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Susitna–Watana Hydroelectric Project
(FERC No. 14241)

Bat Distribution and Habitat Use
Study Plan Section 10.13

Initial Study Report
Part A: Sections 1-6, 8-10

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

ABR, Inc.—Environmental Research & Services

Forest Grove, Oregon

June 2014

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LIST OF ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

Abbreviation	Definition
ADF&G	Alaska Department of Fish and Game
AEA	Alaska Energy Authority
AKNHP	Alaska Natural Heritage Program
APA	Alaska Power Authority
cm	centimeter
CF	compact flash
CIRWG	Cook Inlet Region Working Group
FERC	Federal Energy Regulatory Commission
ft	feet
GB	bravel bar
GIS	geographic information system
ILP	Integrated Licensing Process
ISR	Initial Study Report
km	Kilometer
m	Meter
mi	mile
PRM	Project River Mile
Project	Susitna-Watana Hydroelectric Project
QA/QC	quality assurance and quality control
RSP	Revised Study Plan
SPD	study plan determination
USNO	United States Naval Observatory

1. INTRODUCTION

On December 14, 2012, Alaska Energy Authority (AEA) filed with the Federal Energy Regulatory Commission (FERC or Commission) its Revised Study Plan (RSP) for the Susitna-Watana Hydroelectric No. 14241 (Project), which included 58 individual study plans (AEA 2012). Section 10.13 of the RSP described the Bat Distribution and Habitat Use Study (Bat Study). On February 1, 2013, FERC staff issued its study determination (February 1 SPD) for 44 of the 58 studies, approving 31 studies as filed and 13 studies with modifications. The Bat Study was one of the 31 studies approved with no modifications.

This study evaluates the occurrence of bats and the distribution of habitats used by bats in the study area. Project biologists deployed ultrasonic acoustic detectors and conducted searches for evidence of roosting sites, maternity colonies, and hibernacula to better understand how bats might be affected by the Project. RSP Section 10.13 described the goals, objectives, and proposed methods of data collection regarding bats.

Following the first study season, FERC's regulations for the Integrated Licensing Process (ILP) require AEA to "prepare and file with the Commission an initial study report describing its 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)). This Initial Study Report (ISR) on the Bat Study has been prepared in accordance with FERC's ILP regulations and details AEA's status in implementing the study, as set forth in the FERC-approved RSP (referred to herein as the "Study Plan").

2. STUDY OBJECTIVES

The goal of the Bat Study is to collect baseline data on bats in the Project area to enable the assessment of potential impacts on bats from development of the proposed Project.

The Bat Study objectives are established in RSP Section 10.13.1:

- Assess the occurrence of bats and the distribution of habitats used by bats within the proposed reservoir inundation zone and associated infrastructure areas for the Project.
- Review geological and topographical data to assess the potential for roosting, maternity, and hibernacula sites in the study area.
- Examine suitable geological features (caves, crevices) and human-made structures (buildings, mines, bridges) for potential use by bats as roosting sites, maternity colonies, and hibernacula.

3. STUDY AREA

As established by RSP Section 10.13.3, the bat study area (Figure 3-1) encompasses the proposed reservoir inundation zone, the proposed dam and powerhouse locations, and the associated camp facilities area, but not the access and transmission corridors.

4. METHODS AND VARIANCES IN 2013

The methods for each of the Bat Study components are presented in this section.

4.1. Acoustic Surveys

During the 2013 study season, AEA implemented the acoustic survey methods described in RSP Section 10.13.4 with the exception of variances explained below (Section 4.1.1).

Acoustic surveys of bats employed the use of echolocation detectors to assess bat activity patterns and habitat associations across the study area during May 25–October 7, 2013. Twenty Anabat® SD1 broadband acoustic detectors (Titley Electronics, Ballina, New South Wales, Australia) were deployed to record the ultrasonic sounds produced by echolocating bats (Figure 4.1-1). Scientists use these detectors commonly for passive detection of free-ranging, echolocating bats (O'Farrell et al. 1999). Each detector had a detection range of approximately 20 m (66 ft), with the actual range depending on air temperature, humidity, elevation, and the frequency and intensity of echolocation calls. A sensitivity setting of 6 was used on each detector to minimize reception variability among all detectors. Microphones were housed in waterproof "bat-hats" (EME Systems, Berkeley, California) and were secured to a section of rebar or tree, approximately3–5 ft (~1–1.5 m) above ground level. All associated electronic equipment for the detectors was enclosed in waterproof plastic cases (Pelican Products, Inc., Torrance, California) located below each microphone and a photovoltaic system (GoGreenSolar.com, Placentia, California) was connected to each detector to provide solar power for recharging the batteries.

Sampling sites for the detectors were selected using random points (20 primary and 40 alternative) generated within the study area with a geographic information system (GIS). The random points were stratified by broad habitat type (pond, stream, cliff, upland) based on preliminary water body mapping and cliff mapping prepared for other wildlife and botanical studies (Study 10.14, Surveys of Eagles and Other Raptors, and Study 11.5, Vegetation and Wildlife Habitat Mapping in the Upper and Middle Susitna Basin). The non-pond habitat types were stratified further by forest structure type (closed, open, dwarf, shrub; Table 4.1-1) using the existing vegetation map prepared for the Alaska Power Authority (APA) Susitna Hydroelectric Project in the 1980s (Kreig and Associates 1987) because an updated vegetation map for the current Project was not available in 2013. The forest structure types used in this study were based on the original vegetation classification system created by Viereck et al. (1980) and were adapted to be biologically relevant to bats by recognizing the potential importance of structural complexity on bat activity. Closed structure types were forests with 60–100 percent canopy cover; open structure types included open (25–60 percent) and woodland (10–25 percent) forest types; the dwarf structure had at least 10 percent canopy cover of dwarf forest [defined as trees under 5 m (16 ft) at maturity]; and the shrub structure type comprised at least 25 percent shrub cover and <10 percent forest canopy cover. Within each habitat type, the study team selected one site in each of four vegetation structure types (closed, open, dwarf, shrub). Among habitat types, sampling points were selected within 200 m (656 ft) of a pond for pond habitat; within 200 m (656 ft) of a perennial stream for stream habitat; within 200 m (656 ft) of a cliff for cliff habitat; and all other remaining land as upland habitat. The area of each habitat and forest structure type was measured using GIS. The final sampling locations included eight pond sites, four stream sites, three cliff sites, and five upland sites. Detector stations were placed as close as possible to the primary random points. In several cases, alternative random points were chosen because of inaccurate vegetation classifications or difficult helicopter access at primary points.

