1b condition were developed using the routed flows from the 1-D bed evolution model as described in Section 4.2.3 of the technical memorandum *Decision Point on Fluvial Geomorphology Modeling of the Susitna River below PRM 29.9* (Tetra Tech 2014g) filed September 26, 2014. The methods for developing the peak flow and flow duration analyses are presented in Section 4.3.1 of Tetra Tech (2014g).

4.6.1. Variances from Study Plan

In the RSP Section 6.5.4.6.2.1 and the ISR Study 6.5, Part A, Section 4.6.3, it was indicated that hydrologic analysis of operational scenarios beyond the initial streamflow assessment would be performed in the Fish and Aquatics IFS (Study 8.5). However, in 2014 in support of the decision on whether to extend the 1-D bed evolution model downstream of PRM 29.9, hydrologic analyses of Max LF OS-1b were performed in the Geomorphology Study (6.5). The analysis is documented in Tetra Tech (2014g). Therefore in 2014, there was not a variance related to performance of hydrologic analysis by the Geomorphology Study (6.5).

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

This study component consists of an initial assessment of the potential for Project effects associated with changes in stage to alter Lower Susitna River Segment riverine habitat (RSP Section 6.5.4.7). This study component was completed in 2013 and the methods and results are summarized in the ISR 6.5 Section 4.7 and Section 5.7., respectively. The detailed results were presented in three technical memoranda filed in February and March 2013 titled *Stream Flow Assessment. Susitna-Watana Hydroelectric Project* (Tetra Tech 2013d), *Synthesis of 1980s Aquatic Habitat Information* (Tetra Tech 2013e), and *Mapping of Aquatic Macrohabitat Types at Selected Sites in the Middle and Lower Susitna River Segments from 1980s and 2012 Aerials* (Tetra Tech 2013f). As described in ISR Section 4.7.3, there were no variances to the Study Plan.

4.8. Study Component: Reservoir Geomorphology

This study component consists of characterizing geomorphic changes resulting from conversion of the channel and portions of the river valley to a reservoir. Specific tasks under this study component include: 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).

The 2014 activities for this study component involve three of the four study tasks (ISR Study 6.5, Part C, Section 7.2.1.8). The first set of activities fell under the Reservoir Trap Efficiency and Sediment Accumulation task and included coordinating with the Water Quality Modeling Study (Study 5.6) and the sediment transport aspects of the reservoir modeling and supplying trap efficiency estimates to the Fluvial Geomorphology Modeling Study (Study 6.6). The sediment trap efficiency estimates were used in Study 6.6 to modify the sediment supply to the Middle River Segment for modeling of the with-Project conditions.

In addition, an analysis of the potential changes to sediment delivery from the upper Susitna watershed into the reservoir from glacial surges was performed. This effort was added as a result of the February 1, 2013 FERC SPD. The methods to conduct this effort are documented in the technical memorandum *Assessment of the Potential for Changes in Sediment Delivery to Watana Reservoir Due to Glacial Surges* filed November 14, 2014 (Tetra Tech. 2014e).

Under the Delta Formation task an aerial reconnaissance of selected tributaries for potential delta formation was performed. The purpose of this effort was to assist in developing plans for field data collection efforts.

For the third task, Reservoir Erosion, the 2014 activities consisted of performing coordination with the Geology and Soils Characterization Study (Study 4.5). These activities were performed with methods identified in ISR Study 6.5, Part A, Section 4.8.

4.8.1. Variance from Study Plan

There were no variances in 2014 to the Study Plan for this study component.

4.9. Study Component: Large Woody Debris

This study component, as identified in RSP Section 6.5.4.9, assesses the potential for Project construction and operation to affect the input, transport, and storage of large woody debris (LWD) in the Susitna River. Data development efforts to support the assessment of Project effects include inventory of LWD from aerial photography and inventory of LWD from field surveys.

The 2014 activities for this study component include digitizing large woody debris from 2012, 2013, and 1983 aerial photography in the Lower, Middle, and Upper river segments, and completing a field inventory of LWD within the remaining LWD sample areas downstream of PRM 187.1 (ISR Study 6.5, Part C, Section 7.2.1.9). These activities were performed with methods identified in ISR Study 6.5 Section 4.9.

4.9.1. Variance from Study Plan

There were no variances to the Study Plan related to the work carried out in 2014 for this study component.

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

This study component as identified in RSP Section 6.5.4.10 consists of characterizing the existing geomorphic conditions at stream crossings along access road/transmission line alignments and to determine potential geomorphic changes resulting from construction, operation, and maintenance of the roads and stream crossing structures.

The 2014 activities for this study component include an aerial field reconnaissance to identify conditions along the corridors and refinement of remaining field data collection (ISR Study 6.5, Part C, Section 7.2.1.10).

4.10.1. Variance from Study Plan

No variances from the Study Plan occurred in 2014.

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

This study component as identified in RSP Section 6.5.4.11 consists of two-way integration between the Geomorphology Study and the Fluvial Geomorphology Modeling Study (Study 6.6). The efforts of the Geomorphology Study identify the specific geomorphic (and habitat-related) processes that require further quantification, identify a significant portion of the data needs, and provides the basic information and context for performing the Fluvial Geomorphology Modeling Study. The Geomorphology Study (6.5) will apply its results to help guide the development and application of the various modeling efforts. After completion of the modeling, the study team will use the results from both studies in an integrated manner to provide interpretations with respect to the issues that must be addressed, including predictions of potential changes to key geomorphic features that comprise the aquatic and riparian habitat.

The 2014 activities for this study component included reviewing the initial pre-Project and post-Project 1-D model run in the Middle and Lower Susitna River segments, interpreting results in terms of geomorphic response, and refining conceptual models describing the system, where necessary (ISR Study 6.5, Part C, Section 7.2.1.11). These activities were performed with methods identified in ISR Study 6.5 Section 4.11.

To support study component objectives, an initial framework for integration of the studies was developed based on the First- and Second-order impacts components of the four-order hierarchical evaluation of dam-related impacts identified in the *Technical Memorandum - Dam Effects on Downstream Channel and Floodplain Geomorphology and Riparian Plant Communities and Ecosystems – A critical Literature Review* (Figure 1) (R2 Resource Consultants and Tetra Tech 2014). First-order impacts are changes to the primary physical drivers of the fluvial system: hydrology, sediment supply and ice processes. Second-order impacts result from changes in hydrology, sediment transport, ice process dynamics and channel and floodplain morphology. Third-order impacts are the ecological responses to the altered physical habitat and Fourth-order impacts describe biogeomorphic feedback between ecological responses and physical processes.

4.11.1. Variance from Study Plan

There were no variances to the Study Plan related to the work carried out in 2014 for this study component.

5. RESULTS

In 2014, activities for 10 of the 11 study components of the Geomorphology Study (6.5) were performed and associated results are reported in this section. In many cases, the results are reported in technical memoranda filed in 2014. In these cases, reference is made to the technical memoranda presenting the results. A list of all data filed in association with the performance of the Geomorphology Study (6.5) is provided in Table 5-1. This table is cumulative and includes data from 2012, 2013 and 2014. Each of the 9 columns of Table 5-1 are described below. The table is broken into two primary columns: (1) Active Data, and (2) Previously Submitted Data (now superseded). Each of these primary columns has sub-columns that further describe the data. To describe Table 5-1 below, the column headings are bolded and underlined, while the description of the contents of each column follow after the colon.

Column heading: description of contents

Active Data

- **Data**: Title of data delivered
- **Data Type**: The type of data delivered (i.e. ArcGIS Shapefile, JPEG, Excel Spreadsheet, MP4 Videos, LRV files, AVCHD Videos, PDF, GeoTIFF or MrSID)
- **File name:** Submitted name of data file.

Location (URLs in footnotes): Alphabetical letter noted. Each letter corresponds to a URL of where to find the data. Locations of the data may be found at the following:

a: http://gis.suhydro.org/isr/06-Geomorphology/6.5-Geomorphology/
b: http://gis.suhydro.org/Post_ISR/06-Geomorphology/6.5-Geomorphology/
c: http://gis.suhydro.org/raster-data
d: http://gis.suhydro.org/SIR/06-Geomorphology/6.5-Geomorphology/
e:http://gis.suhydro.org/SIR/06-Geomorphology/6.6-Fluvial_Geomorphology_Modeling/
f: http://pubs.usgs.gov/sir/2012/5210/

Folder Nesting: The folder nesting sequence to locate the specified data at the corresponding URL.

Study 6.5 Study Component: Study component number associated with Study 6.5. The study component number corresponds to the number identified in the first decimal position of the RSP, ISR, or SIR section number (i.e. Section X.Y) where X identifies the section number (i.e. methods, results, or discussion) and Y identifies the study component associated with Study 6.5.

Data described in following report: Report where data is discussed. Using the indicated report, and study component number (where applicable), one can identify where in the specified report, data is further discussed.

Previously submitted Data (now superseded):

File Name: Submitted name of data file

Location: Alphabetical letter associated with URLs listed in footnotes.

In 2014 three of the Geomorphology Study (6.5) study components were completed. These study components were 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 (RSP Section 6.5.4.2), Assess Geomorphic Change Middle and Lower Susitna River Segments (RSP Section 6.5.4.4) and Riverine Habitat versus Flow Relationship Middle Susitna River Segment (RSP Section 6.5.4.5).

No activities were performed in 2014 on the Riverine Habitat Area versus Flow Lower Susitna River Segment (RSP Section 6.5.4.7) study component as it was completed in 2013.

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

5.1.1. Initial Geomorphic Reach Classification System

No work was performed in 2014 for this task. As identified in ISR Study 6.5 Section 7.2.1.1.1, this task has been completed and reported on in two technical memoranda memorandums (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).

5.1.2. Initial Geomorphic Delineation

As identified in Study 6.5 ISR Section 7.2.1.1.2, bed-material data in the Upper, Middle, and Lower Susitna River segments as part of Study 6.6 was collected during the 2014 study season and was used to update morphometric parameters in the geomorphic reaches. The updated data are presented in Table 5.2-2 of the technical memorandum presented in Attachment 1 titled *Geomorphic Reach Delineation and Characterization, Upper, Middle and Lower Susitna River Segments – 2015 Update*. Further, thalweg profile data in the Middle and Lower Susitna River segments as part of Study 8.5 were collected during the 2014 study season and used to update the profiles in the Middle and Lower Susitna River segments in Figure 5.1-1, Figure 5.4-2, and Figure 5.5-2 of Attachment 1.

5.1.3. Geomorphic Characterization of the Susitna River

Further investigation of the geomorphic surfaces in the 7 Geomorphic Assessment Areas studied in 2013 to ground-truth aerials and LiDAR-based mapping (Section 4.1 Activity 3) and integration of turnover analysis results with FA dynamics (Section 4.1 Activity 6) has initiated an analysis of geomorphic surface heights and flow overtopping frequencies (Section 4.1 Activity 1). The analysis involved comparing geomorphic surface heights derived from 2014 LiDAR to the 100-year water surface elevations from the 1-D Hydraulic Model developed in Study 6.6. Surfaces above the 100-year water surface elevation, by definition, are defined as terraces. These channel-adjacent surfaces were identified throughout the Middle River below Devils Canyon as a result of ground-based observation of surface heights as well as the vegetation assemblage. Using turnover analysis results, the terrace surfaces were evaluated for main channel erosion (i.e., bank retreat) since the 1950s, dissection of the terrace surface since its formation (i.e., relationship to formation of side sloughs), and overall percentage of valley bottom area occupied by the terraces (i.e., the non-fluvial component of the valley floor).

The percentages the terrace units occupy, by geomorphic reach, compared to the overall valley bottom area, in addition to the percent compared to non-channel valley bottom area, are presented in Table 5.1-1. The summaries for the erosion and dissection for each geomorphic reach are presented in Table 5.1-2. These results are part of an initial investigation of geomorphic surface heights and overtopping frequencies and as such the results are preliminary and are intended to be updated in a technical memorandum.

As identified in ISR Study 6.5, Part C, Section 7.2.1.1.3 an Upper River Reconnaissance and Characterization was performed during the 2014 field study season (Section 4.1 Activities 7, 8, and 9). This effort was conducted by boat between the Denali Bridge at PRM 292 and the Watana Dam site at PRM 187.1. As part of the characterization effort, lateral controls of the channel planform, sediment storage zones and the caliber of the stored sediments, erosional areas, and areas of active landslides (sediment sources) were mapped for the entire Upper Susitna River Segment.

In addition, the area between the Denali Bridge and the official start of the Upper River Segment at the Maclaren River confluence was also characterized. This reconnaissance included investigating sources of sand that are a volumetrically significant fraction of the sediment load of the Middle River. Further data on sediment size fractions transported through the Susitna River Segments were developed as part of Study Component 3 and presented in Tetra Tech 2014b. These data were collected in the field with a Trimble GeoExplorer 6000 GeoXH GPS unit, noted in field books, and on field maps and documented with georeferenced photographs. The results of this effort are summarized in a series of maps; Figure 5.1-1 through Figure 5.1-9. Figures are referenced by geomorphic reach.

While the area above the Maclaren River confluence is not part of the Study Area (PRM 0- PRM 261.3), this section of the river was still investigated as it contributes sediment and flow to the Upper River Segment. Thus, the section between the Denali Bridge (PRM 292) and Maclaren River confluence (PRM 261.3) is noted as the "Upstream of Maclaren River Confluence" section and is discussed in further detail in Section 5.3.7 of Attachment 1 with representative photographs presented in Section 1 of Appendix A. Overall, upstream of the Maclaren River confluence, there is a relatively mild slope of roughly 6 ft/mile, mostly fine-grained lateral sediment sources with some gravel and cobble, limited presence of mid-channel islands in expansion zones, with very-low sediment delivering, small tributaries. These geomorphic variables indicate that delivered sediment composition to the Upper River Segment are mostly fine-grained materials from active glaciers and fine to coarse-grained materials derived from erosion and failure of the glacio-fluvial deposits that form the channel banks for most of the section.

With the absence of bathymetric data in the Upper River Segment, depths of the channel were estimated with a boat-mounted fathometer during the 2014 reconnaissance and are identified in Figure 5.1-10 through Figure 5.1-13. Sediment data collected during the 2014 reconnaissance effort is described and presented in the Study 6.6 Study Implementation Report.

As part of the Upper River Reconnaissance, opportunistic water quality parameters were collected. This included water depth, water temperature, conductivity, turbidity, and reduction potential (ORP). The parameters were sampled on a YSI 556MPS water quality meter and MicroTPW turbidity meter. A summary table of the water quality parameters collected are compiled in Table 5.1-3.

In addition, geomorphic surface mapping was performed for the remaining 3 Focus Areas (FA-151 Portage Creek, FA-173 Stephan Lake Complex, and FA-184 Watana Dam). The results of this mapping effort are presented in Section 5.1 Field Data Collection of the Study 6.6 Study Implementation Report. This effort included identifying the Geomorphic Assessment Area (GAAs) (ISR Study 6.5, Part A, Section 4.1.2.3.2) for each studied Focus Area. These boundaries are compiled in Table 5.1-4.

Activities identified in ISR Study 6.5, Part C, Section 7.2.1.1.3 including integration of ice-modeling efforts with geomorphic surfaces and system dynamics (Study 7.6) (Section 4.1 Activity 2), integration of data from riparian investigations including vegetation mapping and aging to better define age constraints in FAs (Section 4.1 Activity 4), and analysis of the spatial distribution of geomorphic surfaces and channel types within different aged components of the

FAs (Section 4.1 Activity 5) are part of an ongoing effort. In addition to these characterization efforts, the technical memorandum *Susitna River Historical Cross Section Comparison* (Tetra Tech. 2014a) was filed on September 17, 2014. This technical memorandum provides a comparison of cross sections that were surveyed in the 1980s with those surveyed in 2012 and 2013. This effort was part of the third task of this study component identified in Study 6.5 RSP Section 6.5.4.1.2.3.

5.2. 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

As identified in ISR Study 6.5 Section 7.1 and Section 7.2.1.2, two prior years (2012 and 2013) of data collection had been performed by the USGS and the USGS continued to perform suspended-sediment and bed-load measurements and to the extent that conditions allow, bed-material samples in 2014. The dates of collected sediment samples in 2014 are compiled in Table 5.2-1. Locations and types of USGS sediment transport data collected for the period of study from 2012 through 2014 are presented in Table 5.2-2. Tables 5.2-3, 5.2-4 and 5.2-5 provide the data collected for all three years; 2012, 2013 and 2014; for suspended sediment, bed-load and bed material, respectively. The reporting of the sediment transport data from the 2012, 2013 and 2014 collected by the USGS completes this study component.

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

As identified in ISR Study 6.5 Section 7.2.1.3, 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) than presented in an earlier technical memorandum (Tetra Tech 2013a) using hydraulic and sediment transport modeling results for this portion of the study area from the 1-D bed evolution model developed in Study 6.6. This task was completed and reported on in the September 17, 2014 posted Technical Memorandum, *Update of Sediment-Transport Relationships and a Revised Sediment Balance for the Middle and Lower Susitna River Segments* (Tetra Tech 2014b).

To support estimates of the contributions to the sediment supply from mass wasting, bank erosion and tributaries in the Middle and Lower Susitna River segments (ISR Study 6.5, Part C, Section 7.2.1.3), aerial videos were collected in August and September 2014. This data collection effort was conducted in conjunction with aerial reconnaissance of selected reservoir tributaries identified in the reservoir geomorphology study component (ISR Study 6.5, Part C, Section 7.2.1.8). Opportunistic video of the Susitna River was collected in this process in order to support identification of mass wasting and sediment supply within the channel for both the Middle and Lower Susitna River segments. The videos are a mechanism to characterize tributaries and their contributing watersheds in terms of bed rock controls, lateral sediment sources, and potential sediment sinks. This data will support a more detailed pre-Project sediment balance for the Middle and Lower Susitna River segments.

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

This study component was completed in 2014. The results of the completed study are presented in September 26, 2014 filed technical memorandum *Mapping of Geomorphic Features and Turnover within the Middle and Lower Susitna River Segments from 1950s, 1980s, and Current Aerials* (Tetra Tech 2014c).

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

This study component was completed in 2014. The results are presented in September 26, 2014 *Updated Mapping of Aquatic Macrohabitat Types in the Middle Susitna River Segment from 1980s and Current Aerials* (Tetra Tech 2014d).

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

As identified in RSP Section 6.5.4.6.2.4 and ISR Study 6.5 Section 7.2.1.6 a Literature Review on the downstream effects of dams has been integrated into technical memorandum developed jointly by the Riparian Instream Flow Study (Study 8.6) and the Geomorphology Study (6.5). This technical memorandum, the *Dam Effects on Downstream Channel and Floodplain Geomorphology and Riparian Plant Communities and Ecosystems – A Critical Literature Review* (R2 Resource Consultants and Tetra Tech 2014) was filed November 14, 2014. The results of this effort helped in the development of an initial framework presented in Section 5.11 to qualitatively and semi-quantitatively identify the anticipated trends and levels of project effects.

As identified in ISR Study 6.5 Section 7.2.1.6, a refinement of the sediment transport assessment results for the pre-Project condition was performed. This included an update of the rating curves for bedload transport and suspended-load transport. The results of this effort are presented in the technical memorandum *Update of Sediment-Transport Relationships and a Revised Sediment Balance for the Middle and Lower Susitna River Segments* (Tetra Tech 2014b) filed September 17, 2014. These rating curves were used in the development of the 1-D bed evolution model as presented in Study 6.6 SIR Attachment 1 *2014 Fluvial Geomorphology Modeling Model Development Technical Memorandum* (Tetra Tech 2015b).

In support of the decision as to whether to continue the 1-D bed evolution model downstream of PRM 29.9, Project related changes in the magnitude of peak flows at Sunshine and Susitna station and changes in flow duration at Susitna Station were determined based on comparison of pre-Project and Max LF OS-1b flows. The effort to quantify these changes in flows is a continuation of the streamflow assessment identified in Study 6.5 ISR Section 4.6.2.1. The results of this effort are reported in Section 5.1 of the technical memorandum *Decision Point on Fluvial Geomorphology Modeling of the Susitna River below PRM 29.9* (Tetra Tech 2014g) filed September 26, 2014.

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

This study component was completed in 2013. The results are described in three technical memoranda filed in 2013: *Mapping of Aquatic Macrohabitat Types at Selected Sites in the Middle and Lower Susitna River Segments from 1980s and 2012 Aerials* Technical Memorandum (Tetra Tech 2013f), *Stream Flow Assessment* Technical Memorandum (Tetra Tech 2013d), and *Synthesis of the 1980s Lower Susitna River Segment Aquatic Habitat Information* Technical Memorandum (Tetra Tech 2013e).

5.8. Study Component: Reservoir Geomorphology

5.8.1. Reservoir Trap Efficiency and Sediment Accumulation Rates

Estimates of reservoir trap efficiency for this study component were used by the Fluvial Geomorphology Modeling Study (6.6) to adjust the upstream sediment supply for the 1-D bed evolution model as described in Study 6.5 ISR, Part C, Section 7.2.1.8. The sediment sizes routed by the 1-D modeling effort include sand, gravels and cobbles. For these sizes, a trap efficiency of 100 percent was utilized as estimated in Study 6.5 ISR Section 5.8.1.

An analysis of the potential changes to sediment delivery from the upper Susitna watershed into the reservoir from glacial surges was performed. The results of this effort are documented in the technical memorandum *Assessment of the Potential for Changes in Sediment Delivery to Watana Reservoir Due to Glacial Surges* filed November 14, 2014 (Tetra Tech. 2014e).

Based on the results of this analysis it was concluded that no further geomorphic investigations were warranted for flow or sediment production from glacial surges (Tetra Tech 2014e). This included a recommendation to not include a glacial surge sediment loading scenario in the reservoir sediment trap efficiency and sediment accumulation modeling in the reservoir trap efficiency and sediment accumulation rates task (RSP Section 6.5.4.8.2.1) in Reservoir Geomorphology study component of the Geomorphology Study (6.5).

5.8.2. Delta Formation

As identified in ISR 6.5, Part C, Section 7.2.1.8, an aerial reconnaissance of selected tributaries was performed during the 2014 field season. These data include aerial reconnaissance videos of Oshetna River, Goose Creek, Jay Creek, Kosina Creek, Watana Creek, and Deadman Creek. The aerial reconnaissance of selected reservoir area tributaries for potential delta formation, performed on September 29, 2014, was carried out under the Delta Formation task. The primary objective of this reconnaissance was to support planning of field data collection efforts. Specifically, the potential formation of deltas is expected within the fluctuation zone of the proposed Watana Reservoir (i.e., between elevations of 1,850 feet and 2,050 feet, NAVD88). In addition to the aerial reconnaissance, opportunistic ground reconnaissance of the six reservoir area tributaries was performed during the Upper Susitna River Reconnaissance effort noted in Section 4.1 of this SIR. A summary of these observations from both reconnaissance efforts is presented in Table 5.8-1. The reconnaissance information will further support planning of the field data collection effort associated with the reservoir tributary deltas (ISR Study 6.5, Part C, Section 7.2.1.8).

The aerial reconnaissance provided a means to identify locations for field teams deployed in helicopters to safely access the tributaries near the areas where deltas may form so that sediment, primarily bed material, can be sampled and channel geometry surveyed. These data will be used to estimate sediment supplied to the potential deltas so formation of the deltas can be modeled.

Starting from upstream and proceeding downstream, some observations concerning the selected tributaries are summarized in the following paragraphs. The mouth of the Oshetna River is at an elevation above 2,050 feet. While the flow in the creek was relatively clear (Figure 5.8-1), the channel splits in the upstream direction with larger gravel bars and a more active planform, indicating potential for substantial gravel yield. Safe landing sites and access were noted near the mouth of the Oshetna River (Figure 5.8-2).

The elevation of the mouth of Goose Creek is about 2,050 feet. Goose Creek flows from a lower relief valley than the downstream tributaries, and exhibits stable hillslopes and a coarse plane bed channel (Figure 5.8-3). Safe access was identified at sites on the fan at the mouth of Goose Creek (Figure 5.8-4).

Jay Creek transports large woody debris and gravel as it flows through a narrow valley (elevated sediment yield may be driven by landslides and colluvial input from the hillslopes) (Figure 5.8-5). Safe landing sites were noted on the fan at the mouth of Jay Creek (Figure 5.8-6), upstream of elevation 1,850 feet and at an elevation of 2,050 feet.

Upon entering Kosina Creek, the multi-channel planform was apparent, which transitions into a sinuous channel in an unconfined valley in the upstream direction. Safe landing sites were identified at the confluence with the Susitna River (Figure 5.8-7), near elevations of 1,850 feet and 2,050 feet.

Large gravel bars, ample large woody debris, and evidence of an active channel transporting sediment and reworking deposits were observed in Watana Creek (Figure 5.8-8). Along Watana Creek, many safe landing sites were noted at the confluence with the Susitna River (Figure 5.8-9) near elevations of 1,850 feet and 2,050 feet.

A steep confined channel was observed in Deadman Creek near the confluence with the Susitna River (Figure 5.8-10), and the creek opens into an unconfined meadow in the upstream direction. Safe access was identified at the confluence with the Susitna river (Figure 5.8-11), and within the reservoir fluctuation zone along Deadman Creek either (1) in the creek channel if flows are low enough, or (2) on the left bank terrace.

5.8.3. Reservoir Erosion

In 2014, as identified in ISR 6.5, Part C, Section 7.2.1.8 the preliminary results of the Study 4.5 Reservoir Slope Stability Assessment and associated GIS coverages of preliminary soil and mass wasting conditions around the proposed reservoir site were reviewed to help plan field efforts to assess potential areas and types of reservoir shoreline erosion. Coordination between the Study 4.5 and the assessment of reservoir erosion (RSP Section 4.5.4.8.2.3) will continue.

5.8.4. Bank and Boat Wave Erosion downstream of Watana Dam

No work was performed on this task in 2014.

5.9. Study Component: Large Woody Debris

As identified in Study 6.5 ISR Section 7.2.1.9 the large woody debris (LWD) analysis completed in 2014 included finalizing the inventory of wood from the 1983, 2012, and 2013 aerial photographs and a field inventory of wood in six LWD sample areas in the Middle and Lower Susitna River to determine wood loading, input mechanisms, input and transport frequency, species, and function in the river. Methods followed those described in the RSP.

5.9.1. Aerial Photograph Inventory

LWD and log jams were digitized in the selected areas/geomorphic units listed in the RSP from the 1983, 2012, and 2013 aerial photographs (Table 5.9-1). The resolution of the 1950s aerial photographs was not adequate to differentiate LWD. The resolution of the 1980s aerial photographs upstream of PRM 159.5 was also not adequate to differentiate LWD so no digitizing was attempted for those years/areas. There were deep shadows in some areas of the channel that made differentiation of LWD and log jams difficult, particularly along southern shorelines where tall trees or topography created shadows.

5.9.2. Field Inventory

LWD sample areas at PRM 9-13, FA-151 Portage Creek, PRM 169, PRM 171, FA-173 Stephan Lake, and FA-184 Watana Dam were inventoried during the summer of 2014. A total of 525 individual pieces of LWD over 20 feet in length and 94 log jams (containing 466 pieces of LWD) were inventoried within the six LWD sample areas. Figures 5.9-1 through 5.9-5 show the characteristics of the combined 2013 and 2014 LWD field data. Maps showing the location of LWD within the six sample areas are included as Figures 5.9-6 through 5.9-11.

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

An aerial reconnaissance of the recently identified Denali East access corridor and portions of the Denali West corridor was made on August 14, 2014 to identify the general geomorphic condition of streams that the corridor crosses and help with logistical planning of field work at each crossing. This task was identified in Study 6.5 ISR, Part C, Section 7.2.1.10. The access routes were flown in a helicopter. A GPS point was taken at each crossing and information on estimated stream width, confinement, substrate, and the potential for helicopter landing sites was determined from the air. A photo was also taken of each crossing.

The route of the aerial reconnaissance flight and each stream crossing identified from the air is shown on Figure 5.10-1. Stream crossings were numbered sequentially as noted on the figure and correspond to the stream condition information recorded at each crossing in Table 5.10-1. All have easy helicopter landing zones nearby.

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

Continual refinement of geomorphic surfaces and interpretation and integration of model results has been performed between the Geomorphology Study and Fluvial Geomorphology Study in 2014 (ISR 6.5, Part C, Section 7.2.1.11). As identified in Section 4.11, an initial framework for integration of the Geomorphology Study and the Fluvial Geomorphology Study has evolved from the hierarchical evaluation of dam impacts presented in the technical memorandum *Dam Effects on Downstream Channel and Floodplain Geomorphology and Riparian Plant Communities and Ecosystems – A Critical Literature Review* (R2 Resource Consultants and Tetra Tech 2014). The initial framework is used to identify qualitatively and semi-quantitatively the anticipated trends and levels of Project effects (Table 5.11-1). The Project effects are divided into First-order (Table 5.11-2), or primary effects related to the Project and Second-order effects (Table 5.11-3) that result from the First-order change in geomorphic drivers. The trends (increasing or decreasing) and level of effects (little or no change, or anticipated low, medium, or high change) are identified for each category of potential effects. Development of the framework will continue resulting in its refinement, expansion and further quantification as more study results became available. It is anticipated that results from the Ice Processes in the Susitna River Study (7.6) and Riparian Instream Flow Study (8.6) will provide valuable information with which to refine, expand and further quantify the framework.

The integrating framework for the Geomorphology (Study 6.5) and Fluvial Geomorphology Modeling (Study 6.6), that is based on the hierarchical evaluation of dam effects (R2 Resource Consultants and Tetra Tech 2014), uses the findings and results of both studies to assess the most likely Project-induced physical trends in the three Susitna River segments. While most of the trend trajectories are presented qualitatively or semi-quantitatively, based on existing information, further results from the 1-dimensional and 2-dimensional bed evolution modeling of pre- and post-Project scenarios will enable quantification of Project impacts. It is highly unlikely that any of the Project scenarios will change the trajectory of the trends, but the magnitude of the individual changes will be dependent on the selected scenarios.

Integration of the Geomorphology (Study 6.5) and Fluvial Geomorphology Modeling (Study 6.6) study results within the framework of First- and Second-order responses to dams provides the expected changes to the physical system and hence the physical habitat within the channel and floodplain system. This in turn provides the basis for assessing Third-order impacts to the biological communities and the ecosystem and the Fourth-order biogeomorphic feedback between ecological responses and physical processes that are being investigated within the Riparian Instream Flow Study (Study 8.6) and Fish and Aquatics Instream Flow Study (Study 8.5), and Study of Fish Barriers in the Middle and Upper Susitna River and Susitna Tributaries (Study 9.12).

6. DISCUSSION

To date significant progress has been made in achieving the objectives of the Geomorphology Study (6.5) and its 11 study components. Discussion of the results for each of the 11 study components is presented in this section. Much of the progress in conducting these studies has been presented in the technical memoranda filed in 2012, 2013 and 2014. The Geomorphology Study 6.5 ISR Part A and its associated appendices also provided considerable information developed in the studies.

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

The vast majority of this study component has been completed. There is a thorough discussion of the progress in Study 6.5 ISR Section 6.1 through the early 2014. Since the reporting in the ISR, the most significant efforts involved the reconnaissance of the Upper Susitna River Segment and the associated update of the *Geomorphic Reach Delineation and Characterization, Upper, Middle and Lower Susitna River Segments – 2015 Update* include as Attachment 1 to this SIR (Note: Two earlier versions of this technical memorandum were filed in 2013 [Tetra Tech 2013a and 2014 (Tetra Tech 2014a)].

The Upper River reconnaissance effort was conducted to better understand the conditions upstream of the Watana Dam site that currently result in the upstream sediment supply to the Middle Susitna River segment. From this effort is was determined that the source of the large sand load in the Susitna River is primarily the glaciated watersheds upstream of the Middle River. In addition, through observations on this trip and in conducting field work in the Middle and Lower Susitna Rivers, it was determined that there is a progression of the relative influence of ice processes versus fluvial processes in determining the morphology of the Susitna River. In the Upper River segment ice processes tend to be dominant. Where coarse bed materials are present there is extensive paving of the bed and banks and there are extensive coarse grained ice deposits on the tops of lower terraces and floodplain segments. An ice trim line on the vegetation is frequently 10 to15 feet above the low-water surface. In the Middle River Segment the form and dynamics of the various order channels, bars and islands as well as floodplains and terraces are the result of the combined effects of both ice and fluvial processes. Ice processes, including ice damming and ice-jam failures, appear to be more important in alluvial reaches located upstream of valley floor constrictions. In the Lower River Segment, while ice processes occur, the widths of the valley bottoms tends to mitigate their effects, and hence the segment is fluvially dominated.

The 2014 field season allowed mapping of geomorphic surfaces in the 3 Focus Areas upstream of Portage Creek to complete the effort that was started in 2013 with the mapping of the 7 Focus Areas downstream of Portage Creek.

On September 17, 2014 the technical memorandum *Susitna River Historical Cross Section Comparison* (Tetra Tech. 2014a) was filed. This technical memorandum provides a comparison of cross section that were surveyed in the 1980s with those surveyed in 2012 and 2013. This information has been used by the Fluvial Geomorphology Modeling Study (6.6) to help in the validation of the 1-D bed evolution model in the Middle Susitna River segment. A significant conclusion from the technical memorandum relates to the relatively small amount of cross section change over the past three decades. In the conclusions of the technical memorandum (Tetra Tech 2014a) it is stated:

> *Overall, the results show that the Middle Susitna River was generally stable in terms of bed elevation change over the 3 decade period between the 1980s studies and the current effort. Changes were typically on the order of several feet or less and there was not a consistent trend toward aggradation (bed elevation increase) or degradation (bed elevation decrease) throughout the Middle River segment. The area with the most consistent trend were geomorphic reaches MR-7 and MR-8 in which the majority of the length was aggradational; however, there were still cross sections within these two reaches that showed degradation over the period of comparison. MR-2 showed the least change, with all cross sections having minimal change in bed elevation and area with the exception of the cross section at PRM 179.5, which aggraded by 2.3 ft and increased in area by 490 sq. ft. The remaining reaches had more of a mix between aggradation and degradation.*

With the completion of the updated technical memorandum (Attachment 1) and the Technical memorandum on historical cross section comparison (Tetra Tech 2014a), the overall objective of this study component to "Geomorphically characterize the Project-affected river channels and floodplain" and the specific objectives listed in the 4 sub-bullets in Section 2 have been largely met. Work remaining involves further development of the characterization by interaction with others studies as results of their analysis and modeling efforts become available. Of particular importance are findings from the Fluvial Geomorphology Modeling Study (6.6), Riparian Instream Flows Study (8.6), and the Ice Processes in the Susitna River Study (7.6).

6.2. 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

A thorough discussion of this effort based on the data collected in 2012 and 2013 was presented in the Study 6.5 ISR Section 6.2. Since that discussion, the USGS collected the 2014 sediment transport data. The collection of data in 2014 provides and additional year of data not originally anticipated in the RSP (Section 6.5.4.2). Using the sediment transport earlier USGS data from the 1980s along with the 2012 and 2013 data, the Fluvial Geomorphology Study has been able to develop a 1-D bed evolution model that extends from the Watana Dam Site (PRM 187.1) downstream to Susitna Station (PRM 29.9). The development, calibration and validation of this model are presented in Attachment 1 to the Study 6.6 SIR (Tetra Tech 2015b). The 1980s and current data have also provided the basis for analysis of sediment transport related issues in five technical memoranda [(Tetra Tech 2013a), (Tetra Tech 2013c), (Tetra Tech 2014b), (Tetra Tech 2014g), and (Tetra Tech 2015b)].

With the delivery of the 2014 sediment transport data by the USGS, this study component is complete and the study objective to, "Collect sediment transport data to supplement historical data to support the characterization of Susitna River sediment supply and transport" has been met.

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

The Study 6.5 ISR Section 6.3 presents a discussion of the status and progress of this study component through the spring of 2014. Since the ISR, the primary work in this study component included an update of the sediment transport relationships developed from the USGS data and an updated of the sediment balance. Both of these efforts are documented in the technical memorandum *Update of Sediment-Transport Relationships and a Revised Sediment Balance for the Middle and Lower Susitna River Segments* filed September 17, 2014 (Tetra Tech 2014b). The updated sediment transport relationships were used in the development, calibration and validation of the latest version of the 1-D bed evolution model presented in Attachment 1 to the Study 6.6 SIR (Tetra Tech 2015b).

As part of this effort, the sediment transport data collected by the USGS in 2012 and 2013 were added to the data collected in the 1980s. In Tetra Tech (2014b) it was concluded from the plots of the various components of the sediment load (bedload, suspended load, total load) combined 1980s and current data that, “The data collected in 2012 and 2013 are very similar to previous data.” It is noted that the results of the 2014 data collected by the USGS were not available at the time the technical memorandum was developed. This data will be plotted with the previously collected 1980s, 2012 and 2013 data and the comparison repeated to again evaluate whether the relationships need to be updated for the 2014 data. It is further indicated in Tetra Tech (2014b):

> *Although the regression analyses included in this TM generally produce lower slopes than the earlier USGS relationships, it is the improved method of analysis, rather than the data, that produces the change. The sediment rating curves were updated to include all the data and are considered more representative of transport conditions than the earlier rating curves. The data and rating curves are sufficient for all remaining analyses.*

Another important finding that helps advance the understanding of the Susitna River sediment transport conditions and the development of the modeling performed in Study 6.6 were the findings Tetra Tech (2014b) concerning tributary sediment loading in the Middle Susitna River segment.

> *A significant change in this analysis from the initial sediment balance analysis (Tetra Tech 2013a) is in the estimates of ungaged tributary loads. In the initial sediment balance the loads were estimated based on assuming sediment loading in proportion to drainage area. This is appropriate for reasonably similar basin conditions, but in this instance does not address differences in glaciated versus non-glaciated basins. Field observations indicate that other than the Chulitna, Talkeetna, and Yentna Rivers, the Middle and Lower River tributaries are clearwater supplying virtually no wash load and little sand to the Susitna River. Data were collected by the USGS at Portage Creek and Indian River in 1984 and are presented in Table 6.0-1. These data are in significant contrast to the mainstem sediment conditions. Where the mainstem and major tributaries are dominated by wash load and sand with orders of magnitude less gravel, the Middle River tributaries have negligible amounts of wash load (silt/clay), slightly higher amounts of sand, and yet larger amounts of gravel. (Tetra Tech 2014b)*

Since the submittal of the ISR, significant progress has been made in meeting the objective of this study component to "Determine sediment supply and transport in Middle and Lower Susitna River Segments." Important progress that support the objectives include determination that the 2012 and 2013 sediment transport data collected by the USGS are comparable to data collected in the 1980s, development of revised sediment transport relationships that have been successfully used to support development of the 1-D bed evolution model, and update of the sediment balance that provides a better understanding of the contribution of tributaries to sediment loading within the Middle Susitna River segment. Efforts remaining to complete the study will further add to the robustness and utility of the information produced by this study component. These activities include an update of the sediment balance to include tributary data collected in 2014 and estimates of sediment loading from mass wasting and bank erosion to be developed from the turnover analysis (Tetra Tech 2014c), and comparison of the 1980 sediment transport data to data collected in 2014 by the USGS. In terms of the latter item, the sediment transport relationships will be revised if the comparison indicates adjustment is warranted. Based on the previous comparison of the 2012 and 2013 sediment transport data with the 1980s data, it is expected that adjustment of the relationships will not be necessary.

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

Since the spring of 2014 and the filing of the ISR the technical memorandum *Mapping of Geomorphic Features and Turnover within the Middle and Lower Susitna River Segments from 1950s, 1980s, and Current Aerials* (Tetra Tech. 2014c) was filed September 26, 2014. This technical memorandum and the effort associated with producing it completed the Assess Geomorphic Change in the Middle and Lower Susitna River Segments study component. This effort was an update to an earlier technical memorandum *Mapping of Geomorphic Features within the Middle and Lower Susitna River Segments from 1980s and 2012 Aerials* (Tetra Tech 2013g). There were two major updates to the technical memorandum. The first was the extension of the period of channel documentation by an additional 30 years through acquisition, processing and incorporation of 1950s aerial photographs. The second update involved inclusion of a turnover analysis. Both of these study components were included in the RSP (Study 6.5 RSP Section 6.5.4.4.2) as a result of consultation with licensing participants. Other less substantial updates included items indicated in Study 6.5 ISR, Part C, Section 7.2.1.4.

The turnover analysis provided both a qualitative visual and numerically quantifiable method of describing geomorphic change in the Middle and Lower Susitna River segments. When comparing channel or floodplain features over time, increases in vegetation and narrowing of channels is associated with net channel to floodplain turnover. A net floodplain to channel turnover indicates an increase in channel width and a removal of vegetation by erosion. As each geomorphic reach varies in length, turnover was presented as normalized rates so that turnover in different geomorphic reaches could be compared to each other. Turnover rates were calculated by dividing the calculated turnover areas by the length of each reach and the span of time between each set of aerials: 30 years for the 1950s to 1980s and 1980s to 2012 analyses, and 60 years for the 1950s to 2012 analysis. Some of the conclusions from the technical memorandum (Tetra Tech 2014c) are summarized below:

- The previous technical memorandum (Tetra Tech 2013g) identified increased vegetation as the primary factor in geomorphic change, the turnover analysis described in this technical memorandum further validates that conclusion, identifying greater channel to floodplain turnover throughout the Middle and Lower Susitna River segments.
- In the Middle River, net channel to floodplain turnover rates increased between the periods of the 1950s to 1980s and the 1980s to 2012 for MR-4 through MR-8. Net channel to floodplain turnover rates decreased in MR-1 through MR-3 over the same two periods.
- Compared to the Middle River, the Lower River had a stronger trend of increasing channel to floodplain turnover between the two periods of the 1950s to 1980s and 1980s to 2012. Five out of six of the Lower River geomorphic reaches had an increase in net channel to floodplain rate between those two periods. LR-4 was the exception. During the 1950s to 1980s, LR-2 and LR-4 were the only Lower River reaches to have a net channel to floodplain turnover rate. For comparison, during the 1980s to 2012 period, LR-1, LR-2, LR-3, LR-4, and LR-6 all had net channel to floodplain turnover rates.
- Among the Middle River geomorphic reaches, MR-6, MR-7, and MR-8 exhibited the greatest amounts of turnover during the period of the 1980s to 2012. The net channel to floodplain turnover rate exceeded 7,000 ft^2/yr/mile between 1980s to 2012 for MR-6, MR-7, and MR-8. All the other Middle River geomorphic reaches had net turnover rates less than 4,000 ft^2/yr/mile.
- The mapping of channel change that occurred between 2012 and 2013 indicates that erosion was the primary process contributing to channel change in LR-1, the Middle River and the Three Rivers Confluence, as opposed to vegetation establishment or encroachment. These two sets of recent aerial photographs provide an understanding of short-term channel change in relation to a large flow event.

The technical memorandum *Mapping of Geomorphic Features and Turnover within the Middle and Lower Susitna River Segments from 1950s, 1980s, and Current Aerials* (Tetra Tech 2013c) represent the completion of the goals and objectives listed in RSP Study 6.5 Section 6.5.4.4 and ISR Study 6.5, Part C, Section 7.2.1.4 “Assess Geomorphic Change Middle and Lower Susitna River Segments.” The turnover results data presented in this 2014 technical memorandum have been used to support the bed evolution modeling and evaluation of the bank energy index in ISR Study 6.6 Section 7.2.2.1 and documented in Tetra Tech 2015b. The information will also support the finalization of the sediment balance as part of this Study (See Section 6.3 above), the Riparian Instream Flow Study (Study 8.6), and Ice Processes Study (Study 7.6).

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

A thorough discussion of this effort based on the data collected and analysis performed in 2012 and 2013 was presented in the Study 6.5 ISR Section 6.5. Since early 2014, three activities identified in Study 6.5 ISR Section 7.2.1.5 were performed to complete this study component. The activities included increasing the percentage of the Middle River below Devils Canyon mapped for aquatic macrohabitat from 50 percent to 100 percent, updating the macrohabitat analysis presented in Tetra Tech (2013f) based on the additional mapping, and coordination with

Studies 9.9 and 8.5 to ensure consistency between the macrohabitat types mapped across the three studies. The results of the 2014 efforts are documented in the update to the 2013 technical memorandum filed September 26, 2014 and titled *Updated Mapping of Aquatic Macrohabitat Types in the Middle Susitna River Segment from 1980s and Current Aerials*. The filing of this technical memorandum completed the Riverine Habitat versus flow Relationships Middle Susitna River Segment component of the Geomorphology Study (6.5).

As a result of analysis of the aquatic macrohabitat mapping performed in 2012, AEA concluded that there had been considerable change in the area of the various aquatic macrohabitat type at specific location within the Middle River that the aerial photography of the 1980s was not an accurate representation of current macrohabitat types at specific locations within the Middle Susitna River. Based on the original objective of this study component to characterize the surface area versus flow relationships for riverine macrohabitat types (1980s main channel, side channel, side sloughs, upland sloughs, tributaries and tributary mouths) over a range of flows in the Middle Susitna River Segment, additional aerial photographs would be collected to establish current aquatic macrohabitat area versus flow relationships. 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 change to the objectives and methods of this study component was presented as a variance in Study 6.5 ISR, Part A, Section 4.5.3 and as a proposed modification to the Study Plan in Study 6.5 ISR, Part C, Section 7.1.2.5.

Though the original specific objectives of the *study component* were not met, this will not interfere with AEA’s ability to meet the overall objectives of the Geomorphology Study (6.5) since the modeling approach adopted by fluvial geomorphology Modeling Study (6.6) will provide more rigorous information than the aquatic macrohabitat area versus flow relationships that would have been developed under the original objectives. However, the effort does provide useful information on how aquatic macrohabitat areas have changed at specific locations between the 1980s and present in relation to the evolution of the various geomorphic features and channel change. For example, in Tetra Tech (2013f) it was determined that aquatic macrohabitat changes in the Middle River due to changes in morphology were primarily related to the biogeomorphic processes of vegetation establishment and beaver dam building. Overall, these processes contributed to a 42 percent reduction in side slough habitat and an18 percent reduction in upland slough habitat for 17 sites studied. Other noticeable physical changes included minor variation in channel location (bank erosion or accretion) or width between the 1983 and 2012 aerials. Localized main and side channel narrowing appears to have been caused by sediment deposition within the Middle Susitna River Segment habitat sites and changed the amount of habitat area available in a few sites.

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

This effort has been divided into 4 tasks: streamflow assessment, sediment transport assessment, framework for identification of geomorphic reach response and literature review on downstream effects of dams. Much of the early work was part of the 2012 studies and was geared to provide information to guide development of the RSP and to support the decision on whether to extend the downstream limits of the Fluvial Geomorphology Modeling Study (6.6) downstream of PRM 79 (9 miles downstream of Sunshine) to PRM 29.9 (Susitna Station). In all, three technical memoranda were produced as part of the effort from 2012 through early 2014 as documented in Study 6.5 ISR Sections 5.6 and 6.6. These technical memorandums were: *Development of Sediment Transport Relationships and an Initial Sediment Balance for the Middle and Lower Susitna River Segments* (Tetra Tech 2013a), *Reconnaissance Level Assessment of Potential Channel Change in the Lower Susitna River Segment* (Tetra Tech 2013c), and *Stream Flow Assessment* (Tetra Tech 2013d).

As a result of analyses of six criteria, AEA confirmed that geomorphic studies would be expanded into a portion of the Lower River Segment. During the February 14, 2013 TWG meeting, this decision was noted and an initial plan presented for commencing such studies in 2013 and completing the studies in 2014 (R2 2013). The sixth criterion considered in defining the downstream extent of the study area in the Lower River Segment was based on the *Reconnaissance Level Assessment of Potential Channel Change in the Lower Susitna River Sediment* (Tetra Tech 2013c). This technical memorandum evaluated potential Project-related changes in morphology of the Lower River to determine whether portions of the Fluvial Geomorphology Modeling Study and other studies need to be extended downstream in the Lower River. Results from the evaluation served as the basis for the conclusion that the 1-D Bed Evolution Modeling should be extended approximately 50 miles farther downstream to Susitna Station (PRM 29.9). This conclusion was based largely on initial results suggesting the portion of the Lower River Segment below Sunshine could tend toward degradation and channel narrowing, which warranted more detailed analyses to further investigate potential Project effects below Sunshine (PRM 88).

Since early 2014, significant additional progress has been made toward the completion of this study component. The effort is documented in the two technical memorandums *Update of Sediment-Transport Relationships and a Revised Sediment Balance for the Middle and Lower Susitna River Segments* filed (Tetra Tech 2014b) filed September 17, 2014 and *Dam Effects on Downstream Channel and Floodplain Geomorphology and Riparian Plant Communities and Ecosystems – A Critical Literature Review* (R2 and Tetra Tech 2014) filed November 14, 2014. This work was identified in Study 6.5 ISR, Part C, Section 7.2.1.6. The latter technical memorandum (R2 and Tetra Tech 2014) was prepared jointly between the Riparian Instream Flow Study (8.6) and the Geomorphology Study (6.5). It includes a draft First- and Second-order analysis of dam effects on river morphology which is being expanded on in Study Component 11 (Section 6.11). The former technical memorandum (Tetra Tech 2014b) supported development of the 1-D bed evolution model and its subsequent application to provide metrics to base the discussion on whether to extend the 1-D bed evolution modeling downstream of Susitna Station (PRM 29.9). The actual application of the model was performed in the Fluvial Geomorphology

Modeling Study (6.6) and the application and decision to not extend the modeling downstream of Susitna Station is documented in the technical memorandum *Decision Point on Fluvial Geomorphology Modeling of the Susitna River below PRM 29.9* (Tetra Tech. 2014g) filed September 26, 2014.

Efforts remaining in this study component involve support in interpreting results from the modeling efforts in the Fluvial Geomorphology Modeling Study (6.6). This includes continued application of the First- and Second-order framework to support evaluation of geomorphic reach response as 1-D bed evolution model results for post-Project scenarios become available and performing a concurrent flow and stage analysis in the Three Rivers Confluence area (Study 6.5 ISR, Part C, Section 7.2.2.6).

Based on the work conducted to date, the objective of this study component to "Conduct a reconnaissance-level geomorphic assessment of potential Project effects on the Lower and Middle Susitna River Segments considering Project-related changes to stream flow and sediment supply and a conceptual framework for geomorphic reach response" has been met and exceeded. The approach and tools developed for the initial assessment have proven valuable to subsequent evaluation of modeling results to interpret potential Project effects.

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

This study component was completed in 2013 and no work was conducted in 2014. A thorough discussion of the results of this study component were presented in Study 6.5 ISR, Part A, Section 6.7.

6.8. Study Component: Reservoir Geomorphology

As described in Study 6.8 ISR Section 7.2.1.8 minor activities in three of the four tasks in this study component were conducted in 2014.

6.8.1. Reservoir Trap Efficiency and Sediment Accumulation Rates

Estimates of sediment trap efficiency from 2013 of 100 percent for sands, gravels and cobbles were confirmed for use in the 1-D bed evolution modeling conducted in the Fluvial Geomorphology Modeling Study (6.6) in 2014.

An analysis of the potential changes to sediment delivery from the upper Susitna watershed into the reservoir from glacial surges was performed. The results of this effort are documented in the technical memorandum *Assessment of the Potential for Changes in Sediment Delivery to Watana Reservoir Due to Glacial Surges* filed November 14, 2014 (Tetra Tech. 2014e); the following conclusions were presented:

- Two large surging-type glaciers with a surge cycle of about 50 years are located within the Upper Susitna River Basin. The West Fork Glacier surged in 1935/1937 and again in 1987/1988. The Susitna Glacier surged in 1952/1953 and was expected to surge again in the first decade of the 21st century. The fact that it has not surged again could be taken as evidence that surging is not required to maintain glacial equilibrium under the warming climatic regime (W.D. Harrison, personal communication, 2012). However, the effects of climate warming on the frequency and magnitude of glacial surge cycles are as yet unknown (Turrin 2014).

- Glacial surges result in increased ablation losses and increased runoff from the glacier. Analysis of the hydrologic record at the USGS Gold Creek gage indicated that the 1952/1953 and 1987/1988 surges had no apparent effect on either the mean annual discharge, the average May-September discharge or the maximum daily discharge and thus would have had no significant influence on the volume of sand transported to the Watana Reservoir.
- Glacial surges also increase the suspended sediment discharge from the glacier for relatively short periods of time by an order of magnitude. Measurements at the outlet to the West Fork Glacier during the 1987/1988 surge indicated suspended sediment concentrations of up to 30,000 ppm which is an order of magnitude higher than under non-surge conditions (3-4,000 ppm) and 30 times higher than the average measured annual suspended sediment concentration (1,000 ppm) at the USGS Denali gage under non-surge conditions.
- If a glacial surge was to occur within the Upper Susitna Basin that is very conservatively estimated as producing 30,000 ppm concentrations for an entire open water flow period (OWFP) during the year, then the elevated silt-clay fraction of the annual suspended sediment load could result in 55 years of sediment delivery to the proposed Watana Reservoir within a 50 year period. This could reduce the longevity of the dead storage pool of the reservoir by approximately 10 percent from 850 to 770 years. If the elevated concentrations are applied to the measured duration of approximately 2 weeks, the surge could reduce reservoir dead storage pool longevity by about 1 percent (850 to 840 years).
- Based on this review and evaluation, no further geomorphic investigations are warranted for flow or sediment production from glacial surges. This includes a recommendation to not include a glacial surge sediment loading scenario in the reservoir sediment trap efficiency and sediment accumulation modeling.

6.8.2. Delta Formation

Aerial reconnaissance provided determination that all six of the tributaries within the reservoir zone can be access by helicopter both in the fluctuation zone as well as at their current confluence with the Susitna River. This information will help plan field activities. In addition, the observations on conditions in the tributaries in relation to the potential for sediment production and delta formation will also be useful in planning the field activities.

6.8.3. Reservoir Erosion

Coordination between the Geology and Soils Characterization Study (4.5) (RSP Section 4.5.4.8.2.3) and the assessment of reservoir erosion task provided information that will be used in planning field activities. The coordination between the two studies and data/analyses to be performed will support the study objectives of analyzing the effect of proposed reservoir operations on erosion and mass wasting as well as developing appropriate protection, mitigation and enhancement measures (PMEs) for erosion.

6.8.4. Bank and Boat Wave Erosion Downstream of Watana Dam

No work on this task was performed in 2014.

6.9. Study Component: Large Woody Debris

The large woody debris (LWD) study component in 2013 and 2014 included two data collection strategies: an inventory of LWD from 1983, 2012, and 2013 aerial photographs; and a field inventory of LWD in selected sample areas to provide more detailed data on LWD characteristics. A total of 5,295 individual pieces of LWD were counted on the 2012/2013 aerials between the mouth and PRM 263. The majority of the wood in the Middle River was located along the margins of the channel; in the lower river the majority was located on mid-channel bars. During the LWD field inventory, total of 2,115 individual pieces of LWD over 20 feet in length and 405 log jams (containing an additional 3,107 pieces of LWD) were inventoried in the Middle and Lower Susitna River. These wood data show that the size, species, decay class, and source/input mechanism of LWD in the Susitna River changes along the river, providing important insights into how LWD may be affected by Project operations.

The species of LWD shifted from primarily White Spruce upstream of PRM 181 to a mix of Balsam Poplar and Spruce between PRM 169-181 to primarily Balsam Poplar downstream of PRM 151. Concurrently, the dominant input mechanism for LWD was ice processes upstream of PRM 151, and bank erosion downstream of PRM 151. These data reflect the geomorphology of the river system as it shifts from a confined river with White Spruce-lined banks upstream of approximately PRM 151 to a wider, alluvial system with a broad floodplain populated by Balsam Poplar that enter the river by bank erosion processes. The majority of LWD was located on the sides of the channel or bars above the low flow wetted channel. The wood generally did not have an obvious aquatic habitat function, but pieces with large root wads did form scour pools, and pieces in upland or side sloughs were more stable and provided cover. Some wood was observed to move at flows over approximately 30,000 cfs (measured at the Gold Creek gage), and pieces of LWD in the main channel had been moved downstream between the 2013 and 2014 field seasons, likely the result of pushing by ice.

These data provide information on the location, species, size, input mechanism, and function of large woody debris in the Susitna River downstream of the proposed dam site which is a goal of the LWD study component. These data, in combination with field data collection to be performed between PRM 184-263, will provide the necessary information to assess current LWD input, loading, and function in the Susitna River as well as potential effects of the proposed Project facilities and operation on LWD in the system.

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

The assessment of the geomorphology of stream crossings along transmission lines and access alignments has not been performed. The reconnaissance information collected in 2014 will be used to plan appropriate field access and field equipment needs for each crossing.

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

The framework developed from the First- and Second-order elements of the dam effects technical memorandum (R2 Resources and Tetra Tech 2014) provides the vehicle with which to integrate the results of the Fluvial Geomorphology and Fluvial Geomorphology Modelling studies and apply them to qualitative and semi-quantitative prediction (Table 5.11-1) of the Project effects on the Upper, Middle and Lower River Segments.

First-order effects are summarized in Table 5.11-2. First-order drivers for geomorphic change include: hydrology, sediment supply, ice processes and geology. The Upper River produces about 16 percent of the average annual flow of the Susitna River at the Susitna Station gauge, but since it is located upstream of the reservoir it will be unaffected by hydrologic changes and hence there will be no hydrologic (peak or base flow) effects on the morphology of the river. In contrast, within the Middle River Segment peak flows will be reduced by about 40 percent and base flows will be increased by an as yet undetermined amount that will depend on selected operational scenarios (Tetra Tech 2013d and Tetra Tech 2014g). Reductions in peak flows are likely to result in a moderate reduction in channel size, most likely the result of vegetation encroachment into the channel, but this could be counteracted by ice processes depending on the Project ice regime (*Dam Effects on Downstream Channel and Floodplain Geomorphology and Riparian Plant Communities and Ecosystems – A Critical Literature Review* (R2 Resource Consultants and Tetra Tech 2014), Moderate increases in base flows are unlikely to have any significant effects on channel morphology since they are below thresholds for sediment transport (SIR Study 6.6). An approximately 20 percent reduction in peak flows in the Lower River segment is likely to have a low impact on channel morphology, and the low, but as yet undetermined increase, in base flows is likely to have very little effect on channel morphology.

Approximately 11 percent of the average annual bed material load of the Susitna River at Susitna Station gauge is derived from the Upper River segment, but more importantly, 99 percent of the Upper River bed material load is composed of sand and only 1 percent is gravel (Tetra Tech 2014b). The Upper River morphology will be unaffected by the Project except in the localized area of the delta at the upstream end of the reservoir. In the Middle River segment, the channel morphology is likely to experience little impact from the reduction in sediment load since the amount of gravel and cobble supplied to and trapped in the dam is quite low. The bulk of the bed material load supplied to the reservoir is sand which does not contribute significantly to the channel boundary materials (Tetra Tech 2014b). However, the reduction in sand delivery from the Upper River is likely to have a moderate effect on floodplain/island construction in the Middle River because the bulk of the floodplain sediments are sand sized and finer. The reduction of the sand fraction in the Middle River will likely not result in channel narrowing as a result of sediment deposition, although vegetation encroachment could result in channel narrowing. Although about 92 percent of the average annual bed material load above the Three Rivers confluence under existing conditions is composed of sand, the Middle Susitna River only contributes about 27 percent of the sand load at the Three Rivers confluence (Tetra Tech 2014b). Therefore the reduction in sand due to the Project is likely to have a minor morphological effect on the Lower River because the combined input of sand from the Chulitna and Talkeetna Rivers represents about 73 percent of the average annual sand load at the Sunshine gauge. In terms of gravel contributions, the other component of the bed material load, at the Three Rivers confluence the Chulitna supplies 87 percent the Talkeetna 9 percent and the Susitna River the remaining 4 percent (Tetra Tech 2014b); therefore, the Project effects will be even less on the gravel supply than on the sand supply below the Three Rivers confluence.

Reductions in peak flow and the sediment supplied by the Chulitna and Talkeetna Rivers are likely to result in a channel narrowing of about 10 percent in the Lower River (Tetra Tech 2013d and Tetra Tech 2014g). Downstream of the Yentna River confluence the Project effects are likely to be even further muted because the Yentna River produces about 40 percent of the average annual flow and 55 percent of the average annual bed material load at the Susitna Station gauge. Estimates of Project related channel narrowing below the Yentna River Confluence are reduced to about 5% of the current channel width (Tetra Tech 2014g).

The role of ice and fluvial processes in shaping the river morphology varies with the segment in question. Based on field observations, the Upper River is an ice-dominated regime (Tetra Tech 2015a), whereas the Middle River has a mixed fluvial and ice regime and the Lower River is fluvially dominated. The Project will have no influence on ice processes in the Upper River, except locally at the head of the reservoir. In the Middle River, the Project is likely to delay freeze up and the ice cover will be less extensive but there are likely to be only minor effects on river morphology. During break up there will be no Project effects on the Upper River and the potential morphologic effects on the Middle River will depend on whether the break up is thermal or dynamic. In either case, there are likely to be only low to moderate impacts on river morphology. A reduced ice regime on the Middle River is likely to reduce the impacts of ice processes on channel avulsions, bank erosion and overbank sedimentation. However, experience with other cold regions hydropower project operations suggest that the ice regimes both at freeze up and break up can be manipulated by Project operations (HDR 2014, R2 Resource Consultants and Tetra Tech 2014). There are likely to be no ice-related effects on the morphology of the Lower River.

The potential for morphological responses to the Project depends to a large extent on the lability (Grant et al. 2003) or sensitivity (Schumm 1991) of the river and two of the determinants of lability or sensitivity are the erodibility of the bed and banks as influenced by their cohesiveness and/or the prevalence of bedrock or other less erodible materials and the opportunity for lateral mobility as determined by the overall width and topography of the valley floor. The Upper River segment is laterally and vertically constrained by extensive bedrock outcrop and the presence of extensive glacial deposits that significantly affect the adjustability of the river. Similarly, the presence of both bedrock outcrop and coarse grained glacial deposits constrain the Middle River segment that lies within a relatively narrow valley (Tetra Tech 2015a). Further, within the Middle River, there are extensive coarse boulder lag deposits within the river bed that significantly reduce the potential for bed mobilization and vertical change (Tetra Tech 2015a and 2015b) and thus the potential for Project impacts on the river morphology. The large tributaries within the Lower River segment, the Chulitna and Talkeetna rivers at the upstream end and the Yentna River near the downstream end, exert the dominant control on the morphology of the river that is less constrained by the presence of coarse grained glacial deposits or bedrock outcrop and occupies a much wider valley than the Upper and Middle rivers.

Second-order effects are summarized in Table 5.11-3. The Second-order effects result from the changes in the primary First-order drivers that included hydrology, sediment supply and ice processes and are reflected in the channel and floodplain morphology and connectivity as well as fluvially-driven hydraulics and sediment transport processes. With the exception of the reservoir pool, where there will be about 3,000,000 tons of sediment deposited annually (Study 6.5 ISR Part A Section 5.8.1), there will be no Second-order impacts in the Upper River segment. In the Middle River Segment, channel impacts are likely to include minor aggradation of gravel, primarily at or downstream of tributary confluences, reduced channel width as a result of vegetation encroachment into the channel and moderately to highly reduced flow/sediment variability as reflected by the ratios of the 2-year peak flows pre- and post-Project and the pre- and post-Project sediment loads (Tetra Tech 2014g). In the Middle River, the bed material load will be reduced, primarily as a result of the significant reduction in the volume of sand available for transport. In the Lower River segment, channel effects are limited because of the tributary contributions of both sediment and water. Existing aggradational trends will continue, but the rate of aggradation is likely to be reduced (Tetra Tech 2014g). Channel width is likely to be reduced by about 10 percent because of the availability of sand required for deposition and stabilization by vegetation. Flow/sediment variability effects are muted by the tributary contributions of both flow and sediment (Tetra Tech 2014g).

The Project will have no impacts on the floodplain and floodplain-related processes, accretion, erosion and inundation, in the Upper River Segment. In the Middle River Segment, the substantial reduction in the sand supply will likely have a moderate impact on floodplain and island formation. Erosion rates are likely to be reduced due to the reduction in peak flows and the frequency and duration of inundation of floodplain/island surfaces will be reduced during the open-water season. However, depending on the ice regime, especially during break up, inundation of geomorphic surfaces could either be increased or decreased. In the Lower River segment, there is unlikely to be a significant impact on either the floodplain or floodplain processes because of the mitigating influence of the sediment supply from the large tributaries.

The Project will have no impact on the planform of the Upper River segment expect in the area of delta formation at the upstream end of the reservoir. Depending on the ice-regime the number of low-order channels (sloughs and side channels) could be reduced in the Middle River segment. No impacts on the river planform are expected in the Lower River segment.

In the Upper River segment there will be no Project impacts on turbidity. However, depending on the season there are likely to be low to moderate impacts on turbidity in the Middle River segment. During the iced-over period, turbidity is likely to increase as reservoir stored flows are released. During the open-water period there is likely to be a reduction in the turbidity because of fine sediment trapping and storage in the reservoir (Tetra Tech. 2014b). There are likely to be very small increases in the turbidity during the iced-over period and very small reductions in the open-water period within the Lower River Segment because of the mitigating effects of the tributaries.

Tributary impacts in the Upper River Segment are restricted to the reservoir. Depending on the volume and timing of sediment supply from the tributary and the reservoir elevation, it is possible that small transient deltas could form within the reservoir. Modeling of the tributaries and their delta formation potential will address this issue (Study 6.5 ISR Part A Section 4.8.2.2 Reservoir Geomorphology). In the Middle River Segment, it is likely that there could be minor tributary impacts related to progradation of the tributary fans into the river and creation of upstream backwater on the river that could affect upstream water-surface elevations and ice jam formation. There are unlikely to be any tributary impacts in the Lower River segment.

7. CONCLUSION

In summary, significant progress has been made in 2014. Four of the eleven study components are now complete including: 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), Assess Geomorphic Change Middle and Lower Susitna River Segments (Study Component 4), Riverine Habitat versus Flow Relationship Middle Susitna River Segment (Study Component 5), and Riverine Habitat Area versus Flow Lower Susitna River Segment (Study Component 7) which was completed in 2013. One study component, Delineate Geomorphically Similar (Homogeneous) Reaches and Characterize the Geomorphology of the Susitna River (Study Component 1), is nearly complete, but requires results from the 2-D hydraulic modeling in the focus areas from Study 6.6 to map inundation of the geomorphic surfaces. Three study components will continue throughout the study effort 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). There are three study components that the majority of the work effort remain to be completed: 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). For these three studies, 2014 activities involved coordination with other studies and aerial reconnaissance to support planning of field data collection efforts.