At each site, the study team positioned the detector and oriented the microphone to maximize the probability of recording echolocation call sequences (bat passes), based on the specific site characteristics. Data were recorded on 1-GB compact flash (CF) data cards. Detectors were programmed to monitor the period from approximately 1 hour before sunset to 1 hour after sunrise, adjusting the duty cycle periodically, to cover the crepuscular and nocturnal periods when bats are most active (Hayes 1997). The sunset and sunrise times were calculated from the United States Naval Observatory website (USNO 2013) for Talkeetna, where extensive periods of twilight occur after sunset and before sunrise. The study team exchanged the CF cards and checked equipment on June 3–4, 14–15, 26–27; July 16–17, 31; August 11–13, 29; and September 10 and 24, 2013. Sampling covered the spring, summer, and fall seasons, encompassing the periods of parturition, lactation, volancy of young, copulation, and possibly hibernation or migration (Gotthardt and Coray 2005).

4.1.1. Variances

No variances from the acoustic survey methods described in the Study Plan were necessary in 2013. However, the Study Plan implicitly assumed that all lands in the bat study area would be available for sampling in 2013. The lack of ground access to Cook Inlet Regional Working Group (CIRWG) lands in the western portion of the study area prevented acoustic sampling in some areas that would otherwise have been included in the random allocation of sampling points. The study team plans to meet study objectives by sampling on CIRWG lands during the next study season, if available.

4.2. Roost Surveys

AEA implemented the methods for natural and artificial roosts described in the Study Plan with the exception of the variances explained below (Section 4.2.3).

4.2.1. Natural Roosts

The research team used a variety of literature-based and field methods to assess the occurrence of natural structures (caves, cliffs, trees) and their suitability as roost sites, maternity colonies, or hibernacula in the study area. The potential occurrence of caves in the study area was assessed by reviewing geological literature regarding the presence of suitable bedrock (e.g., limestone) conducive to the formation of caves.

During June 28–30, 2013, the survey team conducted an aerial survey by helicopter to examine potential roosting habitats in cliffs and other rock structures. The team evaluated discrete cliff sections that had been identified for Study 10.14, Surveys of Eagles and Other Raptors, by using GIS analysis of aerial photography, digital elevation models, and remote-sensing data on plant biomass (Normalized Difference Vegetation Index, or NDVI). Qualitative suitability scores (Table 4.2-1) were assigned to each cliff section in the field. Where possible, cliff habitats were examined from the ground.

Ground searches of potentially suitable tree roosts (large-diameter snags) also were conducted during June 28–30, 2013. The tree-roost search targeted areas near inactive nests of Bald Eagles (*Haliaeetus leucocephalus*) in the study area and opportunistically surveyed other possible roost trees identified in the field. Forest inventory information was not available to assess the presence of large-diameter dead trees as roosting habitat.

In the fall (October 4–6, 2013), additional areas were surveyed for tree roosts, including areas near previously active Bald Eagle nests that were not accessible earlier in the season. The area between Jay Creek and Watana Creek was surveyed to search for the potential presence of caves in a limestone formation reported by Chapin (1918).

4.2.2. Artificial Roosts

The research team used a combination of office-based and field methods to evaluate human-made structures (buildings, mines, bridges) as roost sites, maternity colonies, and hibernacula in the study area. No bridges were present in the study area, so the search concentrated on buildings. Before beginning the search, permission was requested via letters, emails, and telephone calls for access to building sites on private, federal, and state lands in and near the study area. Permission was obtained for access to 11 of the 16 sites identified.

During August 11–13, 2013, the research team examined 25 structures (e.g., cabins, sheds, outhouses) at those 11 sites for the presence of bats and any signs of use as roost sites or maternity colonies. All structures were examined externally and some were examined internally, but not all structures were accessible because they were locked or barricaded. The building search was coordinated with the historical property surveys for the Cultural Resources Study (see ISR Study 13.5). Several mining claims were identified within the bat study area; however, all of those claims involved surface-mining methods (e.g., placer), which do not directly provide roosting habitat, so they were not inspected if no structures were present.

During the fall roost search (October 4–6, 2013), all of the structures surveyed in mid-August were reexamined, along with another site for which permission had not been granted previously. The fall search was focused on potential use of the structures as hibernation sites.

Both artificial roost searches included structures (summer = 19, fall = 20), that were located outside of, but near, the study area. Those additional structures were included because artificial structures potentially suitable for bat roosting were scarce in the study area and permission could not be obtained to examine all of the buildings in the study area.

4.2.3. Variances

Access to CIRWG lands, which encompassed most of the western end of the study area, was not possible in 2013. The lack of ground access to CIRWG lands prevented searches of potential roosting habitat (both natural and artificial) that would otherwise have been included in the roost surveys, resulting in a variance from the Study Plan. The research team was unable to perform ground searches on CIRWG lands at four Bald Eagle nest trees and one limestone area near the northern flank of Mount Watana. The research team was also unable to search two artificial structures on CIRWG lands, both of which were located outside of the Project area. Although the access restrictions resulted in a variance of these methods in 2013, AEA will meet study objectives by conducting these searches on CIRWG lands in the next study season, if access to CIRWG lands is granted.