Given the combination of 2012, 2013 and 2014 efforts, variances (see SIR Study 6.5 Section 4), and the plans for completing Study 6.5 with modifications (see Section 7.2), AEA will achieve the approved objectives (SIR Study 6.5 Section 2) for the Geomorphology Study.

7.1. Decision Points from Study Plan

There was one decision Points beyond those described in Study 6.5 ISR Part C Section 7.1.1 that was established and it involved investigation of the potential for increased sedimentation in Watana Reservoir due to glacial surge. This decision point was established and completed in 2014. The effort associated with this decision point is documented in the technical memorandum

Assessment of the Potential for Changes in Sediment Delivery to Watana Reservoir Due to Glacial Surges (Tetra Tech 2014e) filed November 14, 2014.

In the February 1, 2013 SPD FERC recommended that in support of the Glacier and Runoff Changes Study (Study 7.7) that AEA "analyze the potential changes to sediment delivery from the upper Susitna watershed into the reservoir from glacial surges." To address the FERC recommendation in the February 1, 2013 SPD, the Geomorphology Study (Study 6.5) included the following effort to provide for the potential analysis of the influence of glacial surge on reservoir sediment accumulation rates in RSP Section 6.5.4.8.2.1 if sediment from glacial surge can actually be delivered to the reservoir:

> *Potential additional sediment loading resulting from glacial surge will be investigated in the Glacier and Runoff Changes Study (*[RSP] *Section 7.7.4.4, Analyze Potential Changes in Sediment Delivery to Watana Reservoir). If this investigation indicates that the increased sediment load can actually be delivered in substantial quantities to Watana Reservoir, more detailed analyses of the increased loading will be performed and a sediment loading scenario accounting for glacial surge will be added to the reservoir trap efficiency and sediment accumulation analysis. This would include an estimate of the reduction in reservoir life that could result from sediment loading associated with periodic glacial surges.*

As a result of performing this analysis it was concluded that no further geomorphic investigations were warranted for flow or sediment production from glacial surges (Tetra Tech 2014e). This included a recommendation to not include a glacial surge sediment loading scenario in the reservoir sediment trap efficiency and sediment accumulation modeling in the reservoir trap efficiency and sediment accumulation rates task (RSP Section 6.5.4.8.2.1)in Reservoir Geomorphology study component of the Geomorphology Study (6.5).

7.2. Modifications to Study Plan

The following modifications to the Study Plan beyond those described in Study 6.5 ISR Part C Section 7.1.2 are proposed to complete the study.

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

It is proposed that calculation of the effective discharge associated with operation scenarios to be analyzed not be performed for the Middle River. Due to the supply limited nature of the Middle River (Tetra Tech 2015b), calculation of effective discharge is not meaningful. In terms of the Lower River the effective discharge will be determined, but instead of using sediment transport rating curves, the 1-D bed evolution model sediment transport results will be used to determine effective discharge. This will be accomplished by placing the sediment transport rates from the 1-D bed evolution model for each time increment into bins of equal water discharge and determining which discharge interval transports the largest portion of the sediment load. This will be performed at Sunshine and Susitna Station (represents geomorphic reach LR-5). One representative cross section in each of the four other Lower River geomorphic reaches represented in the 1-D bed evolution model (geomorphic reaches LR-1, LR-2, LR-3 and LR-4) will be used to determine the effective discharge.

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

Two Study Plan modifications are proposed for this study component. One addresses the use of the modified braiding index (MBI) and the other the application of the Grant et al. (2003) framework for interpreting downstream effects of dams.

In the first modification, it is proposed that determination of the MBI not be performed. Its use is not applicable to the Middle River segment because the planform does not consist of dynamic multiple bar-braided channels within a braid plain. The Middle River does have areas with multiple channels upstream of valley floor constrictions, but these are less dynamic island-braided channels. The vegetated islands and channels have been very stable over the last 60 years (Tetra Tech 2014c). Results from the 1-D bed evolution model have shown that in the Lower River, the sediment regime is not substantially altered by the Project (Tetra Tech 2014g and Tera Tech 2015b). The large inflow of sediment and water at the Three Rivers confluence, primarily from the Chulitna River, substantially attenuates the alteration in sediment transport and stream flow that occurs on the Middle River due to the proposed Project. The application of the MBI, which is an index of braiding potential, in the Lower River will not produce useful information that would add to the assessment of potential Project impacts beyond what is proposed in this section with the streamflow assessment, sediment transport assessment and framework for First-order and Second-order analysis of dam effects on river morphology.

The second proposed modification is to replace the Grant et al. (2003) framework for analyzing the downstream impact of the Project with the framework for First- and Second-order analysis of dam effects on river morphology (See Section 5.11 above) that was developed as part of the Geomorphology Study (6.5) specifically for the conditions on the Susitna River. For example, the framework in this study recognizes the influence of ice on the morphology of the Susitna River and includes more parameters that the Project will affect than Grant et al. (2003). The proposed framework developed in this study will have a higher level of sensitivity to Project effects and the ability to discern differences between various Project scenarios since it was specifically designed to utilize a wide range of information that will be provided from the modeling and analysis efforts conducted in the Fluvial Geomorphology Modeling Study (6.6), the Riparian Instream Flow Study (8.6) and the Ice Processes Study (7.6). The Grant et al. (2003) framework provided a useful tool to help with the decision on whether to extend the 1-D bed evolution model downstream of Sunshine in the Lower River (Tetra Tech 2013c) but does not have the resolution to ascertain differences between alternative Project scenarios that has been incorporated into the First- and Second-order Project effects framework developed specifically as part of the Geomorphology Study (6.5) and that are available from the 1-D model results from Fluvial Geomorphology Modeling Study (6.6).

7.2.3. Study Component: Reservoir Geomorphology

One modification is proposed for this study component regarding the reservoir tributary delta formation task. Based on comments at the Initial Study Report (ISR) Meeting held October 16, 2014 in Anchorage, it was decided to develop a 1-D model to determine the depositional characteristics of the sand and larger sediment fraction of the sediment inflow to the reservoir for various operations scenarios in the upper end of the reservoir. Previously, the results of the

Environmental Fluid Dynamics Code (EFDC) model from the Water Quality Modeling Study (5.6) were designated to serve this purpose. The proposed 1-D model will be similar to the 1-D bed evolution model developed for the Middle and Lower Susitna River segments in the Fluvial Geomorphology Modeling Study (6.6). The model will extend from just below the downstream limits of the reservoir fluctuation zone to a distance approximately 5 miles upstream of the Oshetna River confluence. The upstream limit places the model approximately 8 miles upstream of the upper limit of the reservoir inundation zone. This effort would require survey of cross sections in the model domain, collection of bed material samples and measurement of water surface elevations for model calibration. Data collection needs will be similar to those identified in Study 6.6 RSP Section 6.6.4.1.2.9.1. The model would be developed and run for the pre-Project condition as well as the with-Project operations scenarios.

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9. TABLES

Table 5-1: Summary of cumulative data collected as part of the Geomorphology Study (Study 6.5) with URLs to access datasets, notes to find description of data in associated report, and identification if data has previously been submitted and superseded.

Active Data							Previously Submitted Data (now superseded)	
Data	**Data Type**	**File name**	**Location (URLs in footnotes)**	**Folder Nesting**	**Study 6.5 Study Component***	**Data described in following report**	**File name**	**Location**
Geomorphic Reach Breaks	ArcGIS Shapefile	ISR_6_5_GEO_GeomorphicReaches.shp	a	N/A	1	Initial Study Report	n/a	
Opportunistic Water Quality Parameter Sampling	Word Document	SIR_6_5_GEO_SuWa TtGeo 2014 OpportunisticWQ QC3 LWZ 20140309.doc	d	DATA AND SPREADSHEETS > OPPORTUNISTIC WQ	1	Study Implementation Report	n/a	
Opportunistic Water Quality Parameter Sampling Photos	JPEG	SIR_6_5_GEO_SuWa Tt Geo DATA + *photo date + photo number*	d	DATA AND SPREADSHEETS > OPPORTUNISTIC WQ > PHOTOS	1	Study Implementation Report	n/a	
Upper River Channel Depth Estimations	Excel Spreadsheet	SIR_6_6_FGM_2014_TetraTech_Upper River Cross-Sections QC3 LWZ 20141219.xlsx	e	DATASHEETS AND SPREADSHEETS > CROSS-SECTION DATA > SUSITNA	1[aa]	Study Implementation Report	n/a	
Upper River Approximate Cross-Sections	Shapefile	SIR_6_6_FieldData_UR_xsecs.shp	e	SHAPEFILES	1[aa]	Study Implementation Report	n/a	
Bed Load and Suspended-load measurements at select gage locations on the Susitna River, Chulitna River, and Talkeetna River	Excel Spreadsheet	SIR_6_5_GEO_USGS_sediment_data.xlsx	d	DATASHEETS AND SPREADSHEETS > BED LOAD AND SUSPENDED SEDIMENT	2	Study Implementation Report	n/a	
Tributary Aerial Reconnaissance Videos - 8/30/2014	MP4 Video and LRV files	Middle River Tributary Videos: Unnamed Tributary PRM 123 at Oxbow II, Deadhorse Creek (PRM 124.4), 5th of July Creek (PRM 127.3), Skull Creek (PRM 128.1), Sherman Creek (PRM 134.1), 4th of July Creek (PRM 134.3), Gold Creek (PRM 140.1), Indian River (PRM 142.1), Unnamed Tributary PRM 144.0, Jack Long Creek (PRM 148.3), Portage Creek (PRM 152.3), Cheechako Creek (PRM 155.9), Chinook Creek (PRM 160.5), Devil Creek (PRM 164.8), Unnamed Tributary PRM 173.8, Unnamed Tributary PRM 174.3, Fog Creek (PRM 179.3), Unnamed Tributary PRM 184.0, Tsusena Creek (PRM 184.6) Upper River Tributary Videos: Deadman Creek (PRM 189.4), Watana Creek (PRM 196.9)	d	DATASHEETS AND SPREADSHEETS > TRIBUTARY AERIAL RECON > 8-30 RECON	3 (Middle River) 8 (Upper River)	Study Implementation Report	n/a	

Active Data							Previously Submitted Data (now superseded)	
Data	Data Type	File name	Location (URLs in footnotes)	Folder Nesting	Study 6.5 Study Component*	Data described in following report	File name	Location
Tributary Aerial Reconnaissance Photos - 8/30/2014	JEPG	SIR_6_5_GEO_SuWa TtGeo DATA 20140830 + Location + Photo + Photo Number + QC2 ALS 2014MMDD.jpeg.	d		3 (Middle River) 8 (Upper River)	Study Implementation Report	n/a	
Reconnaissance Middle and Upper Susitna River Tributaries Notes - 8/30/14	Excel Spreadsheet	SIR_6_5_GEO_SuWa_TtGeo_Susitna 8-30-14 Trib Recon Notes – Summary.xlsx	d		3 (Middle River) 8 (Upper River)	Study Implementation Report	n/a	
Tributary Aerial Reconnaissance Videos - 9/28 and 9/29/2014	AVCHD Videos	SIR_6_5_GEO_SuWa TtGeo Aerial Recon Video# + *camera assigned file number*	d	DATASHEETS AND SPREADSHEETS > TRIBUTARY AERIAL RECON > 9-28 AND 9-29 RECON	3 (Lower and Middle River) 8 (Upper River)	Study Implementation Report	n/a	
Tributary Aerial Reconnaissance Video File Number List and Notes on Video Location - 9/28 and 9/29/2014	Excel Spreadsheet	SIR_6_5_GEO_SuWa TtGeo 9-28 and 9-29-14 Aerial Recon Video Locations.xlsx	d		3 (Lower and Middle River) 8 (Upper River)	Study Implementation Report	n/a	
Tributary Aerial Reconnaissance Photos - 9/28 and 9/29/2014	JPEG	SIR_6_5_GEO_SuWa_TtGeo_Aerial Recon + *photo number*	d		3 (Lower and Middle River) 8 (Upper River)	Study Implementation Report	n/a	
Aerial Reconnaissance Lower, Middle, and Upper Susitna River Tributaries Field Notes - 9/28 and 9/29/2014	PDF	SIR_6_5_GEO_9-28-15 and 9-29-15 Recon Fieldnotes DPizzi.pdf	d		3 (Lower and Middle River) 8 (Upper River)	Study Implementation Report	n/a	
1950s Middle River Mapped Geomorphic Features	Shapefile	ISR_MTG_6_5_GEO_1950s_MR_GeomFeat.shp	b	N/A	4	Mapping of Geomorphic Features and Turnover within the Middle and Lower Susitna River Segments from 1950s, 1980s, and Current Aerials filed with FERC (Tetra Tech 2014c).	n/a	
1950s Lower River Mapped Geomorphic Features	Shapefile	ISR_MTG_6_5_GEO_1950s_LR_GeomFeat.shp	b		4		n/a	
1980s Middle River Mapped Geomorphic Features	Shapefile	ISR_MTG_6_5_GEO_1980s_MR_GeomFeat.shp	b		4		ISR_6_5_GEO_1980sM_GeoFeAqMHab.shp	a
1980s Lower River Mapped Geomorphic Features	Shapefile	ISR_MTG_6_5_GEO_1983_LR_GeomFeat.shp	b		4		ISR_6_5_GEO_1983_L_GeomFeat.shp	a
2012 Middle River Mapped Geomorphic Features	Shapefile	ISR_MTG_6_5_GEO_2012_MR_GeomFeat.shp	b		4		ISR_6_5_GEO_2012M_GeoFeAqMHab.shp	a
2012 Lower River Mapped Geomorphic Features	Shapefile	ISR_MTG_6_5_GEO_2012_LR_GeomFeat.shp	b		4		ISR_6_5_GEO_2012_L_GeomFeat.shp	a
2013 Middle River (Three Rivers Confluence area) Mapped Geomorphic Features	Shapefile	ISR_MTG_6_5_GEO_2013_MR_3RC_GeomFeat.shp	b		4		n/a	

Active Data							Previously Submitted Data (now superseded)	
Data	**Data Type**	**File name**	**Location (URLs in footnotes)**	**Folder Nesting**	**Study 6.5 Study Component***	**Data described in following report**	**File name**	**Location**
2013 Lower River (Three Rivers Confluence area) Mapped Geomorphic Features	Shapefile	ISR_MTG_6_5_GEO_2013_LR_3RC_GeomFeat.shp	b		4		n/a	
2012 to 2013 Middle River Channel Erosion in Three Rivers Confluence Area	Shapefile	ISR_MTG_6_5_GEO_2012to2013_MR_ChannelErosion.shp	b		4		n/a	
2012 to 2013 Lower River Channel Erosion in Three Rivers Confluence Area	Shapefile	ISR_MTG_6_5_GEO_2012to2013_3RC_ChannelErosion.shp	b		4		n/a	
Middle River Turnover	Shapefile	ISR_MTG_6_5_GEO_MR_Turnover.shp	b		4		n/a	
Lower River Turnover	Shapefile	ISR_MTG_6_5_GEO_LR_Turnover.shp	b		4		n/a	
Middle River Geomorphic Feature Tabulation	Excel Spreadsheet	ISR_MTG_6.5_GEO_GEOMORPH_MR_TABLES_QC3_MRM_20141013.xlsx	b		4		n/a	
Lower River Geomorphic Feature Tabulation	Excel Spreadsheet	ISR_MTG_6.5_GEO_GEOMORPH_LR_TABLES_QC3_MRM_20141013.xlsx	b		4		n/a	
Middle and Lower River Turnover Tabulation	Excel Spreadsheet	ISR_MTG_6.5_GEO_TURNOVER_QC3_MRM_20141013.xlsx	b		4		n/a	
1950s Aerial Photography	GeoTIFF	1950s USGS Historical Susitna Imagery	c	N/A	4	Initial Study Report	n/a	
1980s Aerial Photography	MrSID and GeoTIFF	1983 Historical Susitna Imagery	c		4	Initial Study Report	n/a	
2012 Aerial Photography	MrSID and GeoTIFF	2012 Susitna Riverflow Geomophology	c		4	Initial Study Report	n/a	
2013 Aerial Photography	MrSID and GeoTIFF	2013 Susitna Riverflow Geomorphology	c		4	Initial Study Report	n/a	
1980s Middle River Mapped Aquatic Macrohabitat	Shapefile	ISR_MTG_6_5_GEO_1980s_MR_AqMHab.shp	b	N/A	5	Updated Mapping of Aquatic Macrohabitat Types in the Middle Susitna River segment from 1980s and Current Aerials filed with FERC (Tetra Tech 2014d).	ISR_6_5_GEO_1980sM_GeoFeAqMHab.shp	a
1980s Lower River Mapped Aquatic Macrohabitat	Shapefile	ISR_MTG_6_5_GEO_1980s_LR_AqMHab.shp	b		5 & 7		ISR_6_5_GEO_1983_Lower_AqMHab.shp	a
Current (2012/2013) Middle River Mapped Aquatic Macrohabitat	Shapefile	ISR_MTG_6_5_GEO_Current_MR_AqMHab.shp	b		5		n/a	
2013 Middle River Mapped Aquatic Macrohabitat	Shapefile	ISR_MTG_6_5_GEO_2013_MR_AqMHab.shp	b		5		ISR_6_5_GEO_2012M_GeoFeAqMHab.shp	a
2012 Lower River Mapped Aquatic Macrohabitat	Shapefile	ISR_MTG_6_5_GEO_2012_LR_AqMHab.shp	b		5 & 7		ISR_6_5_GEO_2012_Lower_AqMHab.shp	a

Active Data							Previously Submitted Data (now superseded)	
Data	**Data Type**	**File name**	**Location (URLs in footnotes)**	**Folder Nesting**	**Study 6.5 Study Component***	**Data described in following report**	**File name**	**Location**
Middle and Lower River Aquatic Macrohabitat Tabulation	Excel Spreadsheet	ISR_MTG_6.5_GEO_AQHAB_TABLES_QC3_MRM_20141013.xlsx	b		5		n/a	
Streamflow Record Extension for Selected Streams in the Susitna River Basin, Alaska (USGS 2012)	PDF	Report	f	N/A	6	Initial Study Report	n/a	
Extended and Observed Streamflow Records for Water Years 1950–2010 for Selected Streamgages, Susitna River Basin, Alaska	Excel Spreadsheet	Appendix B	f	N/A	6	Initial Study Report	n/a	
Upper River Tributary Field Reconnaissance Photos	JPEGs	Tributary field photos (divided into subfolders by tributary name): Deadman Creek (PRM 189.4), Watana Creek (PRM 196.9), Kosina Creek (209.1), Jay Creek (PRM 211.0), Unnamed Tributary PRM 228.5, Goose Creek (PRM 232.8), Oshetna River (PRM 235.1)	d	DATASHEETS AND SPREADSHEETS > UR TRIB FIELD RECON	8	Study Implementation Report	n/a	
Upper River Tributary Field Reconnaissance Photo Logs	PDF	Goose Ck and UNT 228.5 - Photo Log.pdf Jay Ck - Photo Log.pdf Oshetna - Notes and Photo Log.pdf Watana Ck - Notes and Photo Log.pdf	d		8	Study Implementation Report	n/a	
Cumulative (2013 & 2014) Large Woody Debris Sample Areas	Shapefile	ISR_6_5_GEO_All_LWD_SampAreas.shp	a	DATA AND SHAPEFILES > LARGE WOODY DEBRIS	9	Initial Study Report	n/a	
Cumulative (2013 & 2014) Large Woody Debris Field Inventory	Shapefile	SIR_6_5_GEO_All_LWD_Piece_Field.shp	d		9	Study Implementation Report	ISR_6_5_GEO_2013_LWD_Field.shp	a
Cumulative (2013 & 2014) Log Jam Field Inventory	Shapefile	SIR_6_5_GEO_All_Log_Jam_Field.shp	d		9	Study Implementation Report	ISR_6_5_GEO_2013_Log_Jam_Field.shp	a
1983 Large Woody Debris Aerial Photography Inventory	Shapefile	SIR_6_5_GEO_LWD_1983_Aerials.shp	d		9	Study Implementation Report	n/a	
1983 Log Jam Aerial Photography Inventory	Shapefile	SIR_6_5_GEO_LJam_1983_Aerials.shp	d		9	Study Implementation Report	n/a	
2012 Large Woody Debris Aerial Photography Inventory	Shapefile	SIR_6_5_GEO_LWD_2012_Aerials.shp	d		9	Study Implementation Report	n/a	
2012 Log Jam Aerial Photography Inventory	Shapefile	SIR_6_5_GEO_LJam_2012_Aerials.shp	d		9	Study Implementation Report	n/a	
2013 Large Woody Debris Aerial Photography Inventory	Shapefile	SIR_6_5_GEO_LWD_2013_Aerials.shp	d		9	Study Implementation Report	n/a	
2013 Log Jam Aerial Photography Inventory	Shapefile	SIR_6_5_GEO_LJam_2013_Aerials.shp	d		9	Study Implementation Report	n/a	

Active Data							Previously Submitted Data (now superseded)	
Data	Data Type	File name	Location (URLs in footnotes)	Folder Nesting	Study 6.5 Study Component*	Data described in following report	File name	Location
Access Corridor Reconnaissance Locations - Stream Crossings	Shapefile	SIR_6_5_GEO_SuWa_TtGEO_Access_2014_Recon_Streams.shp	d	DATA AND SHAPEFILES > ACCESS CORRIDOR RECON > SHAPEFILES	10	Study Implementation Report	n/a	
Access Corridor Reconnaissance Locations - Route	Shapefile	SIR_6_5_GEO_SuWa_TtGEO_Access_2014_Recon_Route.shp	d		10	Study Implementation Report	n/a	
Access Corridor Reconnaissance Photographs	JPEG	SIR_6_5_GEO_Access_Recon_*Photo Number*	d	DATA AND SHAPEFILES > ACCESS CORRIDOR RECON > PHOTOS	10	Study Implementation Report	n/a	

Notes:

*	Further information about data can be found within referenced report and corresponds to study component listed herein. The study component number corresponds to sections identified in the first decimal position. (i.e. Section X.Y) where X identifies the initial section number and Y identifies the study component.
aa	Data collected in collaboration with Study 6.6 therefore posted with Study 6.6 data
Location, a:	http://gis.suhydro.org/isr/06-Geomorphology/6.5-Geomorphology/
Location, b:	http://gis.suhydro.org/Post_ISR/06-Geomorphology/6.5-Geomorphology/
Location, c:	http://gis.suhydro.org/raster-data
Location, d:	http://gis.suhydro.org/SIR/06-Geomorphology/6.5-Geomorphology/
Location, e:	http://gis.suhydro.org/SIR/06-Geomorphology/6.6-Fluvial_Geomorphology_Modeling/
Location, f:	http://pubs.usgs.gov/sir/2012/5210/

Table 5.1-1: Total Valley Bottom Area, Non-channel Valley Bottom Area, and Terrace Areas for Middle River geomorphic reaches below Devils Canyon.

Geomorphic Reach	Total Valley Bottom Area[1] (ac.)	Non-Channel Valley Bottom Area[2] (ac.)	Total Terrace Area[3] (ac.)	Terrace Area as Percent of the Total Valley Area	Terrace Area as Percent of the Non-Channel Valley Area
MR-5	810	480	160	20%	34%
MR-6	7,950	4,900	2,660	33%	54%
MR-7	4,000	2,460	1,410	35%	57%
MR-8	5,250	4,480	1,390	27%	31%
MR-8[4]	*5,250*	*4,480*	*2,550*	*49%*	*57%*

Notes:

1 Total valley bottom area is the total area within 20 feet vertically of the water elevation present at the time of the 2011 Matanuska-Susitna Borough LiDAR.

2 Non-channel valley bottom area is the land area of the valley bottom. It was determined by removing 2012 delineated geomorphic channel (main channel, side channel, side sloughs, and upland sloughs) from total valley bottom area.

3 Total terrace area is the summation of land units and the channels within the land units that are approximately between 0 feet to 5 feet above the 100-year water surface elevation from the Study 6.6 1-D hydraulic model. Total terrace area is approximated from the 1950s delineation in the Middle River Turnover shapefile.

4 Total terrace area summation is calculated with the inclusion of intermediate terrace units (i.e. terrace unit surface heights that are greater than 5 feet above the 100-year water surface elevation from the Study 6.6 1-D hydraulic model).

Table 5.1-2 Area and percentage of dissection and erosion of terrace units in Middle River geomorphic reaches below Devils Canyon.

Geomorphic Reach	Total Terrace Area[1] (Land Area + Dissection Area + Erosion Area) (ac)	Land Area[2] (ac)	Dissection Area[3] (ac)	Erosion Area[4] (ac)	Erosion as Percent of Terrace Area	Dissection as Percent of Terrace Area	Destruction (Erosion and Dissection) as Percent of Terrace Area
MR-5	160	140	10	10	8%	3%	11%
MR-6	2,660	2,040	440	170	7%	17%	23%
MR-7	1,410	1,340	40	40	3%	3%	5%
MR-8	1,390	1,320	20	50	4%	2%	5%

Notes:

1 Total terrace area is the summation of land units and the channels within the land units that are approximately between 0 feet to 5 feet above the 100-year water surface elevation from the Study 6.6 1-D hydraulic model. Total terrace area is approximated from the 1950s delineation in the Middle River Turnover shapefile (Section 5.4.1).

2 Area of Land within a Terrace Area.

3 Dissection Area is channel area within terrace units plus any erosion within the terrace units since the 1950s determined from the Middle River Turnover Shapefile (Section 5.4.1).

4 Erosion Area since the 1950s was determined from the Middle River Turnover Shapefile (Section 5.4.1).

Table 5.1-3 Opportunistic water quality parameters.

Date Time	Location (Northing / Easting)	Location Description	Photo #s Description	Water Quality: Water Depth (ft)	Water Temp. (C)	Cond. (µS/cm) Corr.	Cond. (µS/cm) UnCorr.	Turbidity (NTU)	Comments
8/12/14 1200	3182906.9 N 2102963.5 E	PRM 245.5 – inside of bed (R) single channel	9443 – view u/s TRB 9444- view d/s TRB 9445 – view down bank TRB 9446 – view across xsec TRB - TLB	1	9.92	101	142	162.7	Sample site is d/s of high erosion site on glaciolacustrine near PRM 248
8/12/14 1815	3165795.6 N 2080675.6 E	Oshetna TLB above confluence w/ Susitna	[No photos recorded]	2	11.37	113	153	9.14	
8/13/14 1440	3167056.3 N 2071826.8 E	Upstream Goose Ck confluence – Susitna MC TLB	9801 – view d/s from sample site 9802 – view u/s from samp site 9803 – view up Goose ck	1	9.83	108	152	125.1	
8/13/14 1455	3167128.7 N 2071782.6 E	Goose Ck TRB	9817 – view d/s fan TRB 9806 – view d/s Goose ck 9807 – view of Goose confluence	1	10.43	79	57	1.16	Cond. Corrected reading was with "C" on measuring inst.
8/13/14 1610	3185288.9 N 2066896.9 E	Upstream UNT 228.5 confluence – Susitna MC TRB	1050- view u/s UNT 228.5 1048- view d/s TLB from conf. 1047 – view u/s UNT 228.5	1.8	9.91	151	107	118.0	"
8/13/14 1625	3185316.1 N 2066802.0 E	UNT 228.5 mouth	1050- view u/s UNT 228.5 1048- view d/s TLB from conf. 1047 – view u/s UNT 228.5	1	9.86	199	141	0.84	
8/14/14 1530	3188082.7 N 2033425.7 E	Susitna PRM 221 TRB u/s trib	1147 –view u/s, people at sample site	1	8.85	151	105	135.8	

Date Time	Location (Northing / Easting)	Location Description	Photo #s Description	Water Quality					Comments
				Water Depth (ft)	Water Temp. (C)	Cond. (µS/cm)		Turbidity (NTU)	
						Corr.	UnCorr.		
8/14/14 1535	3188191.4 N 2033354.2 E	TRIB at PRM 221	1151- view u/s 1152 – view d/s	0.5	7.43	182	121	87.81	
8/15/14 1040	3212845.0 N 1993984.9 E	Jay Ck	1258 – view u/s at Ck 1257 – view d/s at Ck	1.0	7.39	204	135	2.83	Conducted in lower most channel of Jay Ck. 3' from TLB. 15 ' above confluce with Susitna. 5 cfs on probe
8/15/14 1100	3212486.9 N 1994607.5 E	Susitna R.	1279 – view u/s at site 1280 – view d/s at site	1.3	9.17	150	107	136.1	Conducted 40' above beginning of Jay Ck. 6' from TRB. 1 cfs on probe
8/15/14 1215	3214453.2 N 1985341.0 E	Susitna R. u/s Kosina Ck	[No Photos recorded]	1.0	9.19	155	108	125.1	Conducted u/s of upmost distributary of Kosina Ck
8/15/14 1220	3214648.2 N 1985046.6 E	Kosina Ck	1339, 1342 –view up Kosina 1343, 1340 – view d/s to mouth	1.3	10.18	85	61	0.51	Conducted 50' u/s of mouth with Susitna
8/16/14 1122	3230358.7 N 1931795.5 E	Watana Ck	1407 – view u/s Watana 1409 – view d/s to mouth	1.0	7.77	188	126	12.75	Conducted 100' u/s of mouth with Susitna. 4' from TRB. 2 cfs on probe

Date Time	Location (Northing / Easting)	Location Description	Photo #s Description	Water Quality: Water Depth (ft)	Water Temp. (C)	Cond. (µS/cm) Corr.	Cond. (µS/cm) UnCorr.	Turbidity (NTU)	Comments
8/16/14 1150	3230253.5 N 1931948.4 E	Susitna R u/s Watana Ck	1427 – view u/s on Su TRB 1428 – view d/s on Su TRB	1.8	9.18	150	105	115.8	Conducted u/s 50' of above Watana ck. 3' From TRB. 2 cfs of probe
8/16/14 1656	3229523.2 N 1895706.3E	Susitna R. u/s Deadman Ck	504 – view u/s TRB 505 – view d/s TRB	1.5	9.55	148	105	125.6	Conducted 250' u/s above Dead man Ck mouth. 3' from TRB. 1 cfs on probe
8/16/14 1700	3229389.0 N 1895409.9 E	Deadman Ck.	517 – view u/s 520 – view d/s ck.	2.2	11.08	65	48	0.66	Conducted 200' u/s of confluence with Susitna. 2' from TLB. 1 cfs on Probe

Table 5.1-4. Upstream and Downstream PRM Boundaries for Geomorphic Assessment Areas Studied in 2013 and 2014.

Geomorphic Assessment Area	PRM		Length	Year of Geomorphic Mapping
	Downstream	Upstream	mile	
GAA-Whiskers Slough	104.2	107.4	3.2	2013
GAA-Oxbow I	113.6	115.3	1.7	2013
GAA-Slough 6A	115.3	117.3	2.0	2013
GAA-Slough 8A	128.1	130.4	2.3	2013
GAA-Gold Creek	137	140.1	3.1	2013
GAA-Indian River	140.1	143.6	3.5	2013
GAA-Slough 21	143.6	146.1	2.5	2013
GAA-Portage Creek	151.8	152.3	0.5	2014
GAA-Stephan Lake Complex	173.6	175.7	2.1	2014
GAA-Watana Dam	184.7	185.7	1.0	2014

Table 5.2 -1. Dates and Locations of Sediment Transport Data collected by the USGS in 2014.

Sediment Sample Type	Susitna River above Tsusena Creek Gage no. 15291700	Susitna River at Gold Creek Gage no. 15292000	Susitna River near Talkeetna, AK Gage no. 15292100	Chulitna River near Talkeetna, AK Gage no. 15292400	Talkeetna River at Talkeetna, AK Gage no. 15292700	Susitna River at Sunshine near Talkeetna, AK Gage no. 15292780	Yentna River near Susitna Station Gage no. 15294345	Susitna River near Susitna Station Gage no. 15294350
Suspended Sediment	5/29/2014, 7/16/2014, 9/10/2014, 9/29/2014	7/30/2014, 8/27/2014	5/12/2014, 5/21/2014, 6/30/2014, 7/30/2014, 9/17/2014	5/8/2014, 5/22/2014, 6/25/2014, 7/29/2014, 8/26/2014, 9/16/2014	5/6/2014, 5/20/2014, 6/24/2014, 6/26/2014, 7/28/2014, 8/25/2014, 9/25/2014	10/22/2013, 5/7/2014, 5/23/2014, 6/23/2014, 7/31/2014, 8/28/2014, 9/30/2014	5/15/2014, 5/28/2014, 8/6/2014, 9/4/2014, 9/15/2014	5/15/2014, 5/27/2014, 5/28/2014, 7/1/2014, 8/6/2014, 9/3/2014
Bedload	N/A	N/A	5/19/2014, 7/30/2014, 9/17/2014	N/A	5/6/2014, 5/20/2014, 6/24/2014, 7/28/2014, 9/25/2014	5/7/2014, 5/23/2014, 6/23/2014, 7/31/2014, 8/28/2014	5/15/2014, 5/28/2014, 7/2/2014, 8/7/2014, 9/4/2014, 9/15/2014	5/15/2014, 5/28/2014, 7/1/2014, 8/5/2014, 9/3/2014
Bed Material	9/29/2014	N/A	9/30/2014	10/21/2013	9/25/2014	10/22/2014, 9/30/2014	N/A	N/A

Table 5.2-2. Summary of Sediment Data Collected by USGS in 2012, 2013, and 2014.

Gage Number	Gage Name	Year of Collection	Discharge Gage Station (Y/N)	Number of Samples Collected		
				Suspended Sediment	Bedload Sediment	Bed Material
15291700	Susitna R above Tsusena Creek	2012	N	6	5	0
15291700	Susitna R above Tsusena Creek	2013	N	5	1	2
15291700	Susitna R above Tsusena Creek	2014	N	4	0	1
15292000	Susitna River at Gold Creek	2012	Y	0	0	0
15292000	Susitna River at Gold Creek	2013	Y	4	0	0
15292000	Susitna River at Gold Creek	2014	Y	2	0	0
15292100	Susitna River near Talkeetna, AK	2012	N	5	6	0
15292100	Susitna River near Talkeetna, AK	2013	N	5	4	1
15292100	Susitna River near Talkeetna, AK	2014	N	5	3	1
15292400	Chulitna River near Talkeetna, AK	2012	N	3	0	0
15292400	Chulitna River near Talkeetna, AK	2013	N	5	0	0
15292400	Chulitna River near Talkeetna, AK	2014	N	6	0	1
15292410	Chulitna River below Canyon near Talkeetna, AK	2012	N	5	4	0
15292410	Chulitna River below Canyon near Talkeetna, AK	2013	N	1	4	0
15292410	Chulitna River below Canyon near Talkeetna, AK	2014	N	0	6	0
15292700	Talkeetna River at Talkeetna, AK	2012	Y	0	0	0
15292700	Talkeetna River at Talkeetna, AK	2013	Y	8	5	1
15292700	Talkeetna River at Talkeetna, AK	2014	Y	7	5	1
15292780	Susitna River at Sunshine near Talkeetna, AK	2012	Y	9	6	0
15292780	Susitna River at Sunshine near Talkeetna, AK	2013	Y	5	4	0
15292780	Susitna River at Sunshine near Talkeetna, AK	2014	Y	7	5	2
15294345	Yentna River near Susitna Station	2012	N	0	0	0
15294345	Yentna River near Susitna Station	2013	N	5	4	0
15294345	Yentna River near Susitna Station	2014	N	5	6	0

Gage Number	Gage Name	Year of Collection	Discharge Gage Station (Y/N)	Number of Samples Collected		
				Suspended Sediment	Bedload Sediment	Bed Material
15294350	Susitna River at Susitna Station	2012	Y	0	0	0
15294350	Susitna River at Susitna Station	2013	Y	5	4	0
15294350	Susitna River at Susitna Station	2014	Y	6	5	0

Table 5.2-3. USGS Suspended Sediment Transport Data Collected in 2012, 2013, and 2014.

Gage Number	Gage Name	Date of Collection	Time of Collection	Discharge	Suspended Sediment Concentration	Suspended Sediment Discharge, Qs	Suspended Sediment Percent finer than size indicated, in millimeters													Silt and Clay	Sand	Sediment Discharge, Qs, Silt and Clay	Sediment Discharge, Qs, Sand
				(cfs)	(mg/L)	(tons/day)	0.001	0.002	0.004	0.008	0.016	0.031	0.0625	0.125	0.25	0.5	1	2	4	%	%	(tons/day)	(tons/day)
15291700	Susitna River above Tsusena Creek	4/10/2012	13:50	1,090	3	9							54							54	46	5	4
15291700	Susitna River above Tsusena Creek	5/10/2012	15:20	8,610	321	7,460	0	8	13	19	27	38	47	62	83	97	100	100	100	47	53	3,506	3,954
15291700	Susitna River above Tsusena Creek	6/3/2012	13:00	14,200	151	5,790	0	0	0	0	0	0	21	28	48	91	99	100	100	21	79	1,216	4,574
15291700	Susitna River above Tsusena Creek	7/2/2012	19:00	20,600	283	15,700	13	19	26	35	46	57	62	69	78	95	100	100	100	62	38	9,734	5,966
15291700	Susitna River above Tsusena Creek	8/7/2012	11:10	14,000	184	6,960	10	16	24	33	42	50	55	62	73	94	100	100	100	55	45	3,828	3,132
15291700	Susitna River above Tsusena Creek	9/14/2012	10:30	8,170	44	971							35	46	67	91	99	100	100	35	65	340	631
15291700	Susitna River above Tsusena Creek	6/21/2013	10:50	25,400	799	54,800	27	39	52	64	74	80	83	88	93	98	99	99	100	83	17	45,484	9,316
15291700	Susitna River above Tsusena Creek	7/25/2013	10:40	17,400	766	36,000							81	85	91	98	100	100	100	81	19	29,160	6,840
15291700	Susitna River above Tsusena Creek	8/5/2013	17:10	14,900	637	25,600	24	32	44	59	71	78	83	86	92	99	100	100	100	83	18	21,128	4,473
15291700	Susitna River above Tsusena Creek	9/3/2013	18:30	18,200	312	15,300							39	51	67	92	99	100	100	39	61	5,967	9,333
15291700	Susitna River above Tsusena Creek	9/23/2013	17:50	7,810	70	1,480							39	51	69	92	100	100	100	39	61	577	903
15291700	Susitna River above Tsusena Creek	5/29/2014	17:55	10,500	140	3,970							25	32	48	91	100	100	100	25	76	955	3,015
15291700	Susitna River above Tsusena Creek	7/16/2014	18:35	22,200	363	21,750	13	26	38	45	50	55	58	63	72	93	100	100	100	58	43	12,506	9,245
15291700	Susitna River above Tsusena Creek	9/10/2014	18:35	13,100	73	2,565							19	25	41	81	96	100	100	19	82	473	2,092
15291700	Susitna River above Tsusena Creek	9/29/2014	15:35	8,500	36	826							33	42	62	95	100	100	100	33	68	268	558
15292000	Susitna River at Gold Creek	3/27/2013	16:10	1,510	498	26,900							44							44	56	2	2
15292000	Susitna River at Gold Creek	6/6/2013	14:30	41,700	375	30,500							54							54	46	33,696	28,704
15292000	Susitna River at Gold Creek	8/15/2013	15:40	19,300	334	25,200							80	86	93	99	100	100	100	80	20	25,120	6,280
15292000	Susitna River at Gold Creek	9/26/2013	14:30	11,500	227	10,800							60	75	87	96	100	100	100	60	40	373	248
15292000	Susitna River at Gold Creek	7/30/2014	17:10	19,900	412	22,100							91	93	96	99	100	100	100	91	9	20,111	1,989
15292000	Susitna River at Gold Creek	8/27/2014	15:20	19,000	129	6,620							46	54	70	94	100	100	100	46	54	3,045	3,575
15292100	Chulitna River near Talkeetna, AK	5/17/2012	14:30	7,940	244	5,230							56							56	44	2,929	2,301
15292100	Susitna River near Talkeetna, AK	5/23/2012	12:10	20,000	498	26,900	0	6	10	14	22	33	43	61	79	98	100	100	100	43	57	11,567	15,333
15292100	Susitna River near Talkeetna, AK	6/5/2012	11:30	30,100	375	30,500	0	6	10	13	18	26	34	50	80	99	100	100	100	34	66	10,370	20,130
15292100	Susitna River near Talkeetna, AK	7/10/2012	13:50	27,900	334	25,200	14	20	29	42	56	67	71	77	87	99	100	100	100	71	29	17,892	7,308
15292100	Susitna River near Talkeetna, AK	8/14/2012	16:50	17,700	227	10,800	29	40	52	65	77	84	87	91	94	99	100	100	100	87	13	9,396	1,404
15292100	Susitna River near Talkeetna, AK	9/25/2012	14:20	43,700	857	101,000	23	29	37	45	54	63	67	78	93	99	100	100	100	67	33	67,670	33,330
15292100	Susitna River near Talkeetna, AK	6/4/2013	17:36	54,400	905	133,000	13	17	22	28	36	45	53	69	90	99	100	100	100	53	47	70,490	62,510
15292100	Susitna River near Talkeetna, AK	7/10/2013	20:00	22,400	334	20,200	18	31	42	56	70	78	83	90	96	100	100	100	100	83	17	16,766	3,434
15292100	Susitna River near Talkeetna, AK	8/13/2013	19:30	17,700	528	25,200	23	36	48	62	75	86	91	95	98	100	100	100	100	91	9	22,932	2,268
15292100	Susitna River near Talkeetna, AK	9/5/2013	12:40	32,200	417	36,300							52	65	86	99	100	100	100	52	48	18,876	17,424
15292100	Susitna River near Talkeetna, AK	9/25/2013	12:40	11,300	20	610							67	78	90	100	100	100	100	67	33	409	201
15292100	Susitna River near Talkeetna, AK	5/12/2014	21:25	22,000	469	27,850	17	21	26	33	42	54	63	75	90	99	100	100	100	63	38	17,407	10,444
15292100	Susitna River near Talkeetna, AK	5/21/2014	19:00	14,200	63	2,420							48	62	81	98	100	100	100	48	52	1,170	1,250

Gage Number	Gage Name	Date of Collection	Time of Collection	Discharge	Suspended Sediment Concentration	Suspended Sediment Discharge, Qs	Suspended Sediment Percent finer than size indicated, in millimeters													Silt and Clay	Sand	Sediment Discharge, Qs, Silt and Clay	Sediment Discharge, Qs, Sand
				(cfs)	(mg/L)	(tons/day)	0.001	0.002	0.004	0.008	0.016	0.031	0.0625	0.125	0.25	0.5	1	2	4	%	%	(tons/day)	(tons/day)
15292100	Susitna River near Talkeetna, AK	6/30/2014	19:50	28,700	252	19,500							25							25	75	4,863	14,637
15292100	Susitna River near Talkeetna, AK	7/30/2014	13:35	19,500	140	7,345	20	38	49	56	61	66	68	75	85	99	100	100	100	68	32	4,997	2,348
15292100	Susitna River near Talkeetna, AK	9/17/2014	12:05	22,100	274	16,350	37	49	57	65	71	76	79	84	92	99	100	100	100	79	22	12,827	3,524
15292400	Chulitna River near Talkeetna, AK	6/7/2012	16:20	19,700	1120	59,600							62							62	38	36,952	22,648
15292400	Chulitna River near Talkeetna, AK	9/19/2012	17:40	34,500	1510	141,000							53							53	47	74,730	66,270
15292400	Chulitna River near Talkeetna, AK	1/23/2013	15:00	1,490	9	36							70							70	30	25	11
15292400	Chulitna River near Talkeetna, AK	3/26/2013	16:30	980	5	13							42							42	58	6	8
15292400	Chulitna River near Talkeetna, AK	6/5/2013	15:25	23,350	880	55,500	31	41	52	62	68	71	79	82	90	98	100	100	100	79	22	43,572	11,928
15292400	Chulitna River near Talkeetna, AK	7/12/2013	19:00	23,700	1,720	110,000	21	29	41	54	66	77	82	91	97	100	100	100	100	82	18	90,200	19,800
15292400	Chulitna River near Talkeetna, AK	8/14/2013	15:10	24,700	1,590	106,000	23	32		57	67	74	78	84	91	98	100	100	100	78	22	82,680	23,320
15292400	Chulitna River near Talkeetna, AK	5/8/2014	14:45	11,700	248	7,533	17	22	30	38	45	50	55	63	75	93	99			55	46	4,068	3,465
15292400	Chulitna River near Talkeetna, AK	5/22/2014	14:12	11,700	461	14,567	22	29	39	48	55	60	62	68	79	96	100	100	100	62	38	9,031	5,535
15292400	Chulitna River near Talkeetna, AK	6/25/2014	18:15	20,900	498	22,300							65							65	36	14,422	7,879
15292400	Chulitna River near Talkeetna, AK	7/29/2014	13:25	21,700	562	31,950	19	26	37	46	54	60	64	72	82	96	100	100	100	64	36	20,346	11,604
15292400	Chulitna River near Talkeetna, AK	8/26/2014	15:25	16,900	595	31,700	27	32	42	50	58	63	66	72	81	94	100	100	100	66	35	20,471	11,229
15292400	Chulitna River near Talkeetna, AK	9/16/2014	15:45	20,700	1,520	82,100	42	56	70	78	83	86	88	91	95	99	100	100	100	88	13	71,543	10,557
15292410	Chulitna R bel. Canyon near Talkeetna, AK	5/17/2012	11:20	7,950	244	5,240	0	15	23	31	41	52	59	74	92	100	100	100	100	59	41	3,092	2,148
15292410	Chulitna R bel. Canyon near Talkeetna, AK	6/7/2012	13:50	19,800	940	50,300	0	29	41	52	61	66	70	81	91	98	100	100	100	70	30	35,210	15,090
15292410	Chulitna R bel. Canyon near Talkeetna, AK	7/11/2012	12:45	15,800	416	17,700	28	37	48	60	68	74	78	84	92	98	100	100	100	78	22	13,806	3,894
15292410	Chulitna R bel. Canyon near Talkeetna, AK	8/23/2012	16:55	15,600	452	19,000	26	33	42	51	61	69	74	80	90	99	100	100	100	74	26	14,060	4,940
15292410	Chulitna R bel. Canyon near Talkeetna, AK	9/19/2012	14:30	33,600	944	85,600	8	14	21	30	37	46	52	65	81	96	99	100	100	52	48	44,512	41,088
15292410	Chulitna R. bel. Canyon near Talkeetna, AK	9/10/2013	15:30	29,700	850	68,200	15	23	33	43	53	60	66	77	89	98	100	100	100	66	34	45,012	23,188
15292699	Talkeetna River at Talkeetna, AK	5/6/2014	18:00	6,700	292	5,285	28	29	31	32	36	40	26	47	74	95	100	100	100	19	82	978	4,307
15292700	Talkeetna River at Talkeetna, AK	10/16/2012	16:40	5,820	104	1,630							27							27	73	440	1,190
15292700	Talkeetna River at Talkeetna, AK	3/25/2013	17:00	470	3	4							65							65	35	2	1
15292700	Talkeetna River at Talkeetna, AK	5/8/2013	11:30	830	20	45							63							63	37	28	17
15292700	Talkeetna River at Talkeetna, AK	5/31/2013	14:40	25,400	1,560	107,000							51							51	49	54,570	52,430
15292700	Talkeetna River at Talkeetna, AK	7/10/2013	16:00	6,420	298	5,170							52	70	86	99	100	100	100	52	48	2,688	2,482
15292700	Talkeetna River at Talkeetna, AK	8/13/2013	12:00	8,130	1,280	28,100	9	1	19	27	36	45	52	71	90	98	100	100	100	52	48	14,612	13,488
15292700	Talkeetna River at Talkeetna, AK	9/5/2013	19:30	14,400	488	19,000							26	43	77	98	100	100	100	26	74	4,940	14,060
15292700	Talkeetna River at Talkeetna, AK	9/25/2013	17:50	5,240	104	1,470							31	54	82	99	100	100	100	31	69	456	1,014
15292700	Talkeetna River at Talkeetna, AK	5/20/2014	15:15	6,210	99	1,660							20	39	75	98	100	100	100	20	81	324	1,336
15292700	Talkeetna River at Talkeetna, AK	6/24/2014	15:35	9,160	189	4,675							36							36	64	1,683	2,992
15292700	Talkeetna River at Talkeetna, AK	6/26/2014	12:05	20,000	1,845	99,650							53							53	48	52,316	47,334
15292700	Talkeetna River at Talkeetna, AK	7/28/2014	17:55	6,790	342	6,260	4	15	27	31	37	42	46	53	70	96	100	100	100	46	55	2,848	3,412
15292700	Talkeetna River at Talkeetna, AK	8/25/2014	18:25	6,490	365	6,400	17	29	34	40	45	49	56	64	79	96	100	100	100	56	44	3,584	2,816
15292700	Talkeetna River at Talkeetna, AK	9/25/2014	14:15	5,590	67	1,003							22	37	68	98	100	100	100	22	79	216	787

Gage Number	Gage Name	Date of Collection	Time of Collection	Discharge	Suspended Sediment Concentration	Suspended Sediment Discharge, Qs	Suspended Sediment Percent finer than size indicated, in millimeters													Silt and Clay	Sand	Sediment Discharge, Qs, Silt and Clay	Sediment Discharge, Qs, Sand
				(cfs)	(mg/L)	(tons/day)	0.001	0.002	0.004	0.008	0.016	0.031	0.0625	0.125	0.25	0.5	1	2	4	%	%	(tons/day)	(tons/day)
15292780	Susitna River at Sunshine nr. Talkeetna, AK	10/6/2011	16:10	13,700	25	925							60							60	40	555	370
15292780	Susitna River at Sunshine nr. Talkeetna, AK	1/31/2012	17:10	3,580	8	77							26							26	74	20	57
15292780	Susitna River at Sunshine nr. Talkeetna, AK	3/19/2012	19:30	2,510	4	27							63							63	37	17	10
15292780	Susitna River at Sunshine nr. Talkeetna, AK	5/22/2012	16:40	35,100	421	39,900	0	9	14	19	27	37	46	62	81	98	100	100	100	46	54	18,354	21,546
15292780	Susitna River at Sunshine nr. Talkeetna, AK	6/5/2012	20:30	63,000	549	93,400	0	13	19	26	33	42	47	63	81	95	100	100	100	47	53	43,898	49,502
15292780	Susitna River at Sunshine nr. Talkeetna, AK	7/10/2012	18:30	53,900	383	55,700	17	25	35	46	57	63	66	74	88	99	100	100	100	66	34	36,762	18,938
15292780	Susitna River at Sunshine nr. Talkeetna, AK	8/13/2012	18:30	43,400	483	56,600	30	39	52	64	75	82	84	90	95	100	100	100	100	84	16	47,544	9,056
15292780	Susitna River at Sunshine nr. Talkeetna, AK	9/17/2012	17:30	69,200	823	154,000	11	19	28	38	47	54	58	74	91	99	100	100	100	58	42	89,320	64,680
15292780	Susitna River at Sunshine nr. Talkeetna, AK	9/22/2012	14:30	154,000	1680	699,000	16	23	31	40	52	63	68	83	96	99	100	100	100	68	32	475,320	223,680
15292780	Susitna River at Sunshine nr. Talkeetna, AK	9/22/2012	15:30	154,000	1680	699,000	0	23	31	40	52	63	68	83	96	99	100	100	100	68	32	475,320	223,680
15292780	Susitna River at Sunshine nr. Talkeetna, AK	3/25/2013	18:20	3,480	2	19							49							49	51	9	10
15292780	Susitna River at Sunshine nr. Talkeetna, AK	6/3/2013	18:25	115,000	1,002	311,000	13	19	26	36	45	54	60	73	90	99	100	100	100	60	41	185,015	125,985
15292780	Susitna River at Sunshine nr. Talkeetna, AK	7/11/2013	18:20	48,100	543	70,500	22	33	46	61	72	79	82	87	92	99	100	100	100	82	18	57,810	12,690
15292780	Susitna River at Sunshine nr. Talkeetna, AK	8/12/2013	15:50	49,700	783	105,000	19	30	40	52	63	73	79	89	96	99	100	100	100	79	21	82,950	22,050
15292780	Susitna River at Sunshine nr. Talkeetna, AK	9/6/2013	14:33	84,000	1,023	232,000	15	21	29	38	47	57	60	75	90	99	100	100	100	60	40	139,065	92,935
15292780	Susitna River at Sunshine nr. Talkeetna, AK	10/22/2013	12:30	29,600	125	9,990							42	52	70	93	99	100	100	42	58	4,196	5,794
15292780	Susitna River at Sunshine nr. Talkeetna, AK	5/7/2014	15:45	45,100	548	66,700	14	19	24	31	37	44	52	64	82	99	100	100	100	52	48	34,684	32,016
15292780	Susitna River at Sunshine nr. Talkeetna, AK	5/23/2014	13:05	29,000	291	22,767	34	40	46	51	56	58	61	66	80	98	100	100	100	61	39	13,998	8,768
15292780	Susitna River at Sunshine nr. Talkeetna, AK	6/23/2014	17:55	55,900	409	61,650							60							60	40	36,990	24,660
15292780	Susitna River at Sunshine nr. Talkeetna, AK	7/31/2014	14:05	48,600	497	65,250	22	30	42	53	63	70	75	82	91	100	100	100	100	75	26	48,610	16,640
15292780	Susitna River at Sunshine nr. Talkeetna, AK	8/28/2014	13:35	48,050	451	58,450	18	25	35	44	53	61	66	75	87	99	100	100	100	66	35	38,274	20,177
15292780	Susitna River at Sunshine nr. Talkeetna, AK	9/30/2014	15:25	24,000	172	11,150							70	75	86	100	100	100	100	70	31	7,773	3,377
15294345	Yentna River near Susitna Station	5/30/2013	18:30	68,500	988	183,000	15	21	28	38	48	57	61	76	90	99	100	100	100	61	39	111,630	71,370
15294345	Yentna River near Susitna Station	6/12/2013	15:10	60,500	830	136,000	24	32	39	47	54	60	63	73	88	99	100	100	100	63	37	85,680	50,320
15294345	Yentna River near Susitna Station	7/8/2013	18:30	58,500	788	124,000	19	26	36	48	58	68	73	83	93	99	100	100	100	73	27	90,520	33,480
15294345	Yentna River near Susitna Station	8/20/2013	13:45	46,500	896	112,000	15	23	32	42	50	56	61	69	80	94	99	100	100	61	39	68,320	43,680
15294345	Yentna River near Susitna Station	9/11/2013	17:40	80,100	972	210,000	12	17	24	33	44	56	63	78	93	100	100	100	100	63	37	132,300	77,700
15294345	Yentna River near Susitna Station	5/15/2014	10:15	32,200	537	46,650	17	20	25	30	37	41	47	56	85	99	100	100	100	47	54	21,677	24,973
15294345	Yentna River near Susitna Station	5/28/2014	12:20	33,350	437	39,300	18	22	27	32	38	42	47	58	82	99	100	100	100	47	53	18,495	20,805
15294345	Yentna River near Susitna Station	8/6/2014	15:10	39,950	470	50,700	25	32	42	52	60	65	69	76	88	99	100	100	100	69	32	34,727	15,973
15294345	Yentna River near Susitna Station	9/4/2014	10:30	24,900	362	24,300	14	22	30	39	47	53	58	69	87	99	100	100	100	58	42	14,094	10,206
15294345	Yentna River near Susitna Station	9/15/2014	16:05	64,950	2,170	380,500	26	37	50	64	74	81	84	91	97	100	100	100	100	84	16	319,655	60,845
15294350	Susitna River at Susitna Station	5/30/2013	14:50	194,000	1,850	967,000	12	17	22	28	34	41	47	65	84	99	100	100	100	47	53	454,490	512,510
15294350	Susitna River at Susitna Station	6/13/2013	14:35	138,000	644	240,000	25	33	43	53	61	66	69	78	96	100	100	100	100	69	31	165,600	74,400
15294350	Susitna River at Susitna Station	7/9/2013	19:50	100,000	581	156,688	17	25	34	43	50	55	58	68	89	100	100	100	100	58	42	90,879	65,809
15294350	Susitna River at Susitna Station	8/19/2013	18:25	89,700	806	195,000	20	30	43	58	71	79	83	88	95	100	100	100	100	83	17	161,850	33,150
15294350	Susitna River at Susitna Station	9/12/2013	16:45	177,000	846	404,000	10	16	23	32	42	54	62	75	91	99	100	100	100	62	38	250,480	153,520

Gage Number	Gage Name	Date of Collection	Time of Collection	Discharge	Suspended Sediment Concentration	Suspended Sediment Discharge, Qs	Suspended Sediment Percent finer than size indicated, in millimeters													Silt and Clay	Sand	Sediment Discharge, Qs, Silt and Clay	Sediment Discharge, Qs, Sand
				(cfs)	(mg/L)	(tons/day)	0.001	0.002	0.004	0.008	0.016	0.031	0.0625	0.125	0.25	0.5	1	2	4	%	%	(tons/day)	(tons/day)
15294350	Susitna River at Susitna Station	5/15/2014	19:50	79,000	361	76,900	17	24	29	35	41	46	50	59	79	99	100	100	100	50	51	37,936	38,964
15294350	Susitna River at Susitna Station	5/27/2014	19:15	59,800	293	47,300	20	26	17	38	43	46	50	60	80	99	100	100	100	50	50	23,666	23,634
15294350	Susitna River at Susitna Station	5/28/2014	18:15	69,300	390	72,967	12	19	26	32	38	44	49	59	80	99	100	100	100	49	51	35,724	37,243
15294350	Susitna River at Susitna Station	7/1/2014	16:10	134,000	559	202,500							66							66	34	133,650	68,850
15294350	Susitna River at Susitna Station	8/6/2014	11:10	90,950	465	114,000	22	29	39	49	57	62	65	71	86	99	100	100	100	65	36	73,500	40,500
15294350	Susitna River at Susitna Station	9/3/2014	15:30	65,100	321	56,400	21	25	32	39	45	51	55	67	88	99	100	100	100	55	45	31,020	25,380

Table 5.2-4. USGS Bed Load Sediment Transport Data Collected in 2012, 2013, and 2014.

Gage Number	Gage Name	Date of Collection	Time of Collection	Discharge	Bedload Sediment Discharge, Qs	Bedload Sediment, Percent finer than size indicated, in millimeters												Sand	Gravel	Sediment Discharge, Qs, Sand	Sediment Discharge, Qs, Gravel
				(cfs)	(tons/day)	0.0625	0.125	0.25	0.5	1	2	4	8	16	31.5	63	128	%	%	(tons/day)	(tons/day)
15291700	Susitna R above Tsusena Creek	5/10/2012	14:40	9,140	142	0	0	1	57	81	90	93	95	98	100	100	100	90	10	128	14
15291700	Susitna R above Tsusena Creek	6/3/2012	11:00	13,700	900	0	0	1	40	70	79	83	87	92	94	100	100	79	21	711	189
15291700	Susitna R above Tsusena Creek	6/3/2012	11:50	13,700	658	0	0	1	45	83	93	96	98	99	100	100	100	93	7	612	46
15291700	Susitna R above Tsusena Creek	7/2/2012	17:10	20,600	488	0	0	0	45	79	89	94	97	99	100	100	100	89	11	434	54
15291700	Susitna R above Tsusena Creek	7/2/2012	18:00	20,600	601	0	0	0	35	60	67	70	74	82	93	100	100	67	33	403	198
15291700	Susitna R above Tsusena Creek	8/6/2012	18:30	16,000	328	0	0	0	48	82	92	95	98	100	100	100	100	92	8	302	26
15291700	Susitna R above Tsusena Creek	8/6/2012	19:00	16,000	307	0	0	1	52	86	94	96	97	98	100	100	100	94	6	289	18
15291700	Susitna R above Tsusena Creek	9/13/2012	16:50	7,650	31	0	0	0	44	78	91	94	96	96	100	100	100	91	9	28	3
15291700	Susitna R above Tsusena Creek	9/13/2012	17:30	7,650	13	0	0	0	55	89	97	99	100	100	100	100	100	97	3	13	0.4
15291700	Susitna R above Tsusena Creek	10/11/2012	15:50	12,200	74	0	0	1	73	92	95	96	97	97			100	95	5	70	4
15291700	Susitna R above Tsusena Creek	10/11/2012	16:20	12,100	126	0	0	1	54	80	90	94	96	99			100	90	10	113	13
15292100	Susitna River near Talkeetna, AK	5/23/2012	12:30	20,000	694	0	0	0	7	8	9	9	9	14	55	100	100	9	91	62	632
15292100	Susitna River near Talkeetna, AK	6/5/2012	13:30	30,100	852	0	1	1	53	71	74	76	77	79	86	100	100	74	26	630	222
15292100	Susitna River near Talkeetna, AK	7/10/2012	14:50	27,900	312	0	0	1	72	92	95	96	98	100	100	100	100	95	5	296	16
15292100	Susitna River near Talkeetna, AK	7/10/2012	15:30	27,700	290	0	0	1	74	94	96	96	98	100	100	100	100	96	4	278	12
15292100	Susitna River near Talkeetna, AK	8/14/2012	15:50	17,700	39	0	1	1	66	80	81	83	87	100	100	100	100	81	19	32	7
15292100	Susitna River near Talkeetna, AK	8/14/2012	16:20	17,700	18	0	0	2	78	98	99	99	100	100	100	100	100	99	1	18	0.2
15292100	Susitna River near Talkeetna, AK	8/24/2012	10:30	16,000	119	0	0	1	61	88	94	98	100	100	100	100	100	94	6	112	7
15292100	Susitna River near Talkeetna, AK	8/24/2012	11:05	16,000	56	0	0	0	76	98	99	100	100	100	100	100	100	99	1	55	1
15292100	Susitna River near Talkeetna, AK	9/25/2012	12:20	43,700	52	0	2	4	79	87	88	88	90	95	100	100	100	88	12	46	6
15292100	Susitna River near Talkeetna, AK	9/25/2012	13:10	43,700	347	0	1	18	59	68	71	73	79	89	100	100	100	71	29	246	101
15292100	Susitna River near Talkeetna, AK	7/10/2013	18:50	22,400	12	0	1	1	79	96	99	100	100	100	100	100	100	99	1	12	0.1
15292100	Susitna River near Talkeetna, AK	8/13/2013	17:50	17,700	32	0	0	1	80	98	99	100	100	100	100	100	100	99	1	32	0.3
15292100	Susitna River near Talkeetna, AK	8/13/2013	18:35	17,700	52	0	0	1	79	96	98	99	100	100	100	100	100	98	2	51	1
15292100	Susitna River near Talkeetna, AK	9/5/2013	14:00	32,200	107	0	0	11	51	66	70	72	74	77	77	100	100	70	30	75	32
15292100	Susitna River near Talkeetna, AK	9/5/2013	14:50	32,200	324	0	0	2	58	76	80	82	85	89	92	100	100	80	20	259	65
15292100	Susitna River near Talkeetna, AK	9/25/2013	13:40	11,300	4	0	1	4	89	99	100	100	100	100	100	100	100	100	0	4	0.0
15292100	Susitna River near Talkeetna, AK	9/25/2013	14:20	11,300	6	0	1	2	81	98	100	100	100	100	100	100	100	100	0	6	0.0
15292100	Susitna River near Talkeetna, AK	5/19/2014	21:15	19,600	110	0	0	0	80	99	100	100	100	100	100	100	100	100	0	110	0.0
15292100	Susitna River near Talkeetna, AK	5/19/2014	21:30	19,600	169	0	0	1	78	98	99	100						99	1	167	2
15292100	Susitna River near Talkeetna, AK	7/30/2014	12:27	19,500	89	0	0	2	69	86	88	89	92	96				88	12	78	11
15292100	Susitna River near Talkeetna, AK	9/17/2014	11:05	22,100	109	0	0	0	9	65	68	69	69	70				68	32	74	35
15292410	Chulitna R Below Canyon near Talkeetna, AK	6/7/2012	12:12	19,800	836	0	0	2	38	67	73	77	82	87	96	100	100	73	27	610	226
15292410	Chulitna R Below Canyon near Talkeetna, AK	7/11/2012	15:10	15,800	1,940	0	0	1	29	52	58	60	63	70	0	100	100	58	42	1,125	815
15292410	Chulitna R Below Canyon near Talkeetna, AK	7/11/2012	16:20	15,800	1,380	0	0	1	25	53	62	66	69	75	92	100	100	62	38	856	524
15292410	Chulitna R Below Canyon near Talkeetna, AK	8/23/2012	15:05	15,600	1,120	0	0	0	13	21	26	36	57	83	0	100	100	26	74	291	829
15292410	Chulitna R Below Canyon near Talkeetna, AK	8/23/2012	15:35	15,600	1,510	0	0	1	15	26	28	36	56	83	95	100	100	28	72	423	1,087