Additionally, the study team expanded roost searches to include nearby areas outside of the study area due to the scarcity of suitable roosting structures within the study area. This additional search effort expanded the scope proposed in the Study Plan and constitutes a variance.

4.3. Data Management and Analysis

AEA implemented the data management and analysis methods as described in the Study Plan with no variances.

To maintain quality assurance and quality control (QA/QC), acoustic monitoring equipment was checked and data cards were downloaded into a database approximately every 1–2 weeks to minimize data loss from equipment failures or other factors, such as damage by other animals. The study lead checked the database periodically for inconsistencies and errors and the entire database was proofed again for errors before data analysis began. All data is stored on a network server with frequent backups to prevent loss of data.

Interpretation of bat acoustic data is subject to several important caveats. The number of "bat passes" recorded is an index of relative activity, but may not correlate directly with numbers of individual bats in the area being monitored (i.e., 10 bat passes may represent a single bat recorded 10 different times or 10 different bats recorded, each with a single pass; Hayes 1997). Activity also may not be proportional to abundance because of variability attributable to (1) detectability (loud vs. quiet species); (2) species call rates; (3) migratory vs. foraging call rates; and (4) attraction to or avoidance of the sampling area by bats (Kunz et al. 2007; Hayes et al. 2009). However, interpreted properly, the index of relative activity can provide useful information on bat use by characterizing temporal (hourly, nightly, and seasonal) and spatial (location) patterns of bat activity (Parsons and Szewczak 2009).

The echolocation sequences recorded by the detectors were analyzed using *Anabat CFC Read* and *AnalookW* software (Corben 2011) to detect and quantify bat passes. A bat pass was defined as a search-phase echolocation sequence of ≥2 echolocation pulses with a minimum pass duration of 10 milliseconds (ms) within each sequence, separated by >1 second (Gannon et al. 2003). The standard metric for quantifying bat activity is the number of bat passes/detector-night (Kunz et al. 2007). The within-night activity rates (hours relative to sunset) observed in this study were compared with a probability distribution generated from 5,000 bootstrap simulations

(Varian 2005). For each simulation, the observed hourly activity rate was recorded randomly within each night and a new average was calculated for each hour. Calls in May and October were so few that they were excluded from the hours-relative-to-sunset analysis. Nonparametric (Kruskal–Wallis) tests were used for statistical comparison of the spatial and habitat differences among detectors. Kruskal–Wallis tests also were used to compare activity rates among stations and months for periods when all 20 detectors were operational. Only June–September data were used for monthly comparisons because of the short duration of sampling conducted in late May and early October. GIS software was used to measure the minimum distances from each detector station to seven landscape features: ponds, streams, rivers, cliffs, and cliffs with roost quality index scores of 1, 2, and 3. Correlation between the mean number of bat passes and the minimum distances to these landscape features was tested using Spearman's rank correlation. SPSS version 18.0 analytical software was used for all statistical comparisons, assuming statistical significance at $\alpha = 0.05$ (SPSS 2009).

4.3.1. Variances

No variances from the data management and analysis methods described in the Study Plan occurred in 2013.

5. RESULTS

Data developed in support of this study are available for download at http://gis.suhydro.org/reports/isr:

- ISR_10_13_BAT_Data_ABR.gdb/ISR_10_13_BAT_Detector_Sites;
- ISR_10_13_BAT_Sonogram.jpg;
- ISR_10_13_BAT_Acoustic_Data.xlsx;
- ISR_10_13_BAT_Station_Locs.xlsx;
- ISR_10_13_BAT_Acoustic_and_Habitat.xlsx;
- ISR_10_13_BAT_Data_ABR.gdb/ISR_10_13_BAT_Habitat_Buffers;
- ISR_10_13_BAT_Data_ABR.gdb/ISR_10_13_BAT_Cliff_Habitat;
- ISR_10_13_BAT_Artificial_Roost.xlsx.

5.1. Acoustic Surveys

5.1.1. General Bat Activity

In 2013, acoustic monitoring at all 20 detector stations resulted in a total of 2,767 potential detector-nights (number of detectors multiplied by number of nights; Table 5.1-1). Across all 20 detector stations, usable data were recorded on 2,660 detector-nights (96.1 percent). Data losses resulted from CF card failures (G7, August 20–28; G9, May 25–June 2 and June 12–26), flooding during breakup of river ice (G18, May 25–June 12), an electrical problem (G1, July 9–14), and damage caused by bears (G7, September 18–October 6; G15, September 16–24; G18, August 6–10; G19, September 20–28) and porcupines (G7, September 5–11).

Bat activity was detected at 17 (85 percent) of the 20 locations sampled (Figure 5.1-1). Overall, 621 bat passes were recorded during the entire sampling period. All calls were identified as having been made by little brown bats (*Myotis lucifugus*) based on their acoustic characteristics (Figure 5.1-2), which were similar to those described by Ober (2006). Activity across all stations and seasons averaged 0.23 ± 0.04 (mean ± SE) bat passes/detector-night (Table 5.1-2).