Gage Number	Gage Name	Date of Collection	Time of Collection	Discharge	Bedload Sediment Discharge, Qs	Bedload Sediment, Percent finer than size indicated, in millimeters												Sand	Gravel	Sediment Discharge, Qs, Sand	Sediment Discharge, Qs, Gravel
				(cfs)	(tons/day)	0.0625	0.125	0.25	0.5	1	2	4	8	16	31.5	63	128	%	%	(tons/day)	(tons/day)
15292410	Chulitna R Below Canyon near Talkeetna, AK	9/19/2012	12:30	33,600	3,700	0	0	1	11	20	24	33	54	75	94	100	100	24	76	888	2,812
15292410	Chulitna R Below Canyon near Talkeetna, AK	9/19/2012	13:20	33,600	7,750	0	0	1	8	15	18	29	47	70	91	100	100	18	82	1,395	6,355
15292410	Chulitna River below Canyon near Talkeetna, AK	6/5/2013	11:20	23,600	812	0	0	2	14	26	32	40	55	75	95	100	100	32	68	260	552
15292410	Chulitna River below Canyon near Talkeetna, AK	6/5/2013	12:20	23,600	1,180	0	0	3	15	30	43	53	63	75	90	100	100	43	57	507	673
15292410	Chulitna River below Canyon near Talkeetna, AK	7/12/2013	15:03	23,500	996	0	0	1	20	37	46	50	55	63	79	100	100	46	54	458	538
15292410	Chulitna River below Canyon near Talkeetna, AK	7/12/2013	15:50	23,500	2,150	0	0	1	26	46	52	56	60	68	84	100	100	52	48	1,118	1,032
15292410	Chulitna River below Canyon near Talkeetna, AK	8/14/2013	11:10	24,100	1,710	0	0	1	22	47	55	58	64	78	89	100	100	55	45	941	770
15292410	Chulitna River below Canyon near Talkeetna, AK	8/14/2013	11:55	24,100	4,070	0	0	1	15	38	52	57	62	70	85	100	100	52	48	2,116	1,954
15292410	Chulitna River below Canyon near Talkeetna, AK	9/10/2013	11:50	28,800	2,930	0	0	0	9	16	23	31	48	72	96	100	100	23	77	674	2,256
15292410	Chulitna River below Canyon near Talkeetna, AK	9/10/2013	12:40	28,800	6,100	0	0	0	8	18	24	30	44	65	83	98	100	24	76	1,464	4,636
15292410	Chulitna River below Canyon near Talkeetna, AK	5/8/2014	11:50	11,700	1,560	0	0	1	24	46	63	70	77	88		100	100	63	37	983	577
15292410	Chulitna River below Canyon near Talkeetna, AK	5/8/2014	12:20	11,700	1,370	0	0	2	36	68	76	82	87	92		100	100	76	24	1,041	329
15292410	Chulitna River below Canyon near Talkeetna, AK	5/22/2014	11:30	11,700	1,510	0	0	1	23	48	55	61	76	88		100	100	55	45	831	680
15292410	Chulitna River below Canyon near Talkeetna, AK	5/22/2014	12:20	11,700	1,640	0	0	2	29	49	58	67	80	90		100	100	58	42	951	689
15292410	Chulitna River below Canyon near Talkeetna, AK	6/25/2014	14:30	20,900	3,590	0	0	1	17	32	40	46	57	69		97	100	40	60	1,436	2,154
15292410	Chulitna River below Canyon near Talkeetna, AK	7/29/2014	11:57	21,200	2,250	0	0	1	14	28	36	41	53	69		100	100	36	64	810	1,440
15292410	Chulitna River below Canyon near Talkeetna, AK	8/26/2014	11:30	16,900	3,670	0	0	0	7	36	47	53	62	75	90	100	100	47	53	1,725	1,945
15292410	Chulitna River below Canyon near Talkeetna, AK	9/16/2014	13:15	20,700	2,680	0	0	0	5	19	29	35	44	62	88	100	100	29	71	777	1,903
15292700	Talkeetna River at Talkeetna, AK	5/31/2013	15:30	24,100	3,960	0	0	0	1	3	5	7	16	35	69	100	100	5	95	198	3,762
15292700	Talkeetna River at Talkeetna, AK	5/31/2013	16:30	24,200	4,770	0	0	1	3	7	15	22	32	47	74	100	100	15	85	716	4,055
15292700	Talkeetna River at Talkeetna, AK	7/10/2013	14:30	6,420	1,700	0	0	1	50	93	98	99	99	100	100	100	100	98	2	1,666	34
15292700	Talkeetna River at Talkeetna, AK	7/10/2013	15:05	6,420	1,470	0	0	2	51	94	99	100	100	100	100	100	100	99	1	1,455	15
15292700	Talkeetna River at Talkeetna, AK	8/13/2013	14:25	7,630	906	0	1	7	61	96	98	98	98	99	100	100	100	98	2	888	18
15292700	Talkeetna River at Talkeetna, AK	8/13/2013	15:05	7,500	1,470	0	0	4	47	88	96	96	97	98	100	100	100	96	4	1,411	59
15292700	Talkeetna River at Talkeetna, AK	9/5/2013	16:10	15,100	1,310	0	0	4	41	80	88	88	89	90	94	100	100	88	12	1,153	157
15292700	Talkeetna River at Talkeetna, AK	9/5/2013	16:50	15,100	643	0	0	4	62	89	94	94	95	97	100	100	100	94	6	604	39
15292700	Talkeetna River at Talkeetna, AK	9/25/2013	16:40	5,160	526	0	0	1	35	93	100	100	100	100	100	100	100	100	0	526	0.0
15292700	Talkeetna River at Talkeetna, AK	9/25/2013	17:20	5,190	949	0	0	2	39	96	100	100	100	100	100	100	100	100	0	949	0.0
15292700	Talkeetna River at Talkeetna, AK	5/6/2014	16:10	6,700	242	0	0	8	60	90	98	99	100	100	100	100	100	98	2	237	5
15292700	Talkeetna River at Talkeetna, AK	5/6/2014	17:10	6,700	260	0	0	4	64	98	100	100	100	100	100	100	100	100	0	260	0.0
15292700	Talkeetna River at Talkeetna, AK	5/20/2014	12:30	6,210	643	0	0	2	48	93	99	100	100	100	100	100	100	99	1	637	6
15292700	Talkeetna River at Talkeetna, AK	5/20/2014	13:20	6,210	519	0	0	2	36	81	96	98	99	100	100	100	100	96	4	498	21
15292700	Talkeetna River at Talkeetna, AK	6/24/2014	14:00	9,160	619	0	0	2	41	75	88	90	92	94		100	100	88	12	545	74
15292700	Talkeetna River at Talkeetna, AK	6/24/2014	14:34	9,160	1,460	0	0	2	28	69	88	92	95	98				88	12	1,285	175
15292700	Talkeetna River at Talkeetna, AK	7/28/2014	16:46	6,790	1,140	0	0	1	36	85	95	96	97	98		100	100	95	5	1,083	57
15292700	Talkeetna River at Talkeetna, AK	9/25/2014	10:50	5,590	393	0	0	0	21	83	99	100	100	100	100	100	100	99	1	389	4
15292780	Susitna River at Sunshine	5/22/2012	14:00	35,100	957	0	0	1	41	54	55	55	56	58	64	90	100	55	45	526	431
15292780	Susitna River at Sunshine	5/22/2012	16:10	35,100	779	0	0	0	11	13	14	14	16	23	40	100	100	14	86	109	670
15292780	Susitna River at Sunshine	6/5/2012	17:50	61,300	1,550	0	0	1	43	66	71	74	77	82	90	100	100	71	29	1,101	450

Gage Number	Gage Name	Date of Collection	Time of Collection	Discharge	Bedload Sediment Discharge, Qs	Bedload Sediment, Percent finer than size indicated, in millimeters												Sand	Gravel	Sediment Discharge, Qs, Sand	Sediment Discharge, Qs, Gravel
				(cfs)	(tons/day)	0.0625	0.125	0.25	0.5	1	2	4	8	16	31.5	63	128	%	%	(tons/day)	(tons/day)
15292780	Susitna River at Sunshine	6/5/2012	18:30	61,300	1,500	0	1	2	40	57	61	65	69	75	86	100	100	61	39	915	585
15292780	Susitna River at Sunshine	7/10/2012	19:00	53,900	518	0	0	1	66	89	91	92	93	95	100	100	100	91	9	471	47
15292780	Susitna River at Sunshine	7/10/2012	19:40	53,900	648	0	1	2	70	90	93	94	96	99	100	100	100	93	7	603	45
15292780	Susitna River at Sunshine	8/13/2012	15:40	43,400	3,700	0	0	0	14	25	33	55	81	96	100	100	100	33	67	1,221	2,479
15292780	Susitna River at Sunshine	8/13/2012	16:20	43,400	2,250	0	0	0	15	41	47	54	65	81	91	100	100	47	53	1,058	1,193
15292780	Susitna River at Sunshine	8/24/2012	13:08	37,000	1,340	0	1	1	36	50	51	55	67	89	98	100	100	51	49	683	657
15292780	Susitna River at Sunshine	8/24/2012	13:40	37,000	579	0	0	1	43	69	73	74	77	87	100	100	100	73	27	423	156
15292780	Susitna River at Sunshine	9/17/2012	15:45	69,200	1,910	0	3	7	52	80	83	84	86	89	94	100	100	83	17	1,585	325
15292780	Susitna River at Sunshine	9/17/2012	16:30	69,200	1,840	0	0	2	40	62	65	68	74	85	98	100	100	65	35	1,196	644
15292780	Susitna River at Sunshine near Talkeetna, AK	6/3/2013	16:10	118,000	1,750	0	0	5	22	29	35	41	48	60	76	100	100	35	65	613	1,138
15292780	Susitna River at Sunshine near Talkeetna, AK	6/3/2013	17:00	116,000	2,450	0	0	3	19	24	28	38	50	65	90	100	100	28	72	686	1,764
15292780	Susitna River at Sunshine near Talkeetna, AK	7/11/2013	15:30	48,400	445	0	0	1	52	74	77	80	83	87	100	100	100	77	23	343	102
15292780	Susitna River at Sunshine near Talkeetna, AK	7/11/2013	16:12	48,400	93	0	0	0	20	25	27	30	40	56	64	100	100	27	73	25	68
15292780	Susitna River at Sunshine near Talkeetna, AK	8/12/2013	12:50	48,800	471	0	0	1	69	95	97	98	99	100	100	100	100	97	3	457	14
15292780	Susitna River at Sunshine near Talkeetna, AK	8/12/2013	13:30	49,000	643	0	0	0	34	50	53	56	59	66	83	100	100	53	47	341	302
15292780	Susitna River at Sunshine near Talkeetna, AK	9/6/2013	11:40	84,900	2,810	0	0	1	20	26	27	30	39	59	86	100	100	27	73	759	2,051
15292780	Susitna River at Sunshine near Talkeetna, AK	9/6/2013	12:30	85,000	2,640	0	0	2	35	52	56	59	63	72	82	100	100	56	44	1,478	1,162
15292780	Susitna River at Sunshine near Talkeetna, AK	5/7/2014	14:05	45,800	1,410	0	0	2	57	71	72	73	74	78		100	100	72	28	1,015	395
15292780	Susitna River at Sunshine near Talkeetna, AK	5/7/2014	14:40	45,800	2,200	0	0	2	31	45	48	51	57	71		100	100	48	52	1,056	1,144
15292780	Susitna River at Sunshine near Talkeetna, AK	5/23/2014	10:00	29,000	1,600	0	0	2	53	95	97	97	98	99				97	3	1,552	48
15292780	Susitna River at Sunshine near Talkeetna, AK	5/23/2014	10:50	29,000	2,650	0	0	2	66	92	94	95	96	97				94	6	2,491	159
15292780	Susitna River at Sunshine near Talkeetna, AK	6/23/2014	14:59	55,900	3,410	0	0	1	32	45	48	52	61	75		100	100	48	52	1,637	1,773
15292780	Susitna River at Sunshine near Talkeetna, AK	7/31/2014	10:58	48,600	1,880	0	0	1	25	37	39	40	46	65		100	100	39	61	733	1,147
15292780	Susitna River at Sunshine near Talkeetna, AK	8/28/2014	10:40	47,200	970	0	0	0	9	51	57	59	64	73	96	100	100	57	43	553	417
15294345	Yentna River near Susitna Station	6/12/2013	16:45	60,500	15,750	0	0	5	59	83	89	92	96	99	100	100	100	89	11	14,018	1,733
15294345	Yentna River near Susitna Station	6/12/2013	18:00	60,800	16,470	0	0	4	55	79	85	89	93	96				85	15	14,000	2,471
15294345	Yentna River near Susitna Station	7/9/2013	11:35	53,200	10,910	0	0	3	53	81	88	92	96	99	100	100	100	88	12	9,601	1,309
15294345	Yentna River near Susitna Station	7/9/2013	12:25	52,900	9,080	0	0	4	50	78	86	90	95	99	100	100	100	86	14	7,809	1,271
15294345	Yentna River near Susitna Station	8/20/2013	10:07	46,100	11,280	0	0	5	57	84	90	93	97	99	100	100	100	90	10	10,152	1,128
15294345	Yentna River near Susitna Station	8/20/2013	11:00	46,000	7,270	0	0	4	48	79	87	90	95	98	100	100	100	87	13	6,325	945
15294345	Yentna River near Susitna Station	9/11/2013	12:40	79,700	3,970	0	0	7	52	79	85	89	94	98	100	100	100	85	15	3,375	596
15294345	Yentna River near Susitna Station	9/11/2013	13:50	80,000	7,260	0	0	7	54	81	88	92	98	98	100	100	100	88	12	6,389	871
15294345	Yentna River near Susitna Station	5/15/2014	11:55	32,500	3,440	0	0	5	52	78	88	93	97	99				88	12	3,027	413
15294345	Yentna River near Susitna Station	5/15/2014	12:45	32,500	4,580	0	0	2	45	77	86	90	93	98				86	14	3,939	641
15294345	Yentna River near Susitna Station	5/28/2014	9:40	33,800	4,830	0	0	4	48	78	86	91	96	99				86	14	4,154	676
15294345	Yentna River near Susitna Station	5/28/2014	10:20	33,800	5,290	0	0	5	50	83	90	94	98	100	100	100	100	90	10	4,761	529
15294345	Yentna River near Susitna Station	7/2/2014	10:32	57,100	5,100	0	0	3	47	75	84	88	92	98				84	16	4,284	816
15294345	Yentna River near Susitna Station	8/7/2014	9:29	45,400	7,390	0	0	3	51	86	92	95	97	99	100	100	100	92	8	6,799	591
15294345	Yentna River near Susitna Station	9/4/2014	9:13	26,800	3,790	0	0	1	28	72	85	91	96	100	100	100	100	85	15	3,222	569

Gage Number	Gage Name	Date of Collection	Time of Collection	Discharge	Bedload Sediment Discharge, Qs	Bedload Sediment, Percent finer than size indicated, in millimeters												Sand	Gravel	Sediment Discharge, Qs, Sand	Sediment Discharge, Qs, Gravel
				(cfs)	(tons/day)	0.0625	0.125	0.25	0.5	1	2	4	8	16	31.5	63	128	%	%	(tons/day)	(tons/day)
15294345	Yentna River near Susitna Station	9/15/2014	13:45	65,000	2,620	0	0	1	12	52	66	73	83	96	100	100	100	66	34	1,729	891
15294350	Susitna River at Susitna Station	6/13/2013	10:55	140,000	6,210	0	0	7	22	43	58	66	76	87	97	100	100	58	42	3,602	2,608
15294350	Susitna River at Susitna Station	6/13/2013	11:42	139,000	4,850	0	0	3	26	55	68	75	84	92	99	100	100	68	32	3,298	1,552
15294350	Susitna River at Susitna Station	7/9/2013	14:40	100,000	5,990	0	0	5	70	86	89	92	95	99	100	100	100	89	11	5,331	659
15294350	Susitna River at Susitna Station	7/9/2013	15:30	100,000	7,140	0	0	17	89	96	97	97	98	99	100	100	100	97	3	6,926	214
15294350	Susitna River at Susitna Station	8/19/2013	12:14	88,000	6,680	0	0	13	73	89	92	93	95	97	98	100	100	92	8	6,146	534
15294350	Susitna River at Susitna Station	8/19/2013	13:23	88,500	3,780	0	0	7	67	89	92	93	96	98	100	100	100	92	8	3,478	302
15294350	Susitna River at Susitna Station	9/12/2013	10:40	176,000	8,430	0	0	6	37	63	75	82	88	94	98	100	100	75	25	6,323	2,108
15294350	Susitna River at Susitna Station	5/15/2014	14:15	79,000	5,350	0	0	2	46	86	93	96	97	99				93	7	4,976	375
15294350	Susitna River at Susitna Station	5/15/2014	15:00	79,000	1,350	0	0	1	30	67	86	93	98	100		100	100	86	14	1,161	189
15294350	Susitna River at Susitna Station	5/28/2014	16:50	72,700	6,470	0	0	2	51	77	84	88	92	98				84	16	5,435	1,035
15294350	Susitna River at Susitna Station	5/28/2014	17:30	72,700	6,760	0	0	3	46	71	79	84	89	96				79	21	5,340	1,420
15294350	Susitna River at Susitna Station	7/1/2014	17:55	134,000	8,180	0	0	5	50	75	81	83	88	93		100	100	81	19	6,626	1,554
15294350	Susitna River at Susitna Station	8/5/2014	13:43	90,900	4,560	0	0	7	50	71	79	84	89	95	99	100	100	79	21	3,602	958
15294350	Susitna River at Susitna Station	9/3/2014	12:42	65,100	1,720	0	0	1	37	81	88	91	95	99	100	100	100	88	12	1,514	206

Table 5.2-5. USGS Bed Material Data Collected in 2012, 2013, and 2014.

Gage Number	Gage Name	Date of Collection	Time of Collection	Discharge	Bed Material Sediment, Percent finer than size indicated, in millimeters														Sand	Gravel
				(cfs)	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	%	%
15291700	Susitna R above Tsusena Creek	10/12/2012	13:30	10,100	0	16	18	18	18	18	19	20	33	52	75	92	96	100	18	82
15291700	Susitna R above Tsusena Creek	9/4/2013	10:30	20,800	0	26	26	26	26	26	26	28	33	42	57	74	92	100	26	74
15291700	Susitna R above Tsusena Creek	9/29/2014	16:30	8,420			22			25	33	42	61	84	97	99			22	88
15292100	Susitna River near Talkeetna, AK	9/25/2013	13:00	11,300	0	0	12	12	12	12	13	20	36	60	86	96	99	100	12	88
15292100	Susitna River near Talkeetna, AK	9/30/2014	19:00			7						13	30	49	82	96	98	100	7	93
15292400	Chulitna River near Talkeetna, AK	10/21/2013	13:00	15,500	0	0	36	36	36	36	38	44	53	65	80	91	96	100	36	64
15292700	Talkeetna River at Talkeetna, AK	9/9/2013	15:40	11,200	0	0	0	0	0	0	0	0	0	59	100	100	100	100	0	100
15292700	Talkeetna River near Talkeetna, AK	9/25/2014	15:00	5,590									52	75	97	100	100	100	0	100
15292780	Susitna River at Sunshine near Talkeetna, AK	10/22/2013	15:00	29,100	0	0	23	23	23	24	31	40	60	89	99	100	100	100	23	77
15292780	Susitna River at Sunshine near Talkeetna, AK	9/30/2014	13:10	23,700	0	0	20			22	26	40	60	84	99	100	100	100	20	80

Table 5.8-1. Geomorphic notes of Upper River tributaries previously selected for study of potential delta formation.

Tributary	PRM	Bank	Presence of Fan during August 2014 Recon	~El. @ Mouth (ft. NAVD88)	Evidence of recent sedimen-tation	Frequency sediment loading	Notes
Oshetna River	235.1	LB	yes	2,100	yes	annual-high loading	Plane bed river that has incised into its fan. Heavily armored and vertically stable. Ice scars are present about 10 feet above water surface elevation or more. Appears to be a substantial sediment source.
Goose Creek	232.8	LB	yes	2,060	unclear	episodic	Uniform lag deposits (boulder and cobble) and imbricate material (gravel and cobble) on large fan. Ice effect on left bank of tributary in moraine which could be source for the sediment deposited at the mouth. Tributary likely not producing much sediment; appears deposition occurs because Goose Creek mouth is just upstream of a constriction on the Susitna River. The constriction, combined with ice effects, likely dire fan formation. Large cobbles and boulders on fan with some gravel.
Jay Creek	211	RB	yes	1,700	yes	episodic	Recent episodic event caused avulsion up tributary and sheet flooding downstream. Event transported material about 128 mm in diameter. Large presence of sand. Channel downcutting through fan deposits but has been filled with sediment and LWD from a recent event. Thus, current channel now perched above previous channel causing sheet flow and less sediment transport. Very unstable channel.
Kosina Creek	209.1	LB	yes	1,680	no	episodic	Very stable, granite dominated channel with well-defined floodplain. Boulders greater than 3 ft present. Channel does not appear to produce much sediment but has high transport capacity. Presence of some fan in Susitna River that is boulder armored. Creek appears to have incised down into its fan. Boulders at mouth of creek combined with bedrock on Susitna river right provide enough constriction for a backwater and sediment storage zone upstream on the Susitna River.
Watana Creek	196.9	RB	yes	1,550	yes	annual - high loading	Recent landslides upstream in tributary basin that are still failing. Large presence of source material in lower portion of tributary basin; till with boulders up side valleys. Wide valley, many bars, and fairly open floodplain. Large landslide dammed the river then had dam break which resulted in huge deposition area. Erosion through landslide creating turbidity. Older landslides further upstream. Presence of scarps and slumps all over basin. Presence of mudstones and sedimentary rocks.
Deadman Creek	189.4	RB	yes	1,510	yes	episodic - low loading	Stable channel. Coarse material at mouth. Doesn't appear to be producing much sediment. Major waterfalls up tributary. Bedrock controlled sinuosity. Some till producing sediment, otherwise coarse material. Flatter (upstream) reach has some sand and fine gravel. Tributary meanders through till deposits where the smaller material has been cleaned out and a boulder dominated channel is left. Upper watershed has sand over coarse bed. Very low gradient, high sinuosity in upper watershed but doesn't seem to be transported to lower reaches. Channel fluctuates to boulder dominated with sand deposits intermittent up to Deadman Lake.

Table 5.9-1. Large Woody Debris (LWD) Digitized from Aerial Photographs.

Aerial photograph year	Date(s) of aerial photographs	Area (PRM)	Entire area or LWD sample area?
1950s	n/a	n/a	Not digitized – poor resolution
1983	9/6/1983, 9/11/1983	PRM 3.3 to PRM 159.5	LWD sample areas
2012	9/30/2012, 10/10/2012	PRM 3.3 to PRM 69	LWD sample areas
	9/30/2012, 10/10/2012	PRM 69 to PRM 143.6	Entire area
	9/30/2012, 10/20/2012	PMR 143.6 to PRM 250	LWD sample areas
2013	9/20/2013	PRM 3.3 to PRM 69	Entire area
	9/20/2013, 9/24/2013	PRM 69 to PRM 143.6	LWD sample areas
	9/16/2013, 9/20/2013, 9/24/2013, 11/6/2013	PMR 143.6 to PRM 260	Entire area

Table 5.10-1. Characteristics of stream crossings along the Denali East and portions of the Denali West access routes.

Crossing Number	Description	Estimated Width (ft)	Confinement	Substrate	Meandering?	LWD Potential	Photos
1 (Deadman Creek)	Rapids	80	Unconfined	Boulder/Cobble	Yes	Low	128-131
2	Step Pool	6	Moderately Confined	Boulder/Cobble	No	Low	132-133
3 (Delusion Creek)	Low Gradient Beaver Ponds, very wet area	10, braided	Unconfined	Fines	Moderate	Moderate	135-137
4	Riffle Run	12	Unconfined	Boulder/Cobble	Low	Low	140-144
5	Riffle Run with beaver dams	10	Unconfined	Gravel/Cobble	Moderate	Low	147-150
6 (Deadman Creek tributary)	Step Pool/Cascade	8, braided	Varies	Boulder/Cobble	Varies	Low/Moderate	154-156
7	Boulder Cascade	10	Moderately Confined	Boulder/Cobble	Low	Moderate	157-158
8	Riffle Run	12	Unconfined	Gravel/Cobble	Moderate	Low	159-160
9	Step Pool/Cascade – 2 channels	6, 3	Unconfined	Boulder/Cobble	Moderate	Moderate	165-166
10	Step Pool/Cascade	4	Unconfined	Coble	Low	Low	167-168
11	Step Pool/Cascade – 2 channels	6, 2	Varies	Boulder/Cobble	Low	Moderate	171-173
12	Riffle Cascade – 2 channels, high sediment load	6, braided	Varies	Boulder/Cobble/ Gravel	Moderate	Moderate	175-177
13	Braided Riffle / Cascade, high sediment load	8 braided	Unconfined	Boulder/Cobble/ Gravel	High	High	179-181
14	Braided Riffle / Cascade	8 braided	Unconfined	Boulder/Cobble/ Gravel	High	High	184-186

Crossing Number	Description	Estimated Width (ft)	Confinement	Substrate	Meandering?	LWD Potential	Photos
15	Step Pool	10	Moderately Confined	Boulder/Cobble	Low	Moderate/High	189
16	Step Pool/Cascade	8	Unconfined	Boulder/Cobble	Low	High	218-220
17 (Seattle Creek)	Step Pool/Cascade	10	Unconfined	Boulder/Cobble	Moderate	High	223-226
18 (Brush Kana Creek)	Beaver Meadow	n/a	Unconfined	n/a	n/a	n/a	227-230
19	Riffle Run	10	Unconfined	Cobble/Gravel	Moderate	Moderate	231-233
20	Riffle Run	50	Unconfined	Cobble/Gravel	High	Low	237-240
21	Riffle Glide	8	Unconfined	Cobble/Gravel	High	Low	243-245
22	Riffle Run	12	Unconfined	Cobble/Gravel	High	Low/Moderate	247-249
23	Riffle Run	6	Unconfined	Boulder/Cobble	Moderate	Moderate	251-252
24	Cascade/Riffle – 3 channels	6, 5, 4	Unconfined	Boulder/Cobble	Low	Low	254-255
25	Cascade/Riffle – braided	35	Unconfined	Boulder/Cobble	Braided	Moderate	256-258
26	Step Pool – 2 channels	6, 6	Unconfined	Boulder/Cobble	Moderate	Moderate	261-263
27	Step Pool	6	Moderately Confined	Boulder/Cobble	Moderate	Low	266
28 (Deadman Creek)	Riffle/Cascade – multi channel	25	Unconfined	Boulder/Cobble	Moderate	High	268-269
29	Riffle/Cascade	15	Moderately Confined	Boulder/Cobble	Low	Low	270-271

Table 5.11-1: Key used for Table 5.11-2.

Change Trend	Level of Potential Effects on River Morphology		
	Low	Moderate	High
Decrease	–	– –	– – –
Increase	+	++	+++
Little to no effect	0		

Table 5.11-2: Initial framework for First-Order analysis of dam effects on river morphology.

<table>
<tr><th colspan="4" rowspan="2">Category[1]</th><th colspan="4">Level of Potential Dam Effects on River Morphology[2]</th><th rowspan="2">Data & Analysis[3]</th></tr>
<tr><th>Upper River[5]</th><th colspan="2">Middle River</th><th>Lower River</th></tr>
<tr><th colspan="9">FIRST ORDER</th></tr>
<tr><td rowspan="2">1</td><td colspan="2" rowspan="2">Hydrology</td><td>Q_{peak} (frequency)</td><td>0</td><td colspan="2">– –
~40 %</td><td>–
~20 %</td><td rowspan="2">Extended and Observed Streamflow Records for the Susitna River (SIR Study 6.5 Table 5-1 and Tetra Tech 2013d)
Operational Scenarios (as available)</td></tr>
<tr><td>Q_{base} (duration)</td><td>0</td><td colspan="2">++</td><td>+</td></tr>
<tr><td rowspan="2">2</td><td colspan="2" rowspan="2">Sediment Supply</td><td>sand</td><td>0</td><td colspan="2">– / 0 (channel)
– – (floodplain)</td><td>–</td><td rowspan="2">Susitna and Tributary Sediment Sampling (SIR Study 6.6 Table 5-1)
USGS sediment data (SIR Study 6.5 Table 5-1)
1-D and 2-D bed evolution modeling (SIR Study 6.6, Attachment 1)</td></tr>
<tr><td>gravel</td><td>0</td><td colspan="2">– / 0</td><td>0</td></tr>
<tr><td rowspan="4">3</td><td rowspan="4">Ice[4]</td><td>Dominant Regime</td><td></td><td>Ice</td><td colspan="2">Ice + Fluvial</td><td>Fluvial</td><td rowspan="4">Ice Studies & models (ISR Study 7.6)
1980's Observed Ice Jams (ISR Study 7.6)</td></tr>
<tr><td rowspan="3">Processes</td><td>Freeze-up</td><td>?
(limited local effects at head of reservoir)</td><td colspan="2">–
(later and less extensive)</td><td>0</td></tr>
<tr><td>Break-up</td><td>0</td><td>Thermal
0 / –</td><td>Dynamic
– / – –</td><td>0</td></tr>
<tr><td>Extent/Timing</td><td>0</td><td>0</td><td>–</td><td>0</td></tr>
<tr><td rowspan="4">4</td><td colspan="2" rowspan="4">Geology</td><td>Geomorphic Setting</td><td>Extensive Glacial deposits</td><td colspan="2">Extensive Glacial deposits</td><td>Extensive Glacial deposits</td><td rowspan="4">Mapping Observations: Geomorphic Surface Mapping in FAs (Table 5-1 and ISR Study 6.5)
Little Ice Age Terraces (SIR Study 6.5 Table 5.1-1 and 5.1-2)
Comparative Thalweg Profile (1980s/2012/2013) (Tetra Tech 2014a)</td></tr>
<tr><td>Controls (i.e. sensitivity)</td><td>Extensive Outcrop</td><td colspan="2">Extensive Outcrop</td><td>Tributaries (large)</td></tr>
<tr><td>Bed Material Lag Deposits</td><td>0
frequent</td><td colspan="2">0
frequent</td><td>0
infrequent</td></tr>
<tr><td>Inherited glacial and paraglacial features</td><td>moraines and outwash terraces</td><td colspan="2">Tributary Fans and outwash terraces</td><td>Outwash and glacio-lacustrine terraces</td></tr>
</table>

Notes:
1 Aspect of the river system that may change due to dam implementation. It is divided into 1st and 2nd order components. Each component is numbered and broken into further categories, where applicable, that may be affected.
2 Values in cells indicate change or trend and level of potential effects, where applicable. Effects do not consider potential operational changes to reduce or mitigate effects.
3 This column is populated with data that supports the assessment in change trend. The text *italicized* and in parenthesis indicates where the data can be found.
4 Depends on ice regime as a function of project operation. Flooding and the disturbance regime vary based on thermal versus dynamic ice break-up regimes.
5 Upper River Segment project effects limited to the reservoir area

Table 5.11-3: Initial framework for Second-Order dam effects analysis.

	Category[1]		Dam Effects[2]			Data & Analysis (*data source*)[3]
			Upper River[5]	Middle River	Lower River	
Second Order						
1	Channel	Aggradation	+ Reservoir pool	+ Local Gravel	+ / –	1-D and 2-D models (*SIR Study 6.6 Attachment 1*) Information from other rivers
		Degradation	0	0 Armored	0	
		Width	0	– Vegetation Encroachment	– 10% (Has Sand and Vegetation)	
		Flow/Sediment Variability (i.e. complexity)	0	$Q_{2\ pre}$ v $Q_{2\ post}$, – – Sed_{pre} v Sed_{post}, – – –	$Q_{2\ pre}$ v $Q_{2\ post}$, – Sed_{pre} v Sed_{post},–	
2	Bed Material	Coarse (Gravel and larger)	0	+ (Less Sand)	0	Incipient Motion Analysis (*Tetra Tech 2013c*) Sediment Transport Analysis (*Tetra Tech 2014b*) 1-D and 2-D models (*SIR Study 6.6 Attachment 1*)
		Fines (Sand)	0	–	– Reduced Rate	
		Sediment Transport	0	–	– / 0	
3	Floodplain	Accretion	0	– –	– / 0	Bank Stratifications (*SIR Study 6.6 Table 5-1*), Dendrochronology + ^{210}Pb (*ISR Study 8.6*) Aerials (1950s, 1980s, 2012, 2013) (*SIR Study 6.5 Table 5-1*) Turnover Analysis (*Tetra Tech 2014c*) 1-D and 2-D Models (*SIR Study 6.6 Attachment 1*)
		Erosion	0	–	– / 0	
		Inundation	0	– Function of Surface and Ice Effects	– / 0	
4	Planform	Single v Multiple channels	0	Could reduce number of lower order channels if ice effects are reduced	0	
5	Turbidity	Iced-over period	0	+ / ++	0 / + very small	EFDC model (*SIR Study 5.5, Attachment 1*)
		Open water period	0	– / – –	0 / – very, very small	
6	Tributary Impacts	f (size, volume, sediment produced & transport capacity of the river)	0 + / – in reservoir	+ Larger fans could impact upstream ice jams	0	Tributary Sediment Data (*SIR Study 6.6 Table 5-1*) Mainstem Hydraulics (*Tetra Tech 2014b*)

Notes:
1 Aspect of the river system that may change due to dam implementation. It is divided into 1st and 2nd order components. Each component is numbered and broken into further categories, where applicable, that may be affected.
2 Values in cells indicate change or trend and level of potential effects, where applicable. Effects do not consider potential operational changes to reduce or mitigate effects.
3 This column is populated with data that supports the assessment in change trend. The text *italicized* and in parenthesis indicates where the data can be found.
4 Depends on ice regime as a function of project operation. Flooding and the disturbance regime vary based on thermal versus dynamic ice break-up regimes.
5 Upper River Segment project effects limited to the reservoir area

10. FIGURES

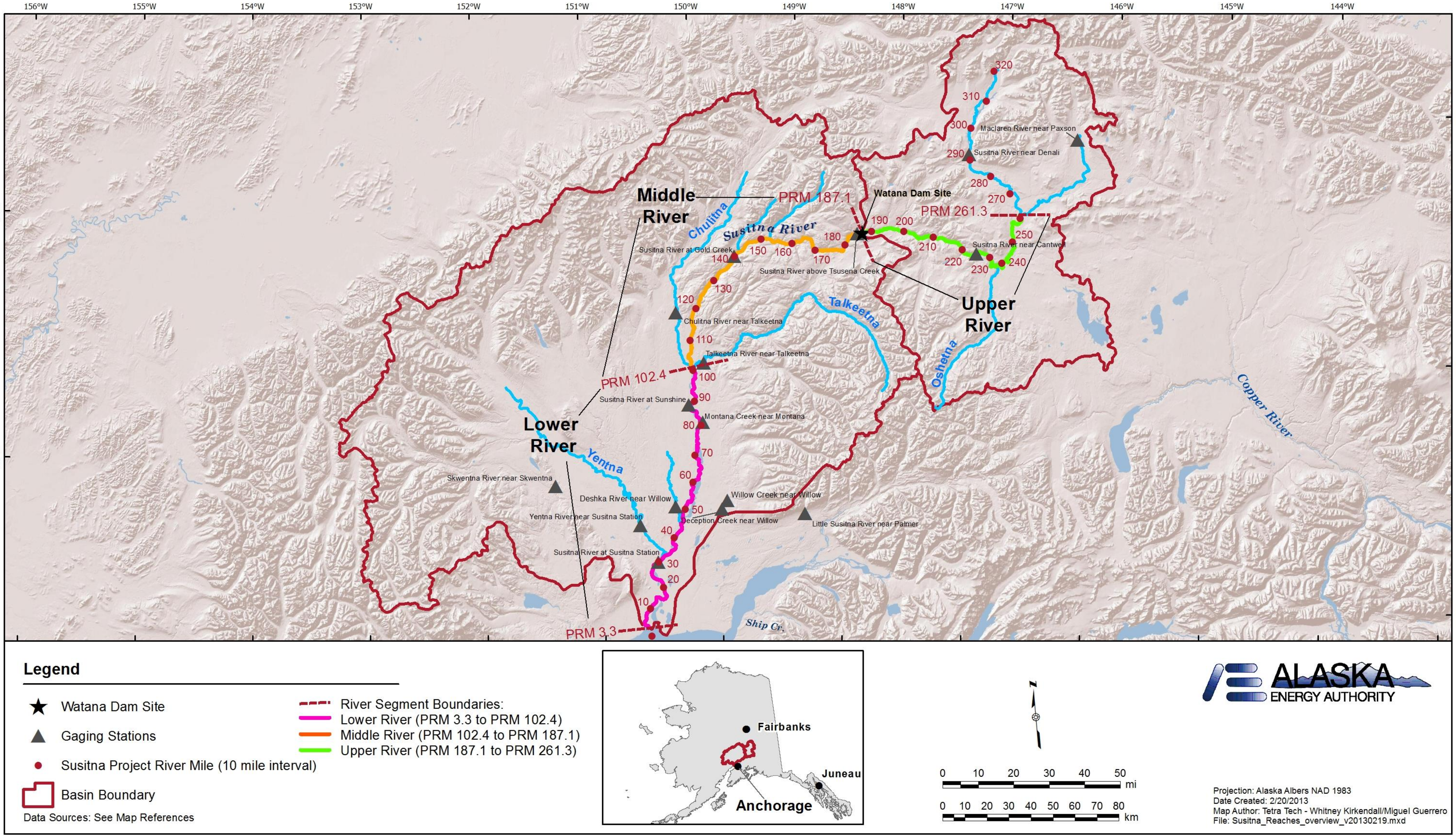

Figure 3-1: Susitna River geomorphology study area and large-scale river segments.

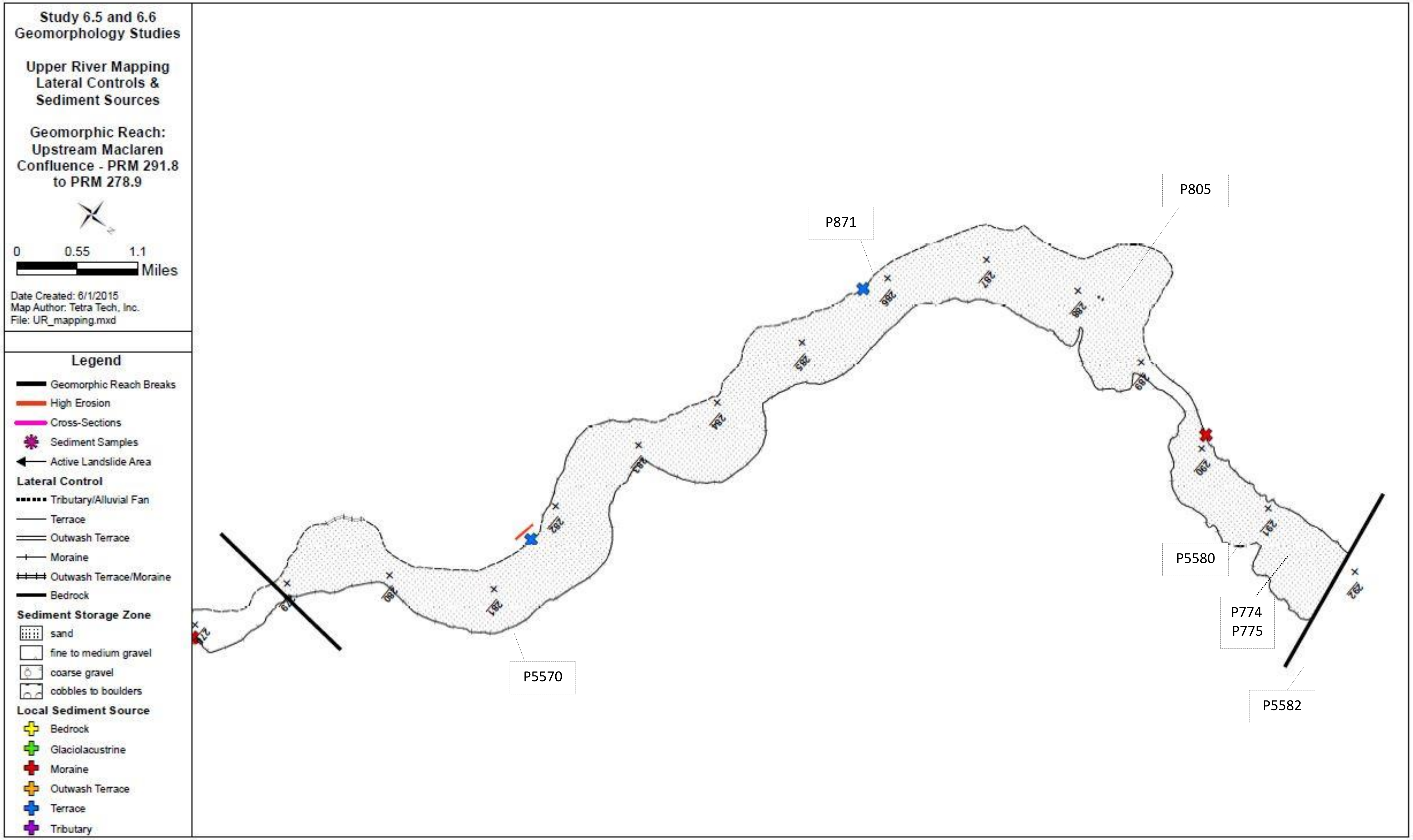

Figure 5.1-1: Upper River Lateral Control and Sediment Source Mapping with illustrative photo numbers noted (See Appendix A for photos) for Upstream Maclaren Confluence - PRM 291.8 to PRM 278.9.

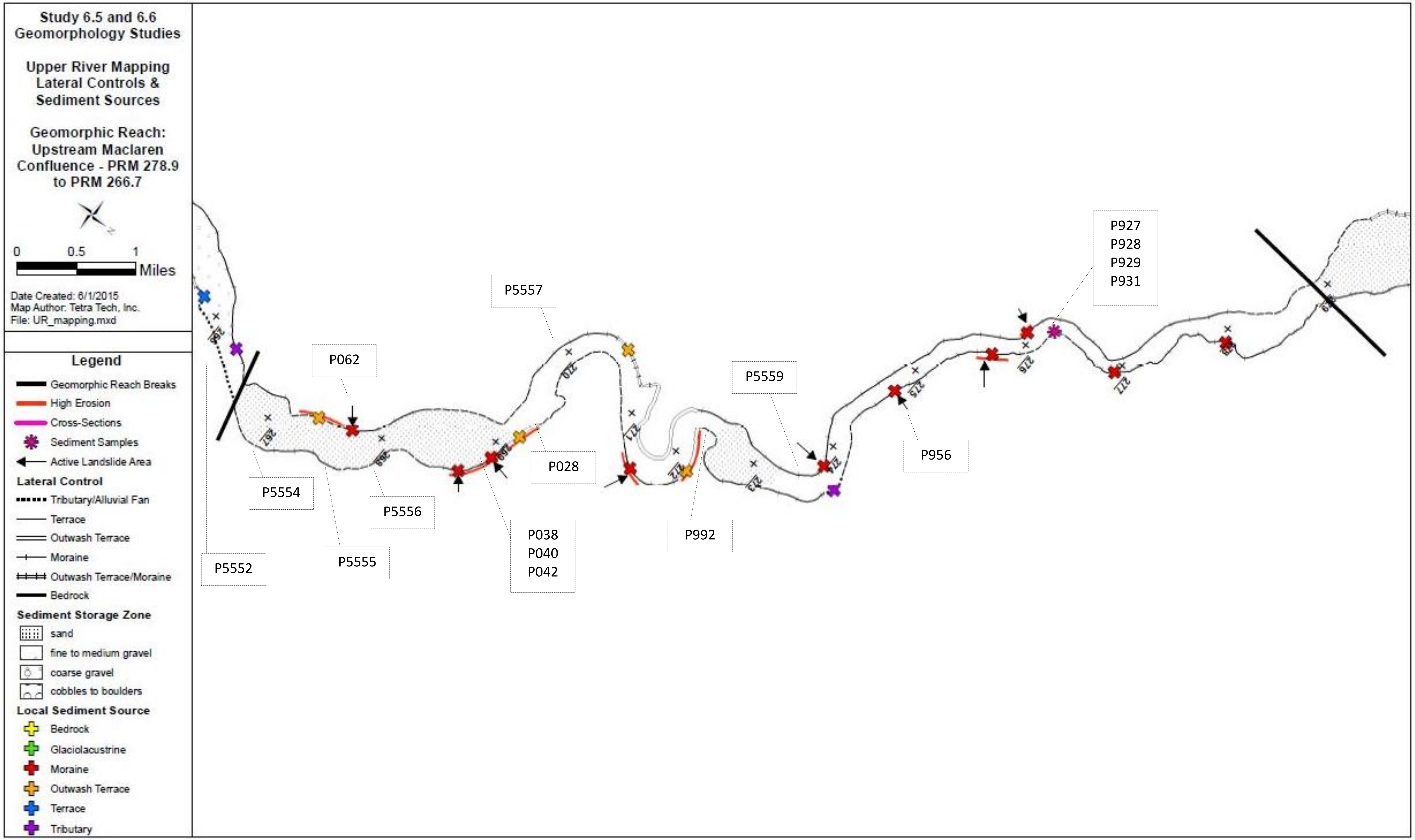

Figure 5.1-2: Upper River Lateral Control and Sediment Source Mapping with illustrative photo numbers noted (See Appendix A for photos) for Upstream Maclaren River Confluence - PRM 278.9 to PRM 266.7.

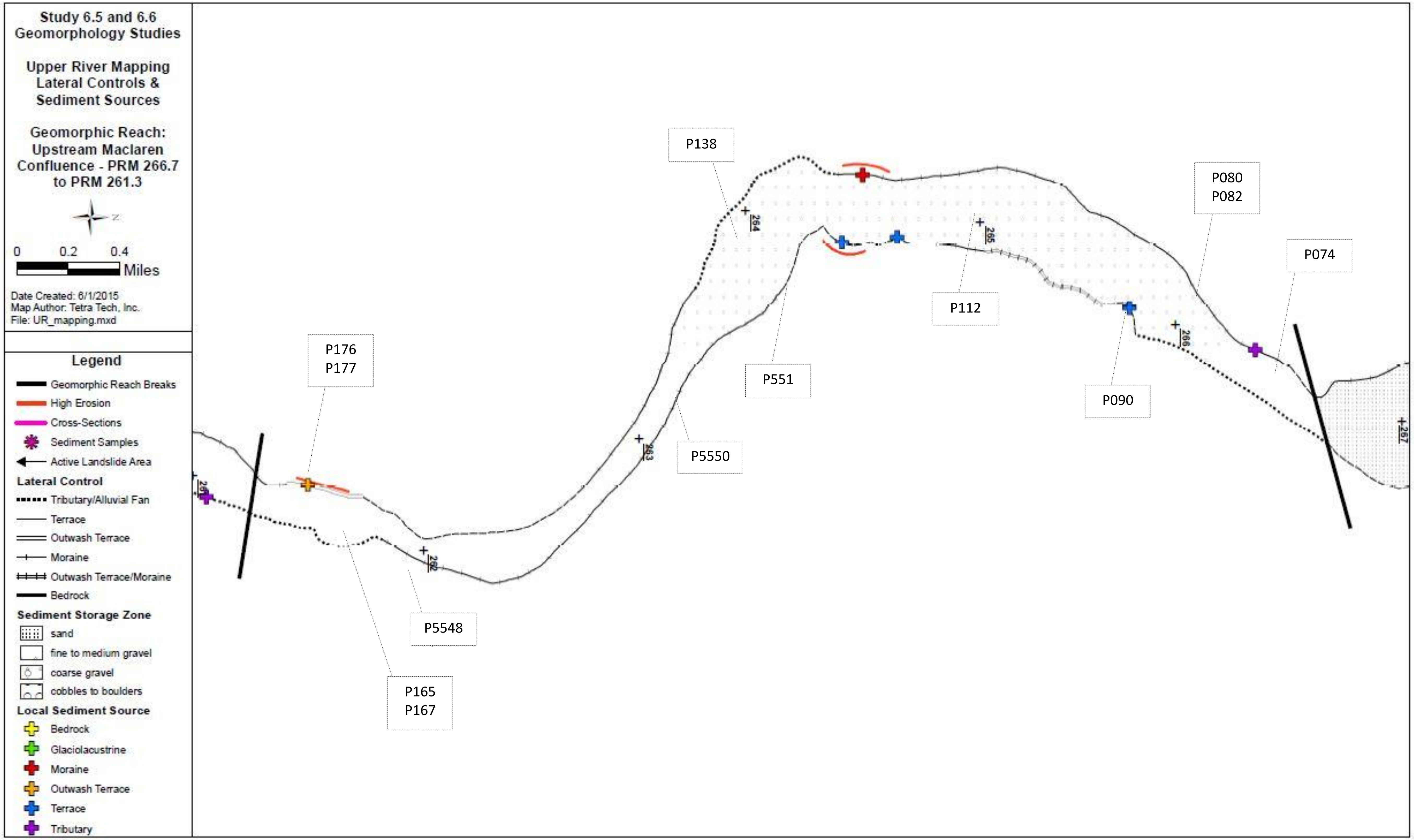

Figure 5.1-3: Upper River Lateral Control and Sediment Source Mapping with illustrative photo numbers noted (See Appendix A for photos) for Upstream Maclaren River Confluence – PRM 266.7 to PRM 261.3.

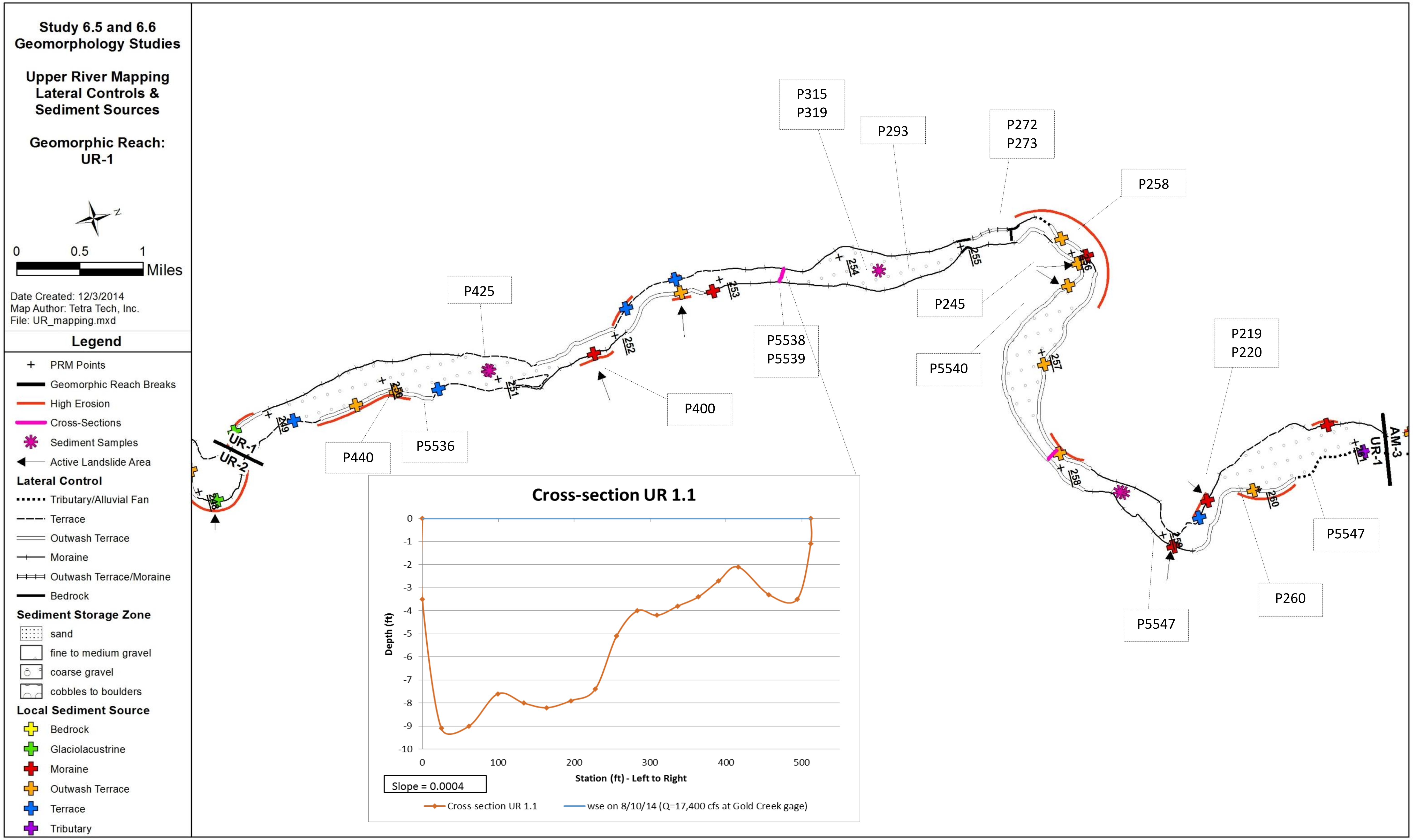

Figure 5.1-4: Upper River Lateral Control and Sediment Source Mapping with illustrative photo numbers noted (See Appendix A for photos) for geomorphic reach UR-1.

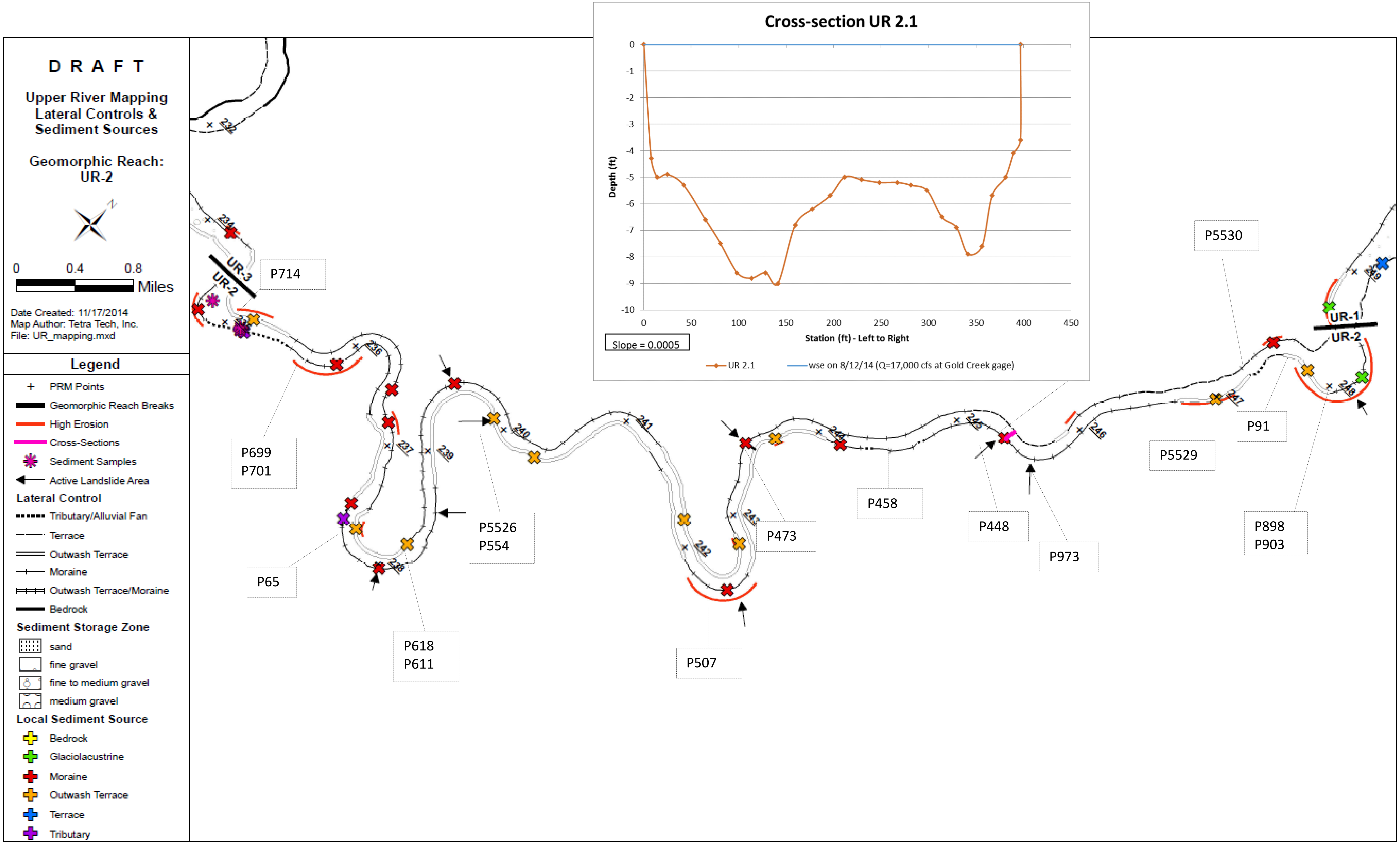

Figure 5.1-5: Upper River Lateral Control and Sediment Source Mapping with illustrative photo numbers noted (See Appendix A for photos) for geomorphic reach UR-2.

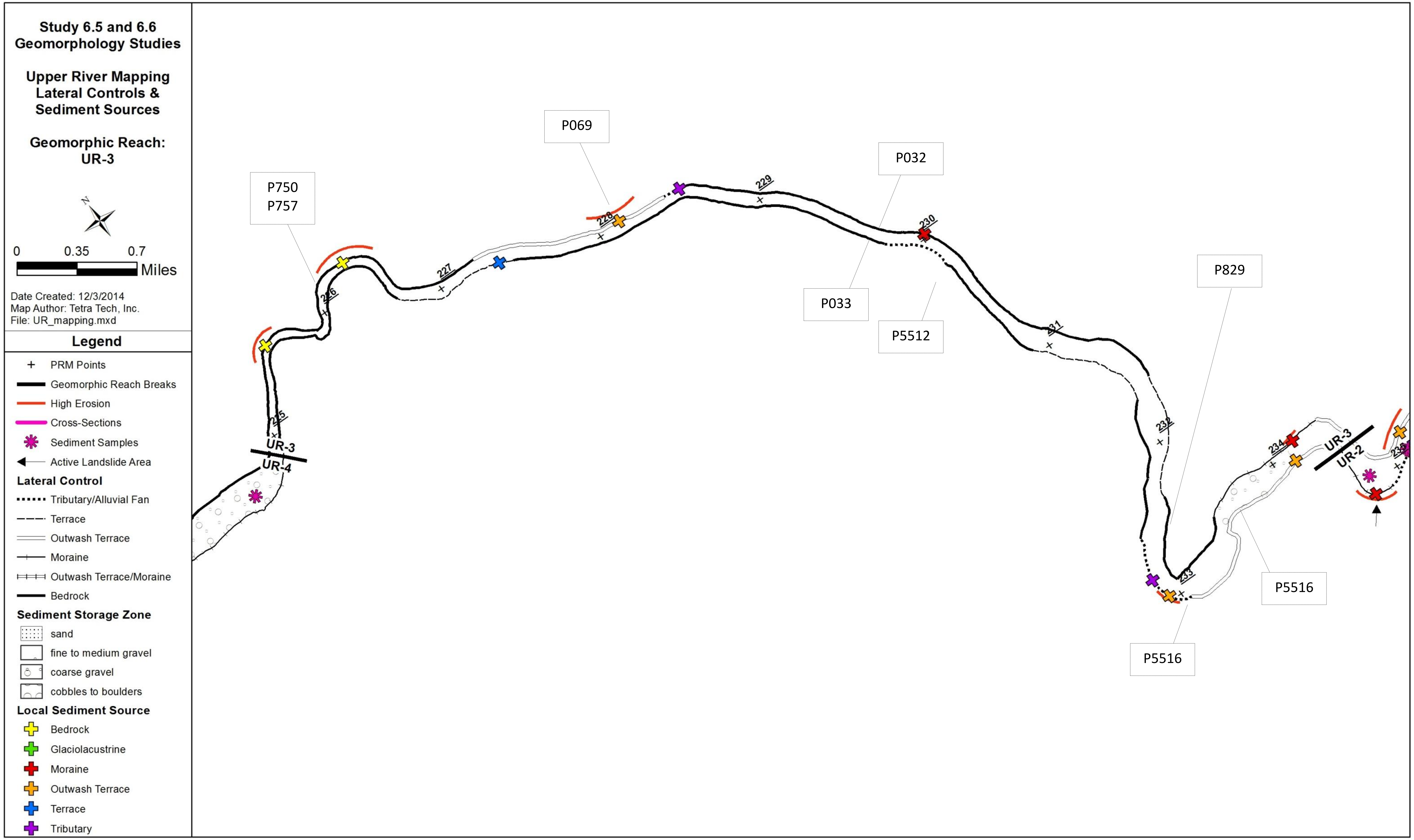

Figure 5.1-6: Upper River Lateral Control and Sediment Source Mapping with illustrative photo numbers noted (See Appendix A for photos) for geomorphic reach UR-3.

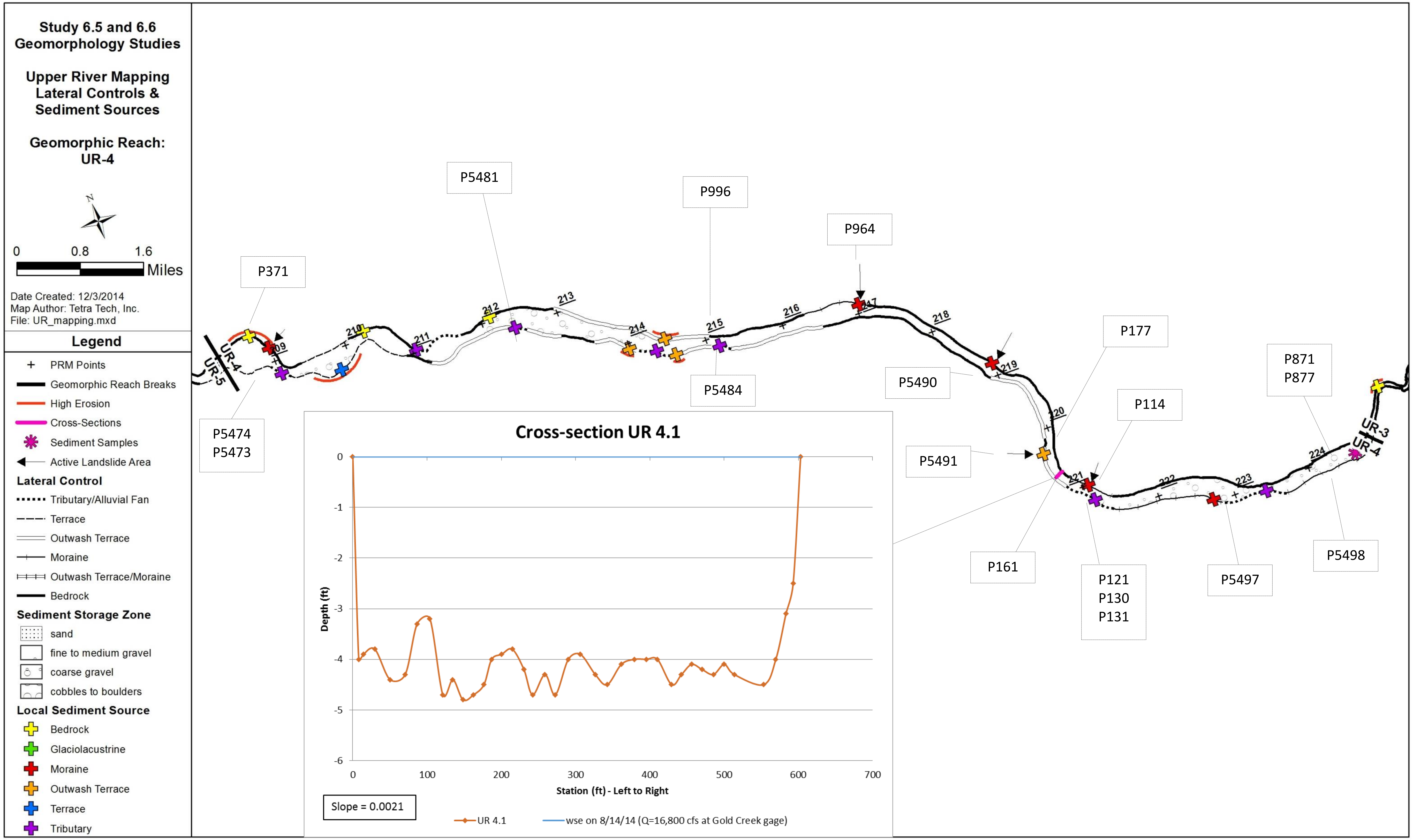

Figure 5.1-7: Upper River Lateral Control and Sediment Source Mapping with illustrative photo numbers noted (See Appendix A for photos) for geomorphic reach UR-4.

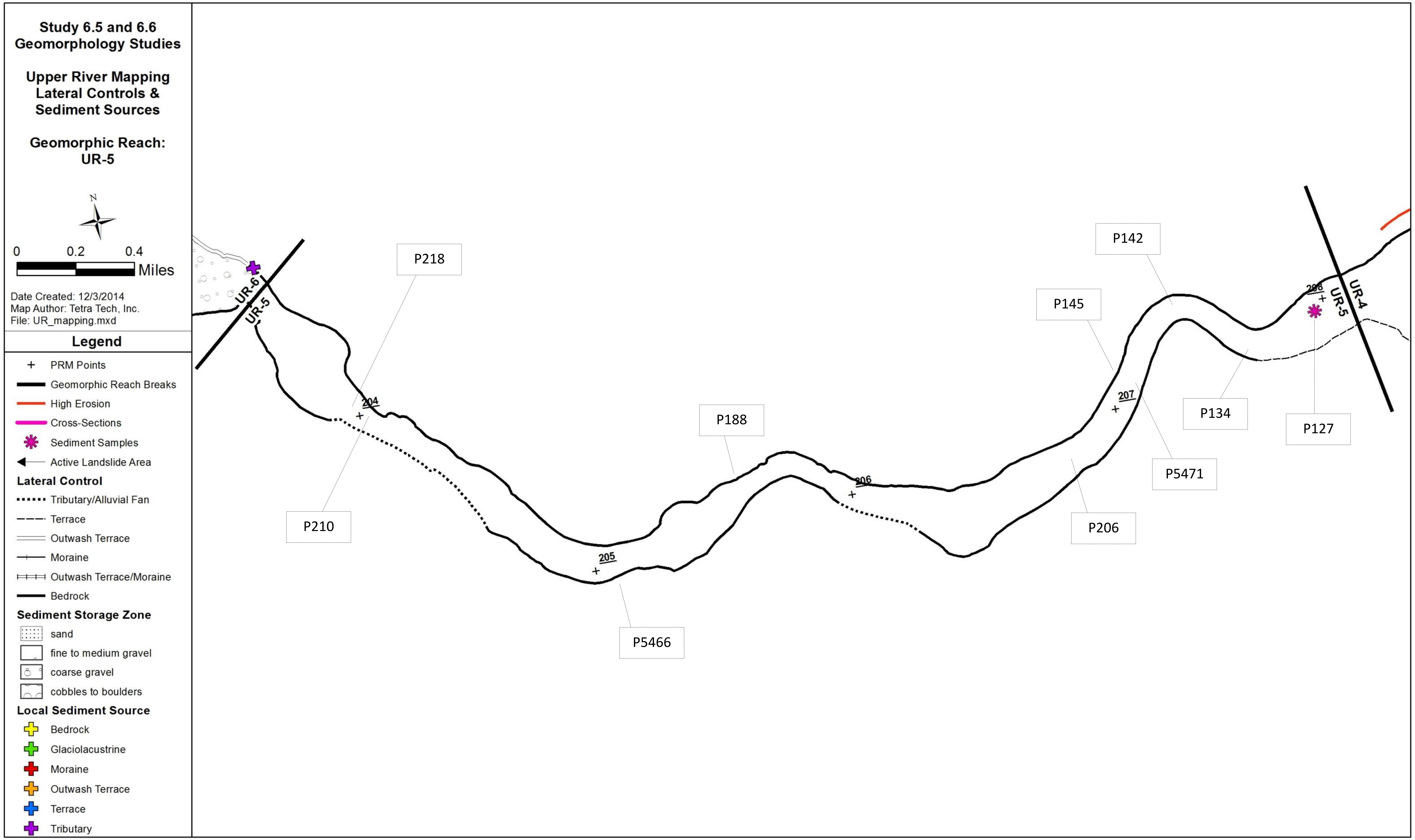

Figure 5.1-8: Upper River Lateral Control and Sediment Source Mapping with illustrative photo numbers noted (See Appendix A for photos) for geomorphic reach UR-5.