5.1.2. Temporal Comparisons

5.1.2.1. Seasonal Activity

Bat activity varied substantially throughout the sampling period (Figure 5.1-3; Table 5.1-2). Despite the variability in monthly activity, statistical differences were not detected among entire months (June–September; H = 2.51; df = 3; P = 0.474), probably because of low statistical power. Bat activity was recorded only sporadically until the end of June, then peaked in July (0.47 ± 0.14 mean passes/detector-night; Table 5.1-2), declined in August (0.22 ± 0.04 mean passes/detector-night), and increased again in September (0.29 ± 0.10 mean passes/detector-night). Most stations recorded the greatest amount of activity in July (8 of 20 stations; 40 percent), followed by August (5 of 20 stations; 25 percent) and September (3 of 20 stations; 15 percent). Very little activity was detected in late May and early October (0.01 ± 0.01 mean passes/detector-night for each). The spatial distribution of bat activity (number of stations with any activity across the study area) by month followed a slightly different trend, with the most widespread detections occurring in August (15 of 20 stations; 75 percent), followed by July (11 of 20 stations; 55 percent), and September (7 of 20 stations; 35 percent).

5.1.2.2. Nightly Activity

Bat activity within nights (expressed as mean number of bat passes per station per hour) varied substantially among hours of the night during all months (Figure 5.1-4), with peak activity generally occurring between 1 and 3 hours after sunset. No bat activity was recorded in the hour before sunset or the hour after sunrise. In June, activity peaked 1–2 hours after sunset, when significantly greater activity occurred (mean passes/site/hour = 0.05; $P < 0.01$). In July, activity peaked 2–3 hours after sunset, with significantly less activity in the first hour after sunset (mean passes/station/hour = 0; $P < 0.05$), and significantly more activity 2–3 hours after sunset (mean passes/station/hour = 0.27; $P < 0.01$). In August, activity peaked 1–2 hours after sunset, when significantly more activity occurred (mean passes/station/hour = 0.08; $P < 0.01$). In September, activity peaked within 2–3 hours after sunset, with significantly more activity during that time period (mean passes/station/hour = 0.09; $P < 0.01$), and significantly less activity in the middle of the night, 4–5 hours after sunset (mean passes/station/hour = 0.002; $P < 0.05$) and 7–8 hours after sunset (mean passes/station/hour = 0.002; $P < 0.05$).

5.1.3. Spatial Comparisons

5.1.3.1. Activity Among Stations

Bat activity differed significantly among sampling stations (H = 274.16; df = 19; $P < 0.001$). Station G6 recorded the greatest total amount of activity (2.02 ± 0.54 mean passes/detector-night), more than twice as much activity as the next most active stations (G3, 0.78 ± 0.38 mean passes/detector-night; G16, 0.74 ± 0.32 mean passes/detector-night; Table 5.1-2). The next three stations in descending order of activity were G13 (0.24 ± 0.13 mean passes/detector-night), G10 (0.21 ± 0.06 mean passes/detector-night), and G19 (0.19 ± 0.05 mean passes/detector-night). No bat activity was detected at three stations during the entire sampling period (G5, G15, G20; Figures 5.1-1 and 5.1-4).

The elevation of detector stations above sea level ranged from 1,680 ft to 2,425 ft (Table 5.1-3). Bat activity was not correlated with elevation (Spearman's $\rho = -0.008$, $P = 0.972$), but bat activity tended to peak at higher elevations later in the sampling period. Although the test statistic for correlation of elevation with the month of peak activity did not meet the criterion for statistical significance of $\alpha = 0.05$, it was very close (Spearman's $\rho = 0.474$, $P = 0.054$), indicating a strong relationship.

5.1.3.2. Activity in Relation to Habitat and Forest Structure

Bat activity varied significantly among the four broad habitat types sampled (pond, stream, cliff, and upland; $H = 8.58$; $df = 3$; $P = 0.035$). Detector stations in stream habitats recorded the greatest level of activity (0.59 ± 0.16 mean passes/detector-night; Table 5.1-4), followed by pond habitats (0.24 ± 0.07 mean passes/detector-night), cliff habitats (0.15 ± 0.05 mean passes/detector-night), and upland habitats (0.004 ± 0.003 mean passes/detector-night). Bat activity at both stream and cliff sites peaked in July, whereas activity at pond sites peaked in September (Figure 5.1-6).

Bat activity did not differ among the four types of forest structure sampled (open, closed, dwarf, and shrub; $H = 5.00$; $df = 3$; $P = 0.175$). Detector stations in closed forest-structure types recorded the greatest level of activity (0.77 ± 0.19 mean passes/detector-night; Table 5.1-5), followed by shrub (0.08 ± 0.02 mean passes/detector-night), open (0.03 ± 0.01 mean passes/detector-night), and dwarf (0.002 ± 0.002 mean passes/detector-night). Activity levels in the closed and shrub types peaked in July, whereas activity in open forests remained consistently low during the entire study (Figure 5.1-7).

The bat study area totaled 33,280 acres (Table 5.1-6). Stratified according to the broad habitat types sampled, the study area comprised these proportions: Upland = 65.8 percent; Cliff = 22.9 percent; Stream = 8.2 percent; and Pond = 3.1 percent (Figure 5.1-8). Stratified by forest-structure type, the non-water-body portion of the study area comprised these proportions: Open = 44.5 percent; Closed = 19.5 percent; Shrub = 15.1 percent; and Dwarf = 5.8 percent (Figure 5.1-9).

None of the minimum distances measured to the seven landscape features (ponds, perennial streams, rivers, any cliff, and cliff-roost quality scores of 1, 2, and 3; Table 5.1-3) were significantly correlated with mean bat passes per detector-night (Spearman's ρ; $P > 0.05$).

5.2. Roost Surveys

5.2.1. Natural Roosts

The 102 discrete cliff sections identified before the field season as potential cliff-roosting habitat were categorized into four groups during the June 28–30 aerial survey: four sections were not suitable, 49 sections were of low suitability (quality score = 1), 33 sections were of moderate suitability (quality score = 2), and 16 sections were of high suitability (quality score = 3) (Table 4.2-1; Figure 5.2-1). Besides cliffs, four areas near Bald Eagle nests were examined for large-diameter snags suitable for use by roosting bats. Project researchers searched for natural caves in a limestone formation reported by Chapin (1918) between Jay Creek and Watana Creek, but no caves were found. Despite the widespread presence of bats revealed by acoustic monitoring, the study team was not successful in locating any roosting locations, maternity colonies, or hibernacula in natural sites during the surveys in 2013.