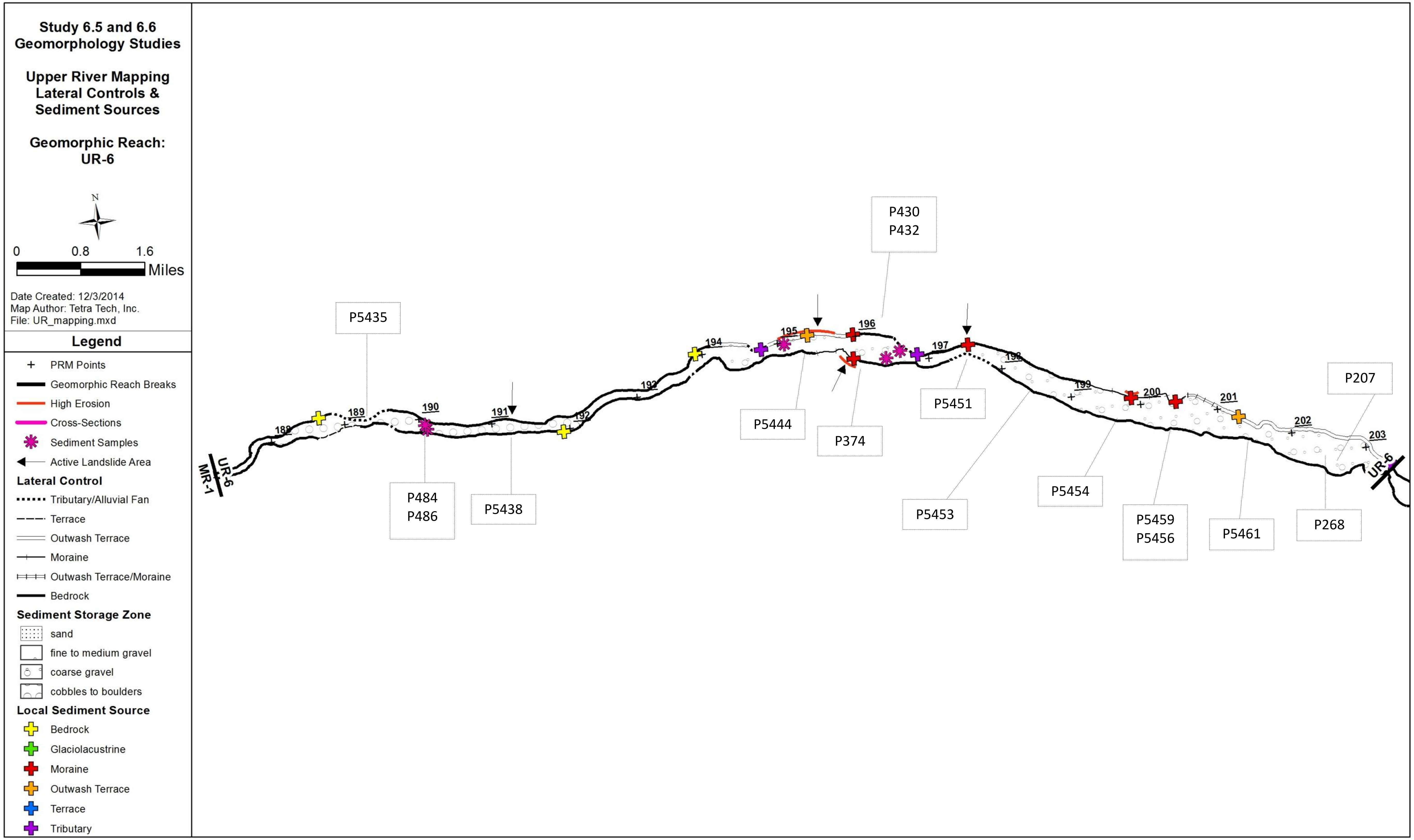

Figure 5.1-9: Upper River Lateral Control and Sediment Source Mapping with illustrative photo numbers noted (See Appendix A for photos) for geomorphic reach UR-6.

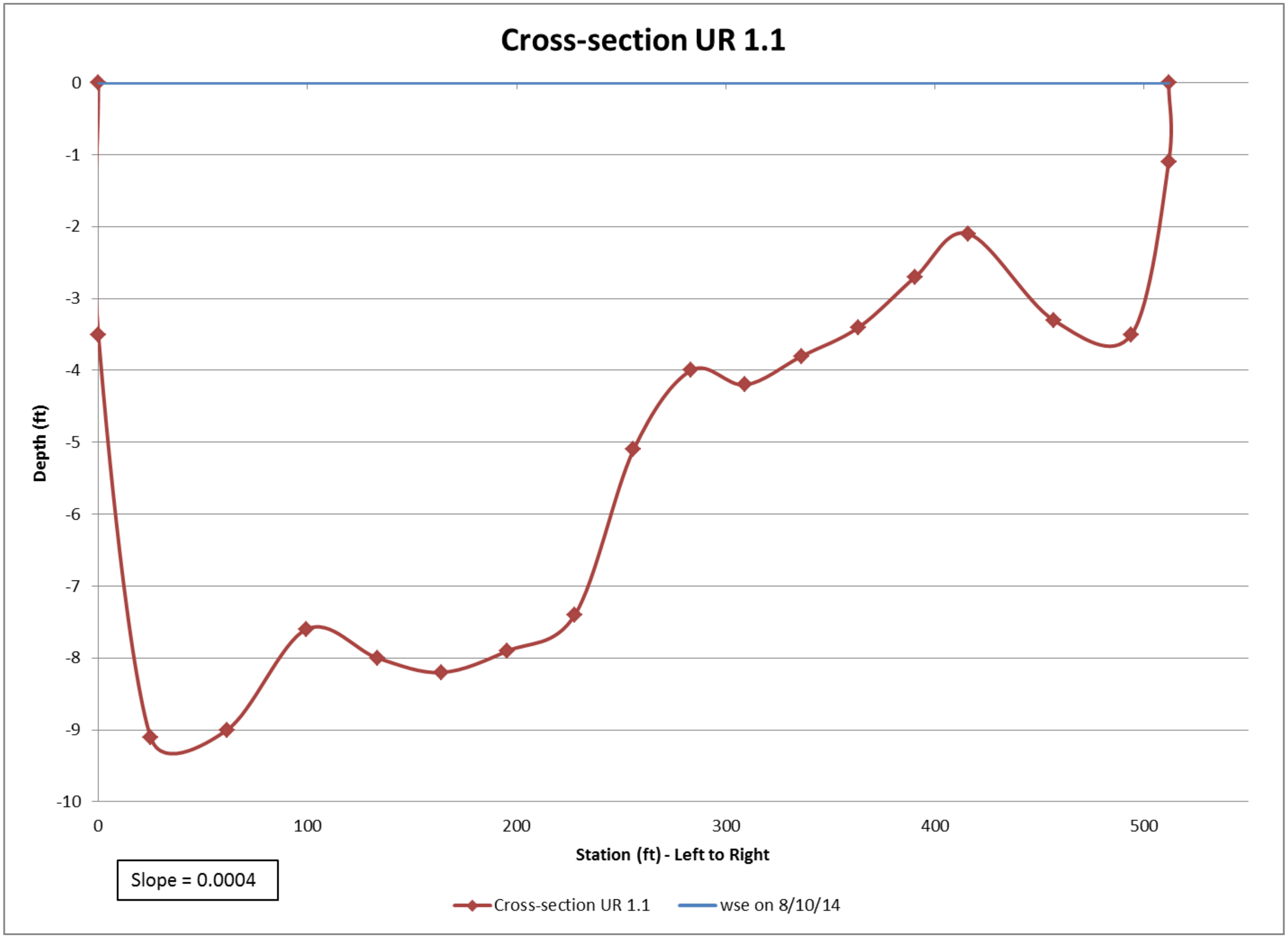

Figure 5.1-10: Cross-section UR 1.1 at PRM 257.9 (Q =- 17,400 cfs at Gold Creek gage).

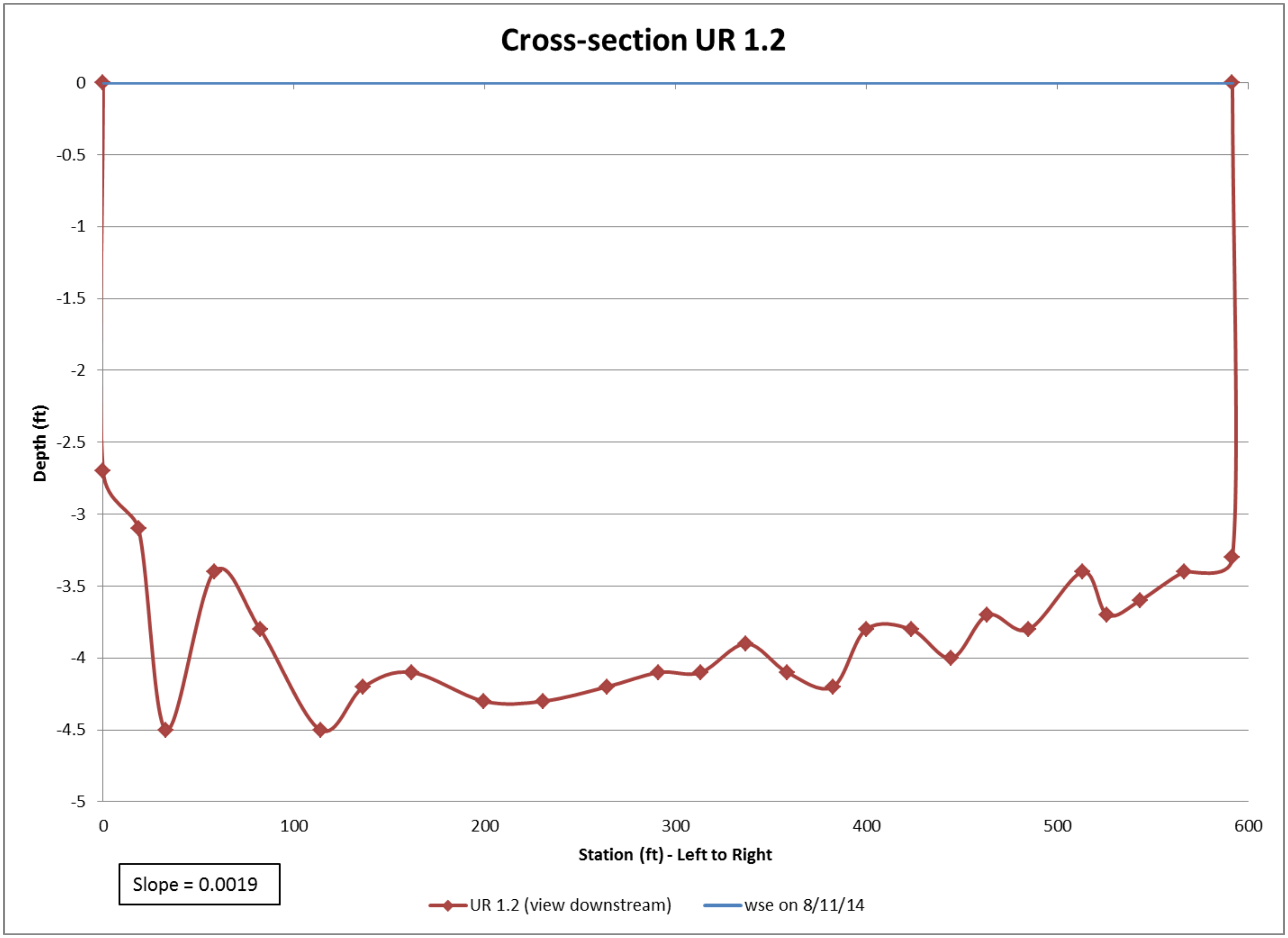

Figure 5.1-11: Cross-section UR 1.2 at PRM 253.4 (Q = 16,700 cfs at Gold Creek gage).

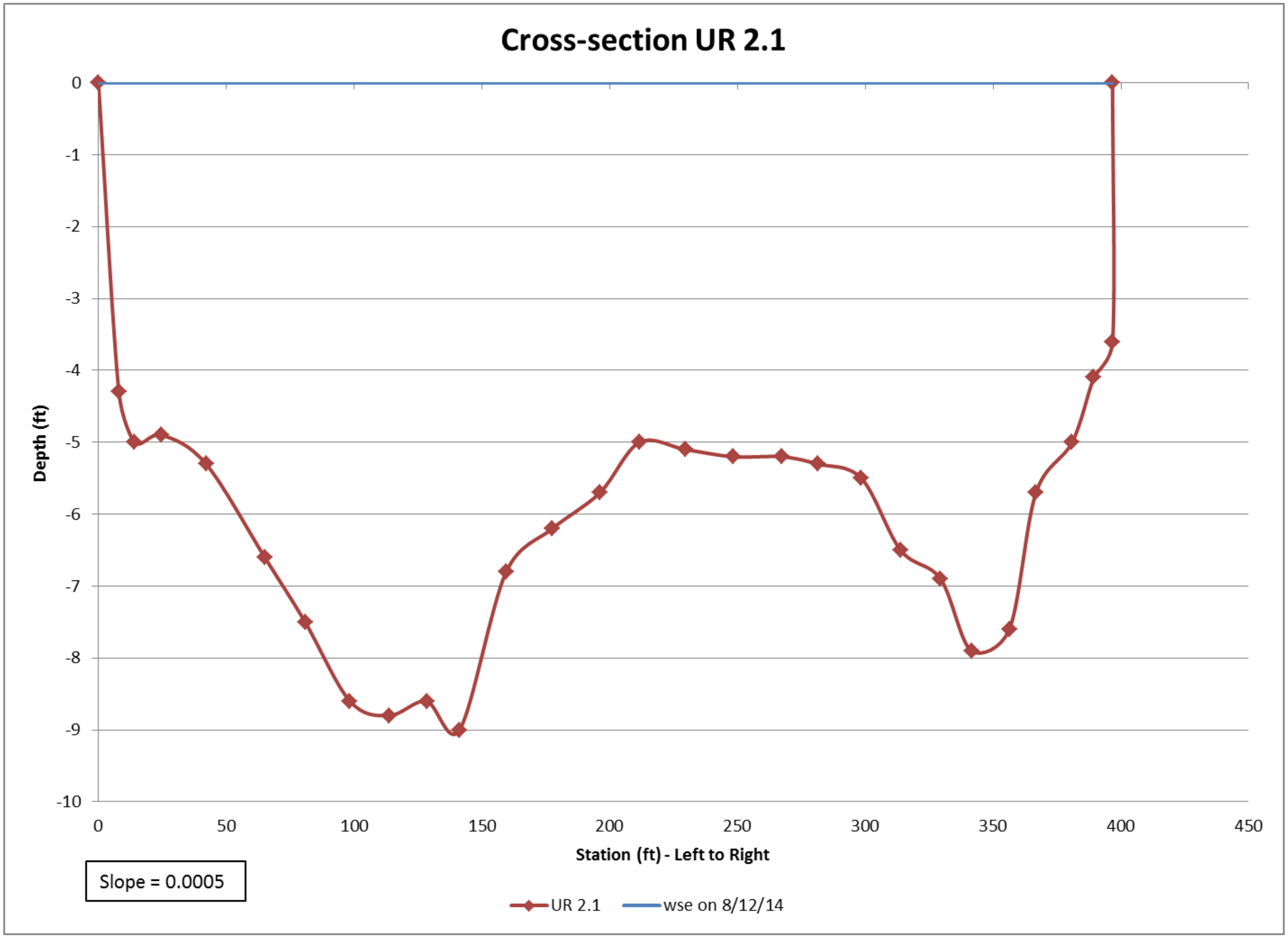

Figure 5.1-12: Cross-section UR 2.1 at PRM 245.4 (Q = 17,000 cfs at Gold Creek gage).

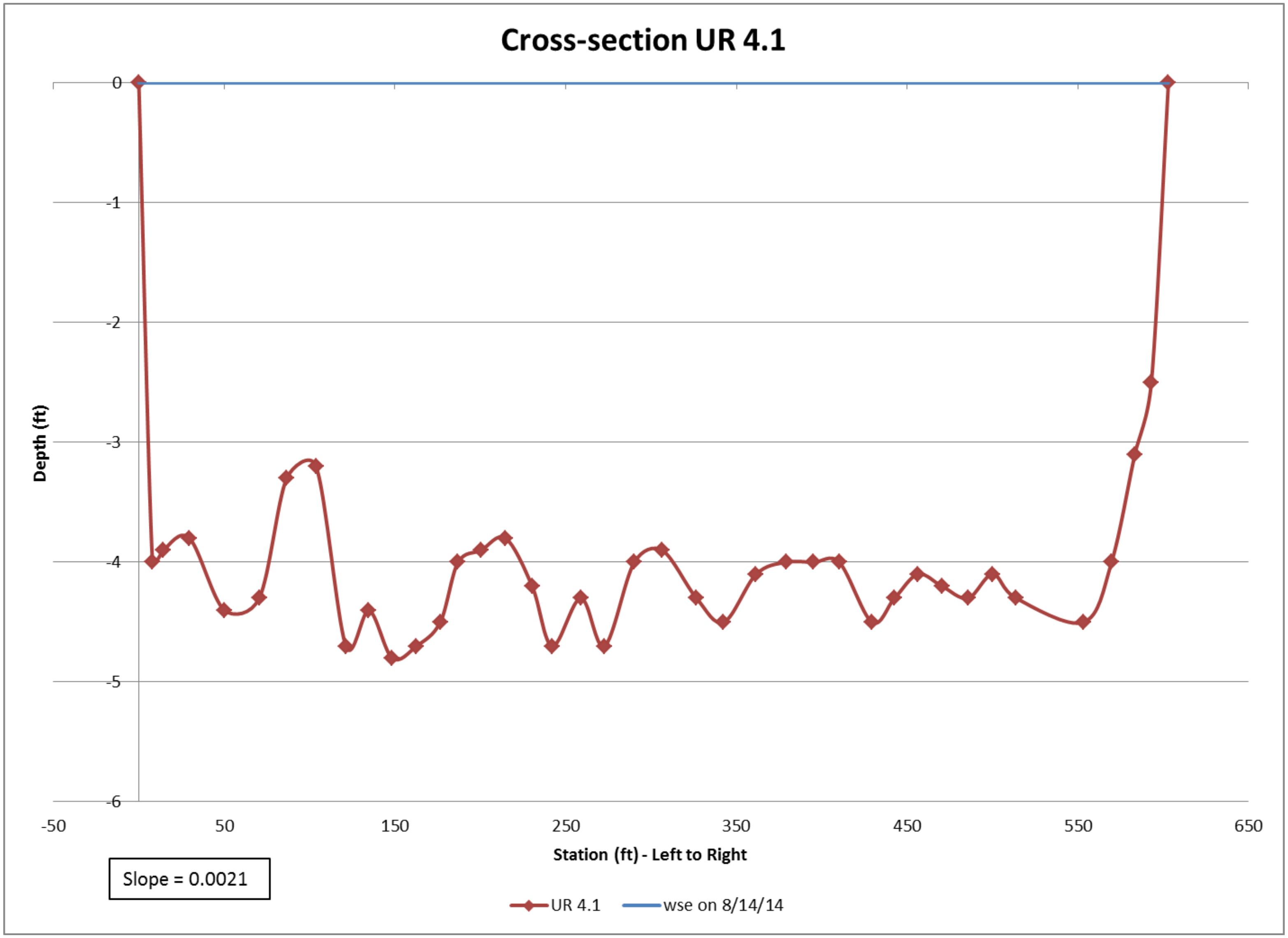

Figure 5.1-13: Cross-section UR 4.1 at PRM 220.7 (Q = 16,800 cfs at Gold Creek gage).

Figure 5.8-1: View upstream Oshetna River from confluence with Susitna River. Clear water evident.

Figure 5.8-2. View upstream of Oshetna River fan at confluence with Susitna River. Helicopter access present upstream and downstream of Oshetna River confluence on Susitna River left.

Figure 5.8-3. View upstream Goose Creek from confluence with Susitna River. Plane-bed channel evident.

Figure 5.8-4. View downstream Goose Creek to confluence with Susitna River. Armored channel evident with large sediment deposition and fan at Goose Creek mouth. Slumping left bank along Goose Creek. Safe landing zone present on Goose Creek fan.

Figure 5.8-5. View upstream Jay creek above Jay Creek confluence with Susitna River. Log jams present in channel. Channel filled-in with sand, gravel, boulder, and large wood deposits.

Figure 5.8-6. Upstream Jay Creek fan, looking upstream Susitna River (right bank) along sheet flow from Jay creek. Safe landing zones present upstream and downstream Jay Creek fan on Susitna River right bank.

Figure 5.8-7. View downstream Susitna River left bank to Kosina River fan. Plane-bed, boulder-cobble channel evident. Safe landing zones present upstream and downstream Kosina River confluence along Kosina fan.

Figure 5.8-8. View downstream Watana Creek towards confluence with Susitna River. Gravel deposits present along Watana Creek right bank.

Figure 5.8-9. View upstream to Watana Creek (Susitna River right bank). Safe landing zones present along Watana Creek fan and floodplain.

Figure 5.8-10. View upstream Deadman Creek. Steep, confined, boulder-dominated channel evident.

Figure 5.8-11. View upstream Susitna River right bank upstream of Deadman Creek fan. Safe landing zones present upstream and downstream of Deadman Creek confluence with Susitna River.

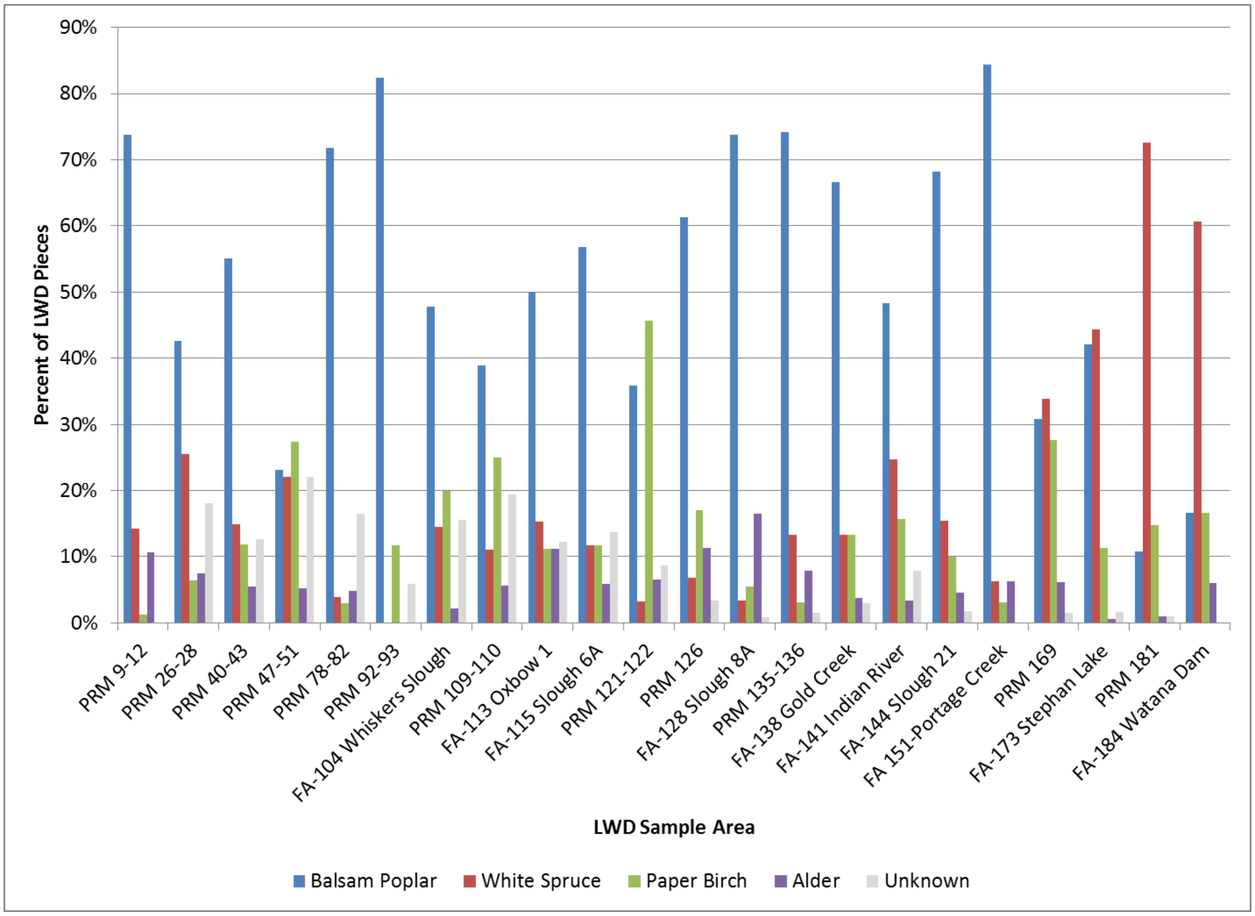

Figure 5.9-1. Large Woody Debris (LWD) by Species, 2013/2014 Field Inventory.

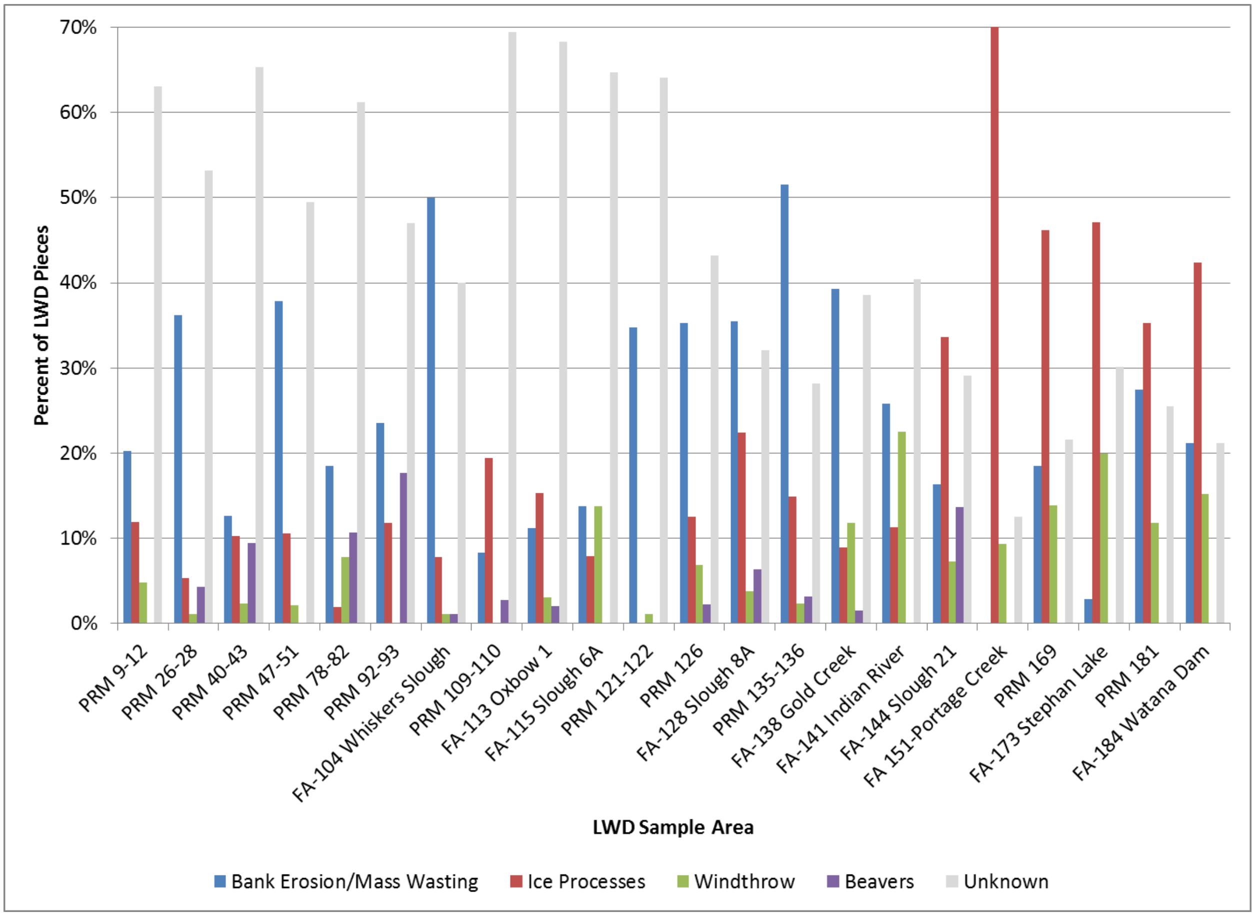

Figure 5.9-2. Large Woody Debris (LWD) by Input Mechanism, 2013/2014 Field Inventory.

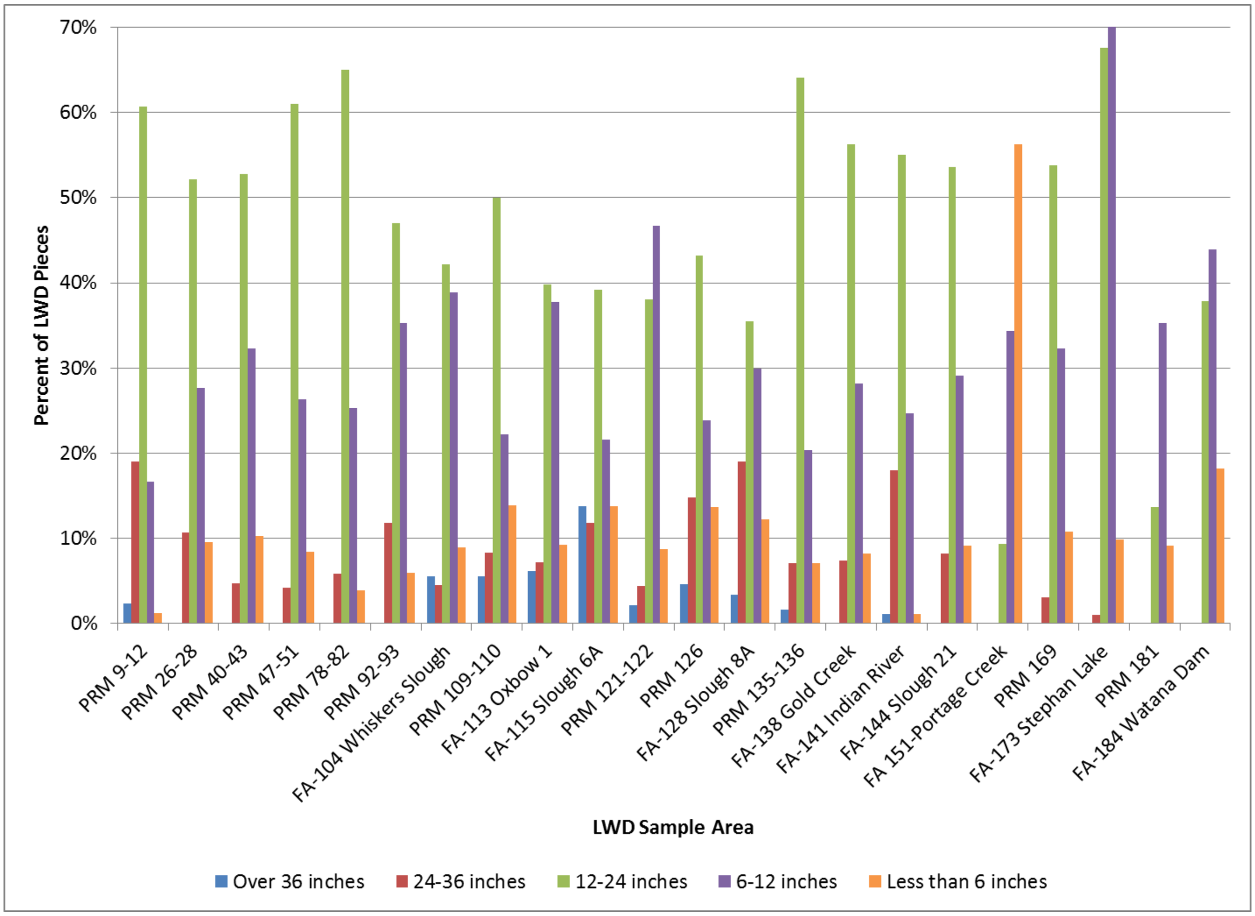

Figure 5.9-3. Large Woody Debris (LWD) by Diameter, 2013/2014 Field Inventory.

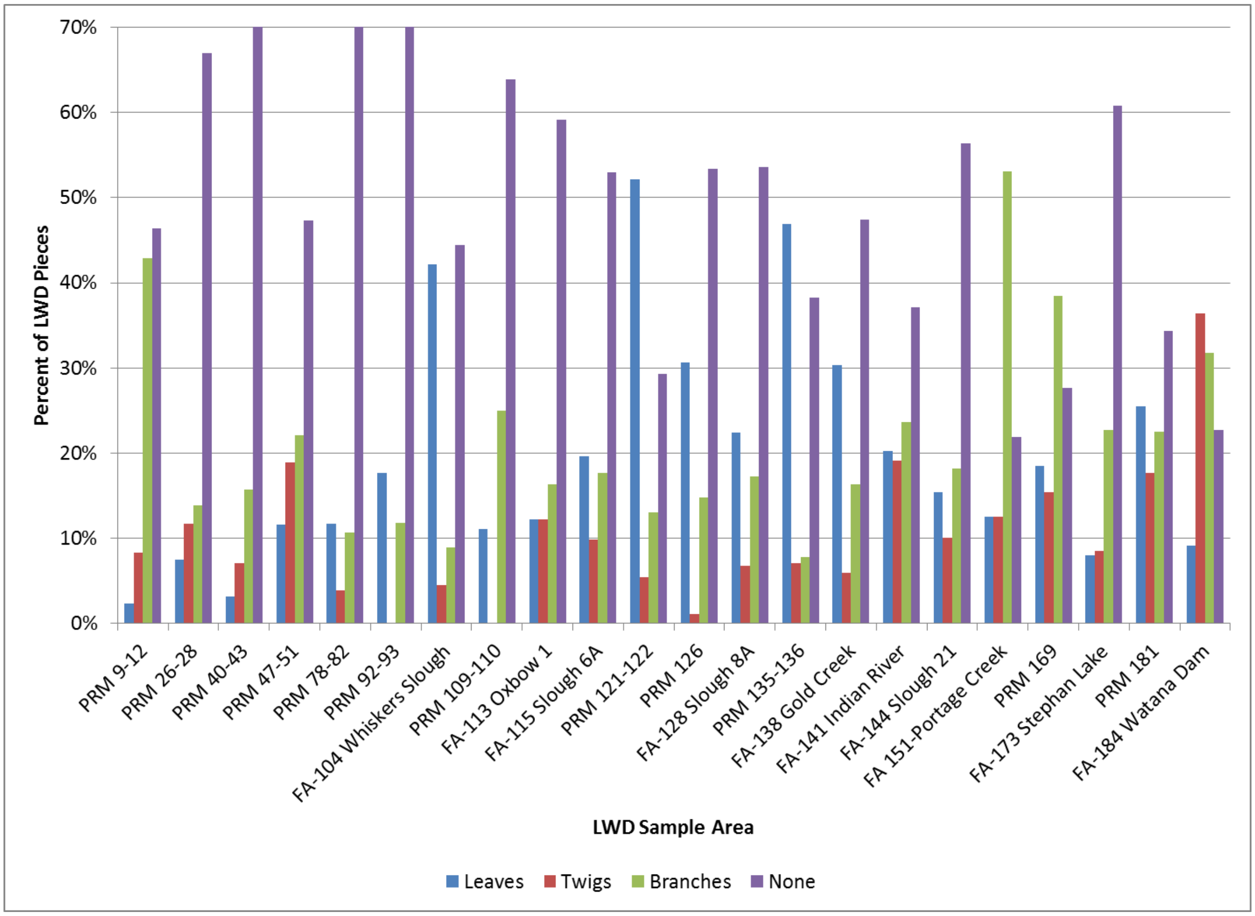

Figure 5.9-4. Large Woody Debris (LWD) by Freshness, 2014 Field Inventory.

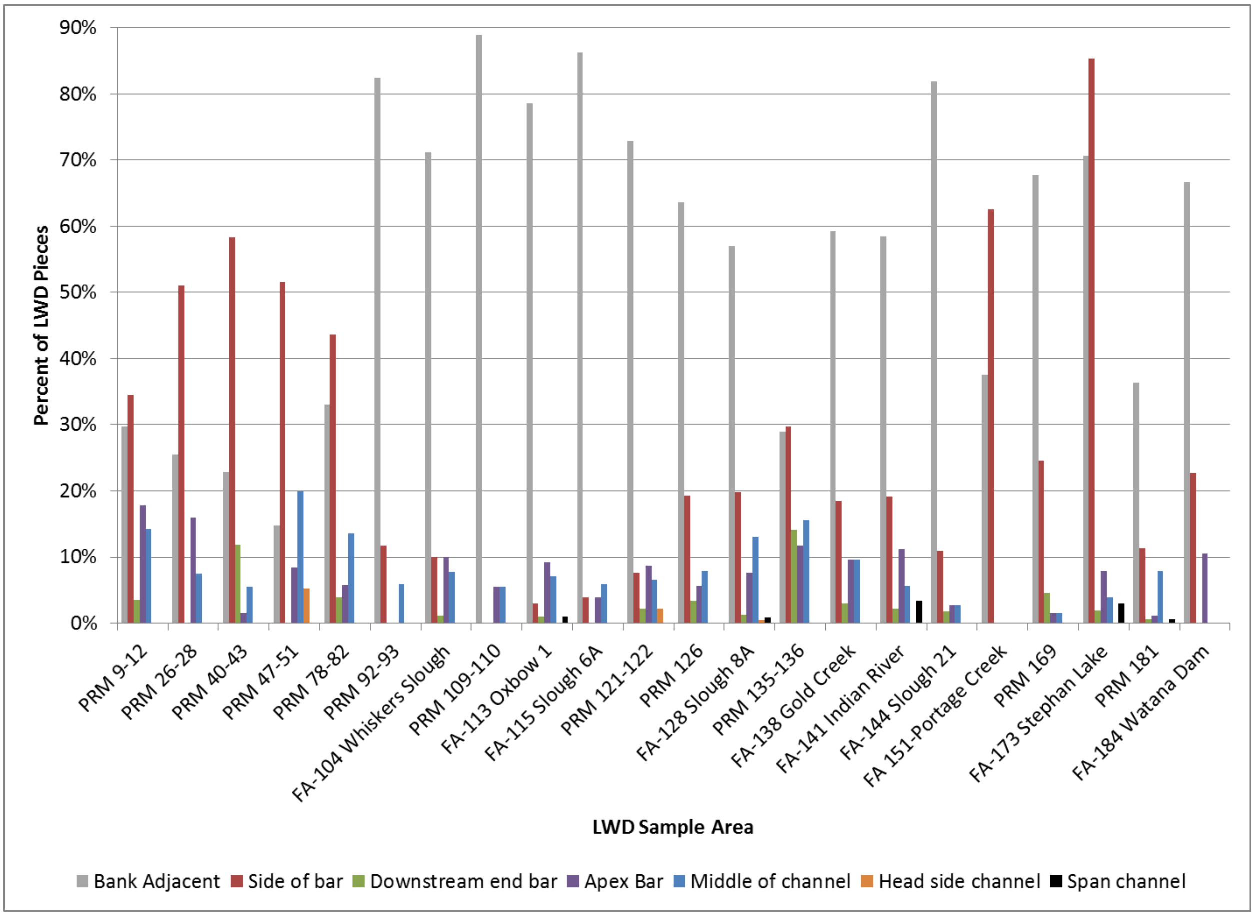

Figure 5.9-5. Large Woody Debris (LWD) by Channel Position, 2014 Field Inventory.

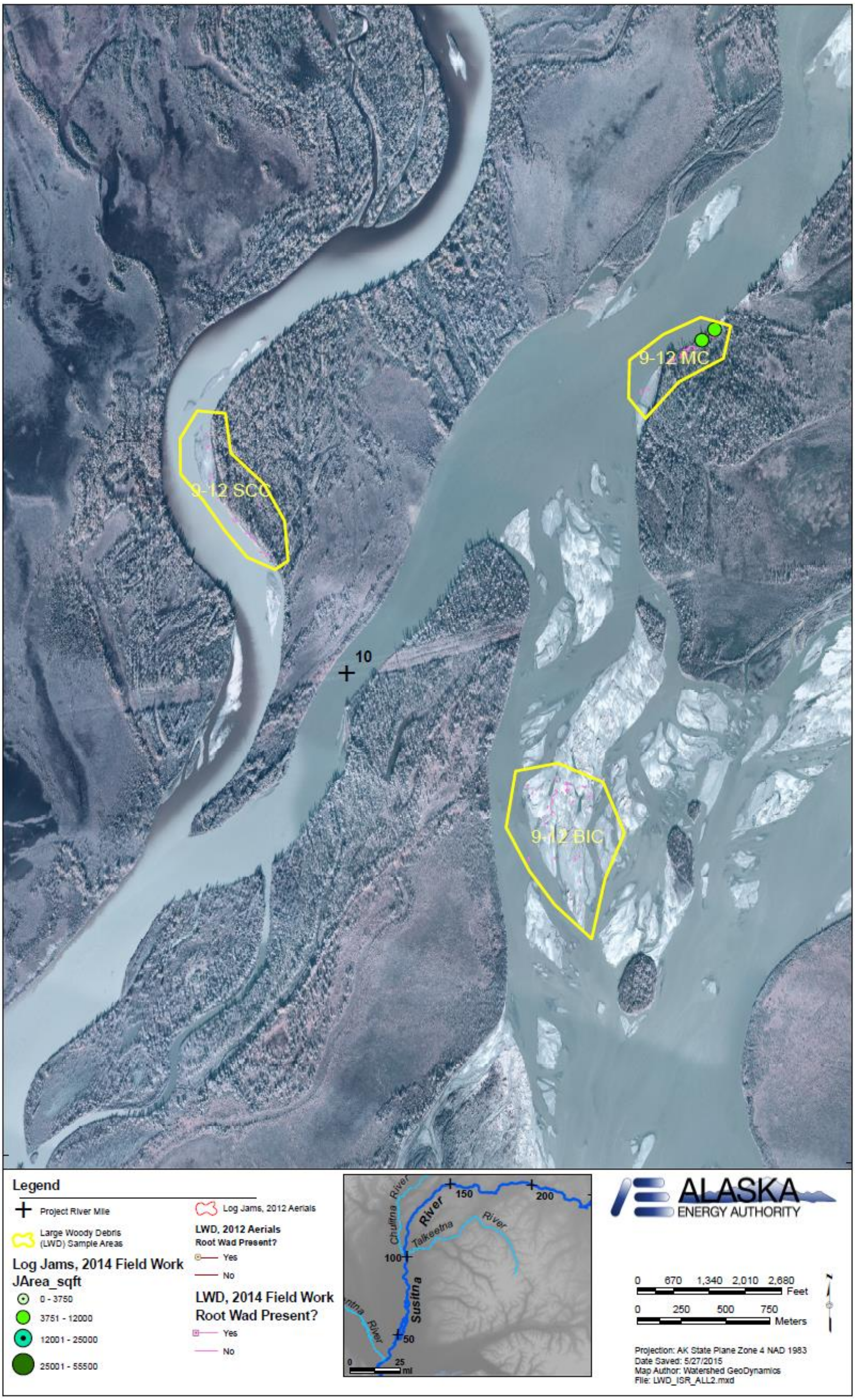

Figure 5.9-6. LWD Sample area PRM 9-12.

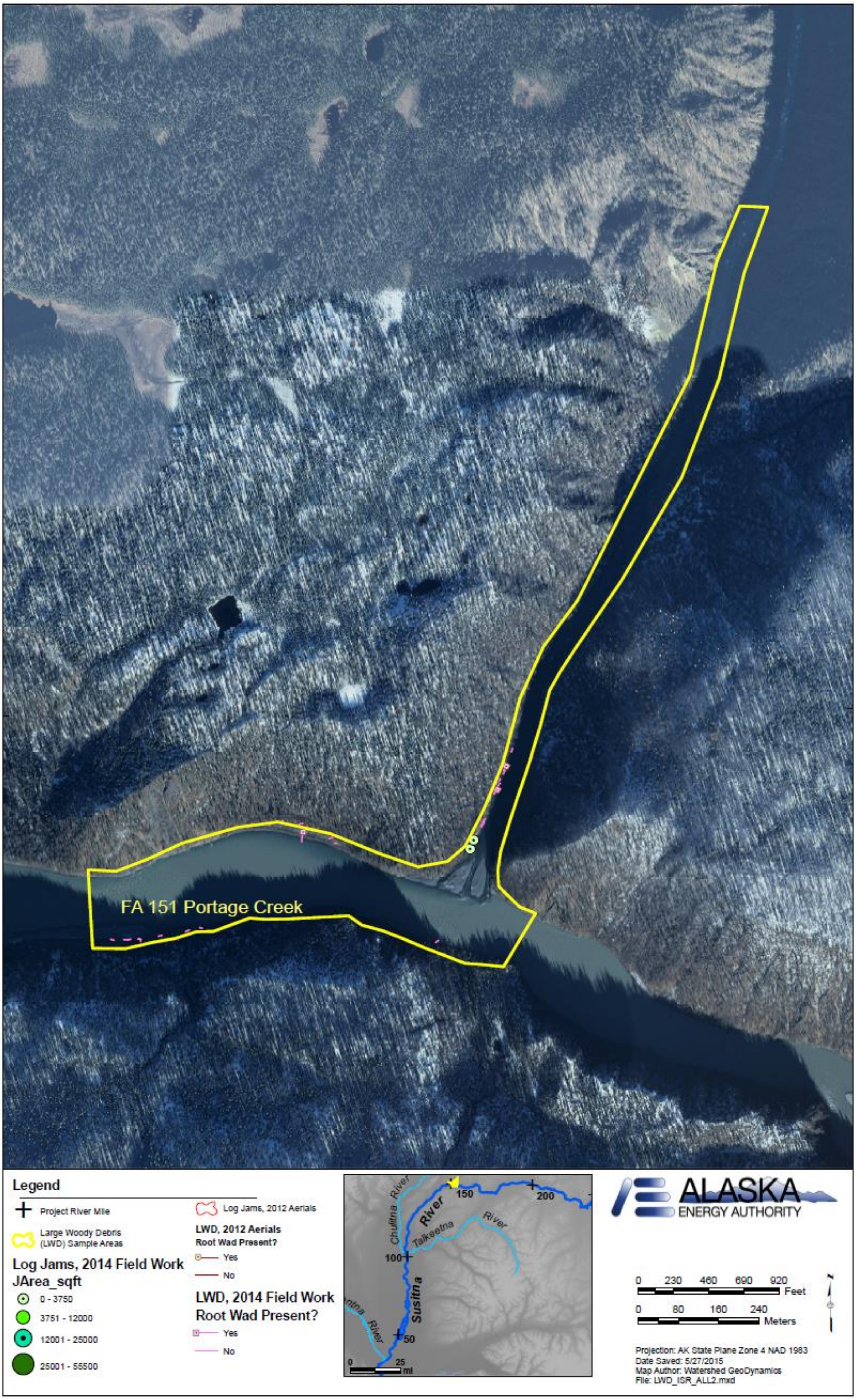

Figure 5.9-7. LWD Sample area FA-151 Portage Creek.

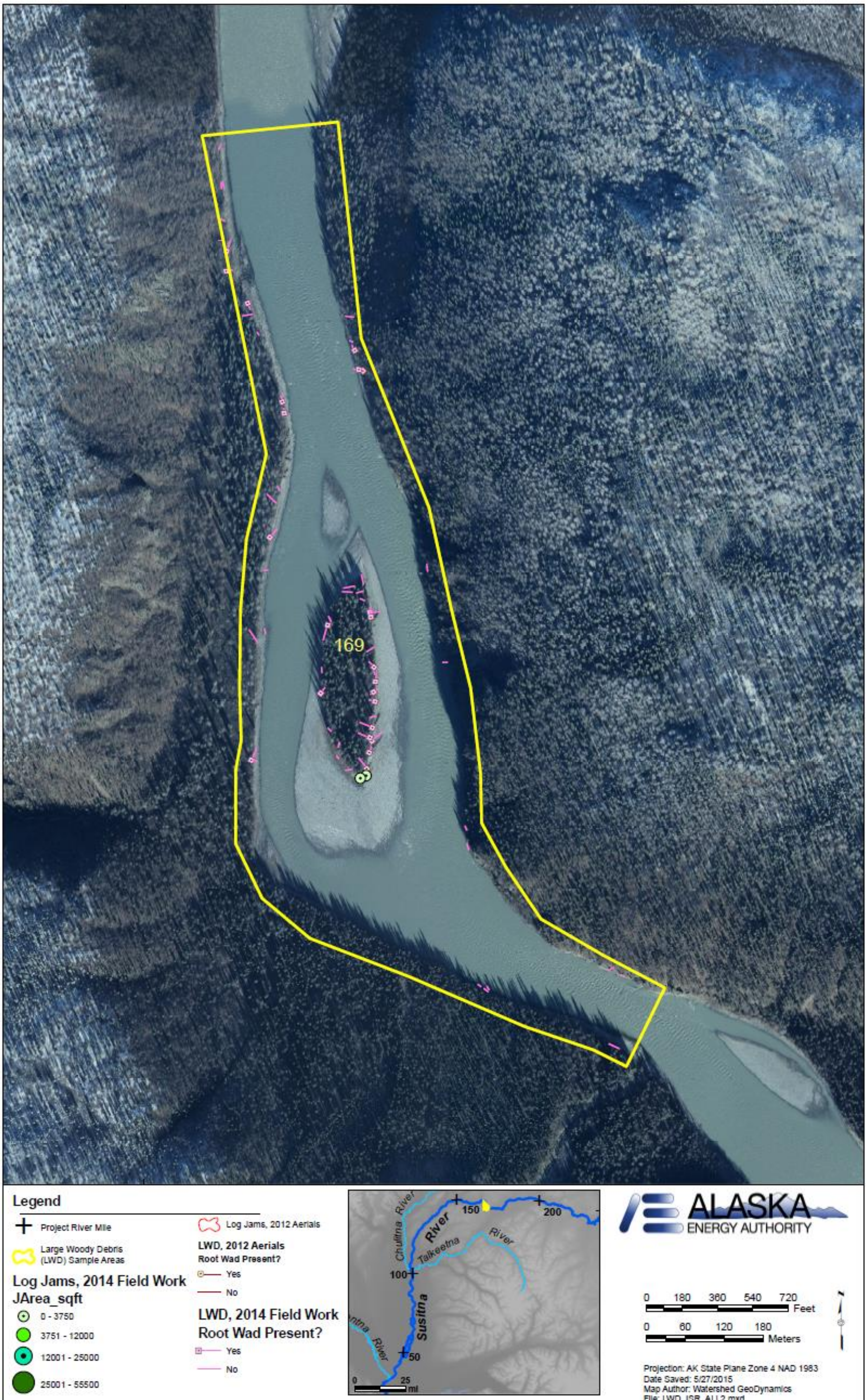

Figure 5.9-8. LWD Sample area PRM 169.

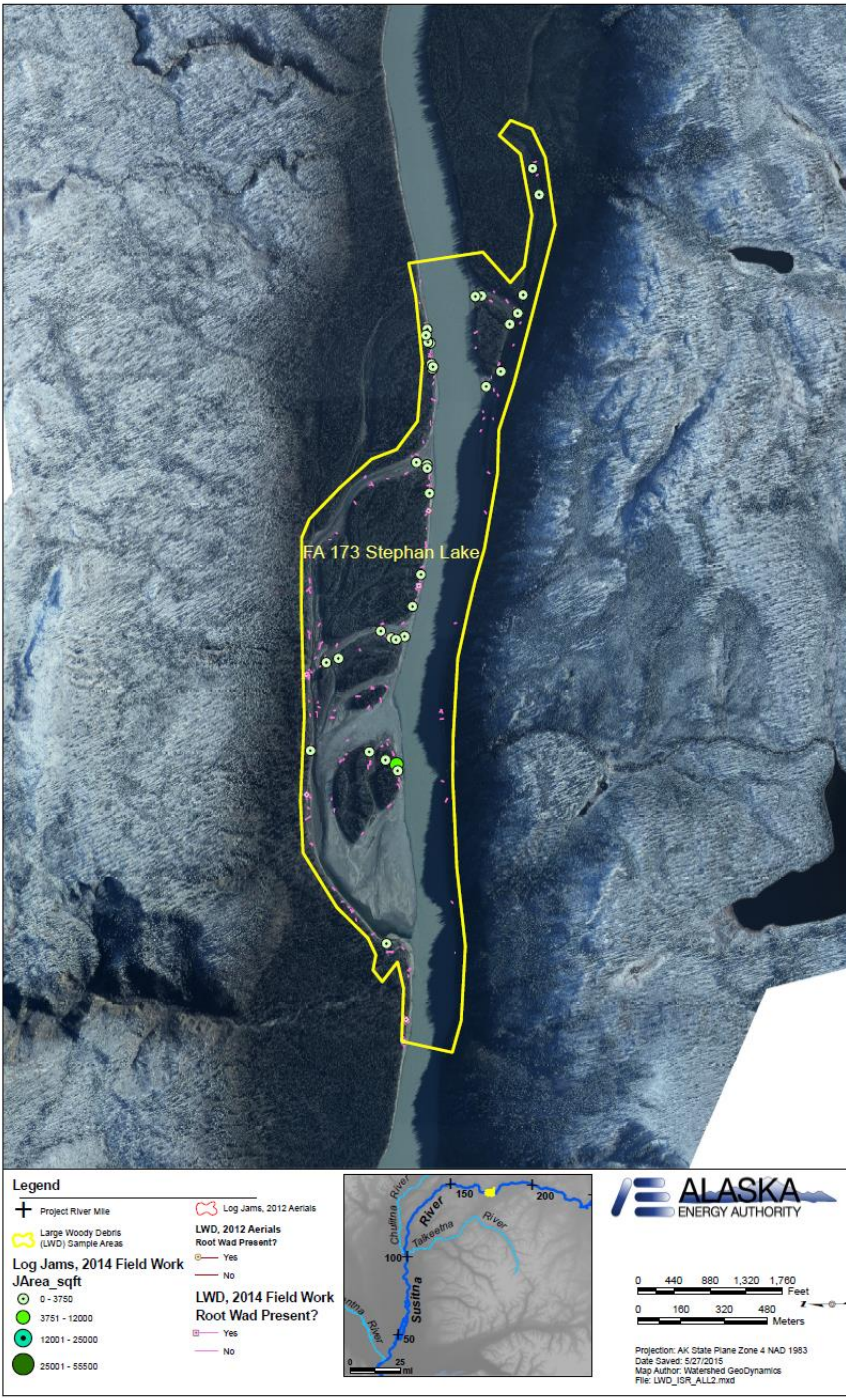

Figure 5.9-9. LWD Sample area FA-173 Stephan Lake Complex.

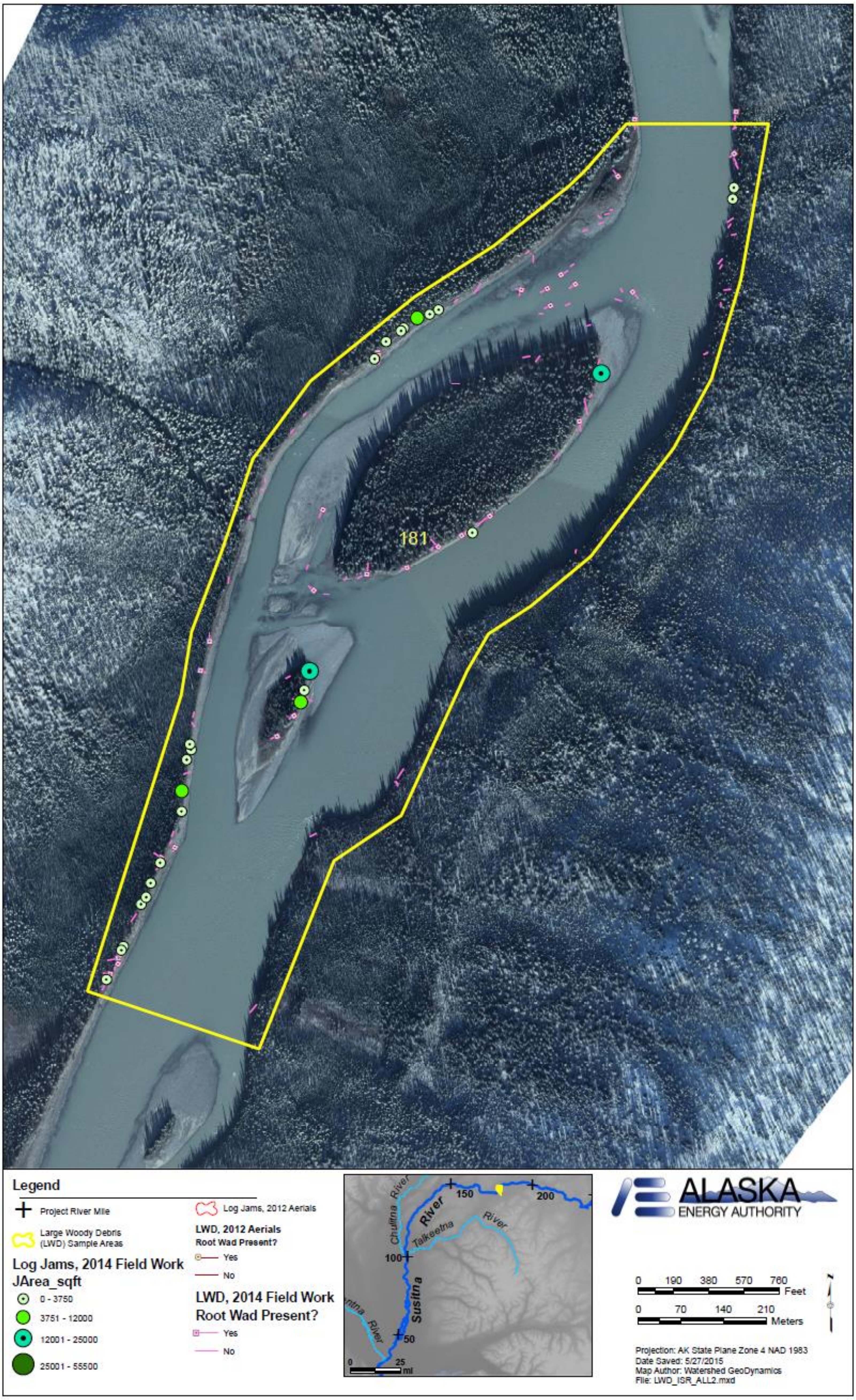

Figure 5.9-10. LWD Sample area PRM 181.

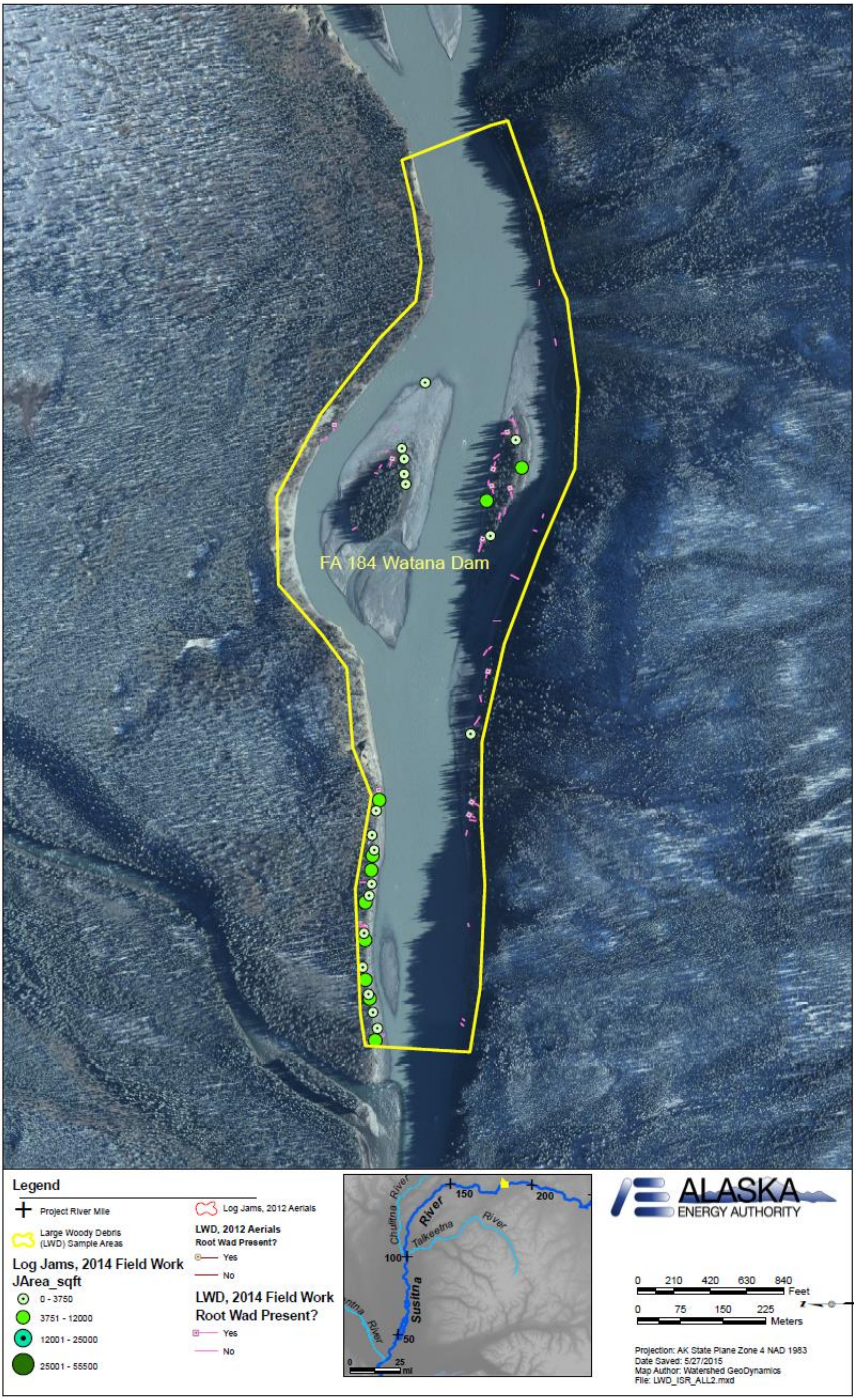

Figure 5.9-11. LWD Sample area FA-184 Watana Dam.

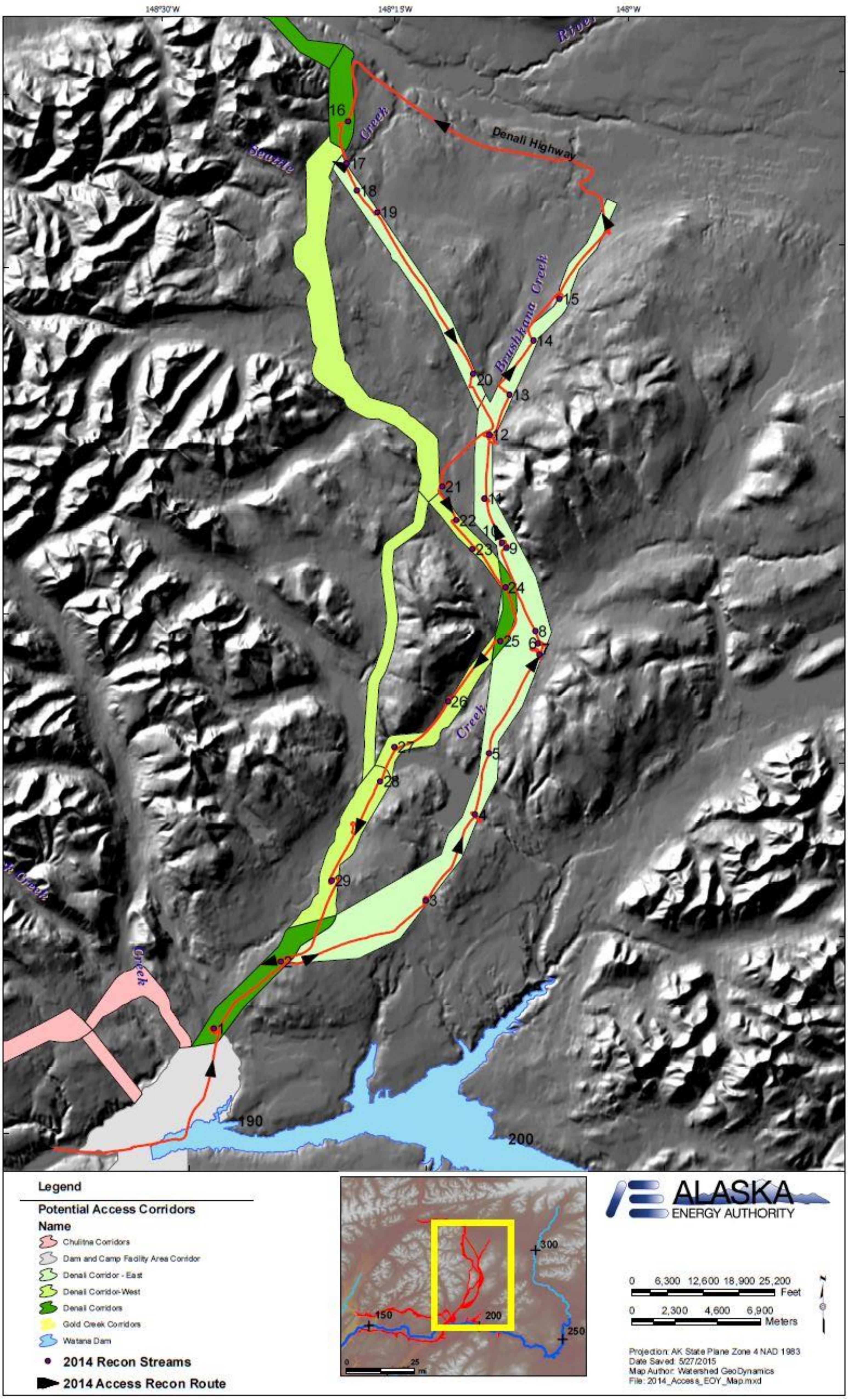

Figure 5.10-1. Map of access corridor reconnaissance route and stream crossings identified during reconnaissance.