5.2.2. Artificial Roosts

The study team obtained permission for access to 10 sites during the August roost search and to 11 sites during the October search, but was unable to secure permission to visit five other sites of interest (Table 5.2-1; Figure 5.2-2). The study team obtained permission for access to 11 of the 16 sites of interest, including the two sites within the study area (RS 04 and RS 09; Table 5.2-1). During August 11–13, 2013, the team investigated 25 structures (e.g., cabins, sheds, outhouses) at 10 sites for the presence of bats and any sign of use as roost sites or maternity colonies. During October 4–6, 2013, the team searched the same sites and structures as in August, plus one additional site and structure (RS 16; Table 5.2-1) for the presence of bats and any signs of use as hibernacula. Of the 26 structures surveyed, 15 were considered to be suitable for roosting by bats; however, no roosting bats or sign of roosting bats were found at any of the sites or within any of the structures during either survey. Two of the 16 sites visited were located within the bat study area (Table 5.2-1). The potential pool of candidate sites was expanded outside the study area because of the rarity of suitable structures in the study area. Despite the widespread presence of bats revealed through acoustic monitoring, no roosting locations, maternity colonies, or hibernacula were located in artificial sites during the surveys in 2013.

6. DISCUSSION

The ecology of bats in Alaska remains largely unknown, especially in the Interior (Parker et al. 1997, AKNHP 2013). Bats were not included in the APA Project studies in the 1980s, so data on the occurrence of bats in the upper Susitna River drainage were lacking and their status in the Project area was essentially unknown at the time this study began. Kessel et al. (1982) reported a single observation of a bat during their bird and mammal surveys in the early 1980s.

6.1. Acoustic Monitoring

Activity of little brown bats was widespread across the study area, occurring from the western end of the Dam and Camp Facilities Area almost all the way to Goose Creek near the eastern edge of the proposed reservoir inundation zone. Only three of the 20 detector stations in the study area did not record any bat activity between late May and early October 2013.

The overall activity rates found in this study would be considered low for locations outside of Alaska (compared to the Lower 48 states) and no other studies are available for comparison in Interior Alaska. Parker et al. (1996) documented highly variable acoustic rates (average calls per night) of bat activity in riparian (81.0), old-growth (6.0), clearcut (2.0) and second-growth (0.03) habitats in Southeast Alaska. Those rates are difficult to compare with the data from this study because of timing differences (their study monitored during June–August), the presence of four additional species in their study, and habitat differences between Southeast Alaska and the study area.

Similarly, Lausen (2006) conducted acoustic monitoring in the Northwest Territories, Canada, but those rates also are difficult to compare with this study because Lausen only sampled during the peak of bat activity for 22 total days in July and August; four additional species were present in that study area; and the study design and objectives of that study differed from this study. Nevertheless, an approximate mean of 20 bat passes per detector- night over the duration of that study was derived from their data (Table 6 in Lausen 2006). Assuming that each of the five species in Lausen's study was equally represented, the activity rates in that study would be similar to the most active station in this study.

Slough and Jung (2008) conducted extensive bat research, including acoustic monitoring, over a 12-year period in the Yukon, Canada. The acoustic activity they documented included three additional species and they only reported total bat passes from sporadic, single-night surveys (not including nights with zero detections). Similar to this study, they found tremendous variability among detector sites, with up to 454 total bat passes in a single night (Table 2 in Slough and Jung 2008). The greatest total activity from a single station in a single night in this study was 63 bat passes, recorded at station G6.

6.1.1. Temporal Comparisons

6.1.1.1. Seasonal Activity

Bats were detected during every month of this study, from late May to early October. Parker et al. (1997) observed a similar pattern in bat activity near Fairbanks and suggested that bats in Interior Alaska may not travel far to hibernate. Substantial variability was evident in the monthly activity rates in this study, but those differences were not statistically significant, probably because of low statistical power. More stations peaked in July than in any other month and overall bat activity in that month was roughly twice the activity detected in August and 1.5 times the activity in September. The periodic pulses of bat activity in June suggested that, although bats were present, foraging conditions may not have been favorable until late June or July. Insect prey would have to be abundant during the few dark hours available for foraging in June or else the animals would be forced to save energy by remaining in torpor. Alternatively, the lack of consistent activity until late June and July may reflect the arrival of migrant bats.

From July to August, bat activity decreased by more than half before increasing again near the end of September. McGuire et al. (2009) documented hyperphagia (greatly increased feeding) that occurred in early August during prehibernation swarming to build energy stores for reproduction and hibernation at a site in southern Canada (45 degrees North latitude). The difference in latitude may account for an earlier onset of increased activity in the Bat Study Area (62 degrees North latitude) in July. It is also possible that the increased activity in July was related to the compressed period of darkness available for foraging, forcing bats to search for and consume prey constantly and efficiently. The pulse of activity near the end of September may indicate prehibernation behavior, premigratory behavior, or migrating bats moving through the study area.

Activity at four of the bat stations peaked in September, including station G3, which also recorded bat activity in October. Those four stations were also among the higher elevation sites, ranging from 240 ft to 562 ft higher than the lowest site. Although this difference in elevation may not seem great, the effect of elevation on bat distribution is more pronounced at high-latitude locations such as Alaska (Parker et al. 1997). Mean activity rates tended to peak later in the year at higher elevation sites. Although not significant in a strictly statistical sense, the difference may be biologically significant. Bats may have been active at higher elevation sites later in the year to take advantage of cooler temperatures to maximize energy savings during torpor or simply to follow the availability of insect prey.

6.1.1.2. Nightly Activity

Bat activity was recorded between sunset and sunrise. Most of the activity likely occurred during periods of low light or darkness, but the study team did not specifically measure the amount of light and the calculation of sunset time did not account for topography. Some bat activity was detected within the first hour after sunset during relatively bright periods, as has been observed at more northerly latitudes in Alaska (Parker et al. 1997). The majority of bat activity observed in this study occurred within 2–4 hours after sunset, likely the darkest hours of the night, for most months (June – August). The limited data recorded in June, when the fewest hours of darkness were available, suggested that bats were most active 1–2 hours after sunset, when darkness can minimize predation risk from avian species (Rydell and Speakman 1995) and reduce competition from avian competitors (Speakman et al. 2000). Significantly fewer bat calls were detected in the first hour after sunset in July, also suggesting an avoidance of foraging during times during relatively light periods. With increasing hours available for foraging in September, a bimodal distribution (two peaks) in the pattern of activity became evident, which also has been documented in other studies (Kunz 1973, Erkert 1982, Taylor and O'Neil 1988, Maier 1992, Hayes1997).

6.1.2. Spatial Comparisons

6.1.2.1. Activity Among Stations

Bat activity recorded among stations varied considerably. Station G6 recorded three times more activity than the station with the next greatest activity (G3). This station (G6) was located adjacent to a pool of slow-moving water in an unnamed stream course between Deadman and Watana creeks, which appeared to provide excellent foraging opportunities. In addition, Station G6 was located less than 1,500 ft upstream from a "highly suitable" section of cliff. Some of the metrics generated from this study were certainly affected by the large number of bat calls recorded at this site, but this single station did not exert undue influence on the overall trends observed across all 17 detector stations at which bats were detected, except in the habitat and forest structure analyses. The results of those analyses appeared to be driven by station G6, due to the small sample size ($n = 20$; df = 3).

6.1.2.2. Activity in Relation to Habitat and Forest Structure

The greatest amount of bat activity in this study occurred in habitat types associated with water (streams and ponds). Similarly, Slough and Jung (2008) documented the highest activity in riparian and lacustrine habitats in the Yukon. This result is expected because riparian habitats are known to provide important foraging and drinking areas for insectivorous bats (Grindal et al. 1999). It is likely that cliff habitats provide the major source of roosting opportunities in the study area, due to the paucity of other roost structures (caves, trees, human-made structures). Detectors located in and near cliff habitats recorded an intermediate level of bat activity, while detectors located in upland habitat types recorded the least amount of bat activity among habitat types. In view of the apparent lack of suitable roost trees, upland habitats probably do not provide many resources needed by bats.

The mean activity levels of bats detected among the habitat types sampled in this study were inversely proportional to their extent on the landscape. Pond and stream habitats composed only 11.3 percent of the total study area acreage, but represented 84.3 percent of all recorded bat activity. Most of the remaining activity (15.2 percent) occurred in cliff habitats, which constituted 22.9 percent of the study area acreage.

The mean activity rates of the little brown bats detected in this study were not influenced significantly by forest structure type. Little brown bats are considered to be foraging generalists because they have the ability to glean insects from slow-moving water, to fly at intermediate speeds through forested habitats, and also to employ aerial pursuit (Adams 2003). Studies of little brown bats and morphologically and ecologically similar species have produced mixed results when evaluating the effect of habitat structural complexity (i.e., clutter) on bat activity. Brigham et al. (1997) reported lower bat activity rates in highly cluttered habitats, whereas Jung et al. (2012) found increased bat activity in more structurally heterogeneous (i.e., more cluttered) environments and Brigham and Sleep (2003) reported no significant relationship between bat activity and clutter. In this study, bats were most active in the closed forest structure type, which was the most complex or cluttered habitat. The rate in that forest structure type was driven largely by the single station that recorded the most bat activity during the entire study (G6). Dwarf forest provided few resources needed by bats within the study area, judging from the lowest activity rate recorded among all habitat and forest structure types. Despite the high acreage of the open forest structure type (44.5 percent) in the study area, detectors located in open forests recorded only 3.4 percent of the overall bat activity.

6.2. Roost Surveys

6.2.1. Natural Roosts

The most likely natural roosting habitats available in the bat study area are the cracks and crevices in the extensive cliffs along the Susitna River. Almost half (48 percent) of the 102 cliff sections mapped along the Susitna River and its major tributaries in the study area were classified as moderately or highly suitable roosting habitat. Little brown bats are widely known to use rock crevices as day roosts (Barbour and Davis 1969; Adams 2003; Lausen and Barclay 2006; Foresman 2012) in the Lower 48 states. A study of bats in the Yukon documented only a few natural roosts in trees or rock crevices, including a rock crack in Miles Canyon on the Yukon River near Whitehorse, which served as a maternity colony for little brown bats; rock crevices above Pine Lake; and behind the exfoliating bark of a fire-killed white spruce (*Picea glauca*) (Slough and Jung 2008). Few trees were found in the bat study area in 2013 that were considered to provide suitable roosting habitat and no bats were found roosting behind the bark of those trees.

In addition to cliffs and trees, the study team searched for limestone formations in and near the study area in an attempt to locate caves, but none were found. The available sources of geologic data for the study area contained conflicting information about the presence of limestone, which has not been resolved at this writing. The preliminary geologic map being produced for the Project (see ISR Study 4.5, Geology and Soils Study) may provide new insights regarding potential cave locations (M. Bruen, Geology and Soils Study Lead, personal communication).

6.2.2. Artificial Roosts

The structures searched in and near the bat study area included buildings associated with seasonal mining or hunting camps, old trapper cabins from the 1930s, and modern, well-maintained cabins. Although more than half (58 percent) of the structures examined were considered to have potential as roost sites, no bats or bat sign were found at any of the structures. Several owners of cabins above tree-line (at Clarence Lake) stated that they had never seen bats at their cabins in the decades they have owned those properties. While it is possible that bats escaped detection during the artificial roost searches in this study, nearly all structures were surveyed twice. Hence, given the paucity of buildings in the bat study area and their apparent lack of use as roosts, it is probable that bats are using natural roost sites in the study area.

Most roost sites documented in the Yukon by Slough and Jung (2008) were maternity colonies in buildings and the vast majority of roosts reported to the Alaska Department of Fish and Game (ADF&G) in Southcentral Alaska have been in buildings (D. Tessler, ADF&G, personal communication). Because of the much greater likelihood of detecting bats in structures visited frequently by humans, however, it is difficult to evaluate the proportional use of artificial roosts in relation to natural roosts.

7. COMPLETING THE STUDY

[Section 7 appears in the Part C section of this ISR.]

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9. TABLES

Table 4.1-1. Categorization of Acoustic Detector Stations by Habitat and Forest Structure Types, 2013.

Station	Habitat Type	Forest Structure Type
G1	Pond	–
G2	Pond	–
G3	Pond	–
G4	Pond	–
G5	Upland	Shrub
G6	Stream	Closed
G7	Pond	–
G8	Upland	Dwarf
G9	Stream	Open
G10	Pond	–
G11	Upland	Open
G12	Pond	–
G13	Cliff	Closed
G14	Cliff	Open
G15	Upland	Dwarf
G16	Pond	–
G17	Upland	Closed
G18	Stream	Shrub
G19	Cliff	Shrub
G20	Stream	Dwarf

Table 4.2-1.Quality Scores for Potential Cliff-Roosting Habitat.

Quality Score	Description	Number (%) of Cliff Sections Identified in Study Area
0	Not suitable: no potential for bat roosts; e.g., unvegetated mud slope with no holes, cracks, or crevices.	4 (3.9%)
1	Low suitability: no or few vertical and/or horizontal cracks or crevices, shallow cracks approximately <2 cm deep[1], vegetation may block access.	49 (48.0%)
2	Moderate suitability: moderate number of vertical and/or horizontal cracks or crevices present, cracks approximately 2 cm–0.5 m deep, no vegetation blocking access.	33 (32.4%)
3	High suitability: large numbers of vertical and/or horizontal cracks or crevices present, cracks >0.5 m deep, no vegetation blocking access.	16 (15.7%)

Notes:

1. Similar size requirement for roost site in trees from Crampton and Barclay (1998).

Table 5.1-2. Number and Percentage of Nights Surveyed by Acoustic Detector Stations in 2013.

Station	Number of Nights in Sampling Period	Number of Nights Actually Surveyed	Percentage of Nights Surveyed
G1	139	133	95.7
G2	139	139	100
G3	139	139	100
G4	139	139	100
G5	139	139	100
G6	142	142	100
G7	136	101	74.3
G8	140	140	100
G9	137	113	82.5
G10	140	140	100
G11	138	138	100
G12	140	140	100
G13	140	140	100
G14	139	139	100
G15	140	131	93.6
G16	136	136	100
G17	136	136	100
G18	136	112	82.4
G19	136	127	93.4
G20	136	136	100
Total	2,767	2,660	96.1

Table 5.1-2. Bat Activity (Bat Passes per Detector-Night) by Station and Month, 2013.

	May			June			July			August			September			October			Total		
Station	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]
G1	0	–	11	0	–	30	0	–	25	0.10	0.07	31	0	–	30	0	–	6	0.02	0.02	133
G2	0	–	11	0	–	30	0	–	31	0.03	0.03	31	0	–	30	0	–	6	0.01	0.01	139
G3	0	–	11	0	–	30	0.03	0.03	31	0.10	0.05	31	3.43	1.68	30	0.17	0.17	6	0.78	0.38	139
G4	0	–	11	0	–	30	0	–	31	0.19	0.11	31	0	–	30	0	–	6	0.04	0.02	139
G5	0	–	11	0	–	30	0	–	31	0	–	31	0	–	30	0	–	6	0	–	139
G6	0	–	11	0.20	0.14	30	5.84	2.23	31	2.23	0.72	31	1.03	0.36	30	0	–	9	2.02	0.54	142
G7	0	–	8	0	–	30	0.23	0.09	31	0.05	0.05	22	0	–	10	–	–	0	0.08	0.03	101
G8	0	–	10	0	–	30	0	–	31	0	–	31	0.03	0.03	30	0	–	8	0.01	0.01	140
G9	–	–	0	0	–	13	0.10	0.07	31	0.03	0.03	31	0	–	30	0	–	8	0.04	0.02	113
G10	0	–	10	0	–	30	0.03	0.03	31	0.26	0.13	31	0.67	0.23	30	0	–	8	0.21	0.06	140
G11	0	–	10	0	–	30	0	–	31	0.03	0.03	31	0	–	30	0	–	6	0.01	0.01	138
G12	0	–	10	0	–	30	0.13	0.08	31	0	–	31	0.03	0.03	30	0	–	8	0.04	0.02	140
G13	0	–	10	0.03	0.03	30	0.71	0.55	31	0.32	0.13	31	0	–	30	0	–	8	0.24	0.13	140
G14	0	–	9	0	–	30	0.03	0.03	31	0.06	0.04	31	0.07	0.07	30	0	–	8	0.04	0.02	139
G15	0	–	10	0	–	30	0	–	31	0	–	31	0	–	21	0	–	8	0	–	131
G16	0.11	0.11	9	0.83	0.64	30	1.55	1.25	31	0.65	0.20	31	0.20	0.12	30	0	–	5	0.74	0.32	136

	May			June			July			August			September			October			Total		
Station	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]
G17	0	–	9	0	–	30	0	–	31	0.03	0.03	31	0	–	30	0	–	5	0.01	0.01	136
G18	0	–	2	0.06	0.06	18	0.10	0.05	31	0.04	0.04	26	0	–	30	0	–	5	0.04	0.02	112
G19	0	–	9	0	–	30	0.48	0.13	31	0.29	0.14	31	0	–	21	0	–	5	0.19	0.05	127
G20	0	–	9	0	–	30	0	–	31	0	–	31	0	–	30	0	–	5	0	–	136
Total	0.01	0.01	181	0.06	0.03	571	0.47	0.14	614	0.22	0.04	606	0.29	0.10	562	0.01	0.01	126	0.23	0.04	2,660

Notes:

1. $\bar{x}$ = Mean bat activity
2. SE = Standard error of mean
3. n = Number of detector-nights used in analysis

Table 5.1-3. Elevation and Minimum Distances to Water Bodies and Cliffs, by Station, 2013.

		Minimum Distance (ft)						
Station	Elevation (ft)	Pond	Stream[1]	River	Cliff Quality Score > 0	Cliff Quality Score = 1[2]	Cliff Quality Score = 2[3]	Cliff Quality Score = 3[4]
G1	2,362	0	1,086	2,408	6,724	9,988	6,724	7,629
G2	2,425	97	3,478	3,487	10,384	13,065	10,384	10,655
G3	2,242	140	1,589	3,568	8,961	12,198	8,961	10,364
G4	2,230	31	1,856	3,170	1,676	8,460	1,676	8,777
G5	2,388	1,477	4,004	7,432	3,506	5,787	3,506	3,517
G6	1,829	2,899	12	5,906	1,417	1,417	7,380	6,910
G7	2,047	441	1,657	4,447	2,309	2,309	7,874	7,787
G8	2,042	4,651	1,519	10,663	5,694	5,694	18,765	10,108
G9	1,869	3,010	2	21,533	4,715	7,468	4,715	21,353
G10	2,031	0	3,542	3,276	2,903	2,903	10,371	8,622
G11	1,748	7,334	685	293	1,931	1,931	4,025	4,113
G12	1,795	20	928	1,490	626	626	668	2,416
G13	1,680	6,523	1,688	210	603	3,231	603	7,594
G14	1,920	3,072	141	10,406	103	1,083	103	13,275
G15	1,711	8,790	1,069	618	1,560	1,560	4,477	2,792
G16	1,751	33	232	724	5,267	5,267	6,112	17,729
G17	1,827	8,405	4,131	740	4,882	4,882	6,468	24,487
G18	1,876	2,501	475	50	472	12,392	1,596	472
G19	1,968	9,331	72	131	336	25,377	14,501	336
G20	1,716	7,749	2,452	811	1,452	1,452	6,233	2,146

Notes:

1. Perennial Stream.
2. Cliff Quality Score 1 = “Low Suitability.”
3. Cliff Quality Score 2 = “Moderate Suitability.”
4. Cliff Quality Score 3 = “High Suitability.”

Table 5.1-4. Bat Activity (Bat Passes per Detector-Night) by Month and Habitat Type, 2013.

	Pond			Stream			Cliff			Upland			Total		
Month	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]	$\bar{x}$[1]	SE[2]	n[3]
May	0.01	0.01	81	0	–	22	0	–	28	0	–	50	0.01	0.01	181
June	0.10	0.08	240	0.08	0.05	91	0.01	0.01	90	0	–	150	0.06	0.03	571
July	0.25	0.16	242	1.51	0.59	124	0.41	0.19	93	0	–	155	0.47	0.14	614
August	0.18	0.04	239	0.60	0.21	119	0.23	0.07	93	0.01	0.01	155	0.22	0.04	606
September	0.59	0.24	220	0.26	0.10	120	0.02	0.02	81	0.01	0.01	141	0.29	0.10	562
October	0.02	0.02	45	0	–	27	0	–	21	0	–	33	0.01	0.01	126
Total	0.24	0.07	1,067	0.59	0.16	503	0.15	0.05	406	0.004	0.003	684	0.23	0.04	2,660

Notes:

1. $\bar{x}$ = Mean bat activity
2. SE = Standard error of mean
3. n = Number of detector-nights used in analysis

Table 5.1-5. Bat Activity (Bat Passes per Detector-Night) by Month and Forest Structure Type for Non-Pond Habitats, 2013.

	Open			Closed			Dwarf			Shrub			Total		
Month	$\bar{x}^1$	SE[2]	n^3	$\bar{x}^1$	SE[2]	n^3	$\bar{x}^1$	SE[2]	n^3	$\bar{x}^1$	SE[2]	n^3	$\bar{x}^1$	SE[2]	n^3
May	0	–	19	0	–	30	0	–	29	0	–	22	0	–	100
June	0	–	73	0.08	0.05	90	0	–	90	0.01	0.01	78	0.02	0.01	331
July	0.04	0.03	93	2.18	0.80	93	0	–	93	0.19	0.05	93	0.60	0.21	372
August	0.04	0.02	93	0.86	0.26	93	0	–	93	0.11	0.05	88	0.26	0.07	367
September	0.02	0.02	90	0.34	0.13	90	0.01	0.01	81	0	–	81	0.10	0.04	342
October	0	–	22	0	–	22	0	–	21	0	–	16	0	–	81
Total	0.03	0.01	390	0.77	0.19	418	0.002	0.002	407	0.08	0.02	378	0.23	0.05	1,593

Notes:

1. $\bar{x}$ = Mean bat activity
2. SE = Standard error of mean
3. *n* = Number of detector-nights used in analysis

Table 5.1-6. Acreage of Habitat and Forest Structure Types in Bat Study Area, 2013.

	Habitat Type				
Forest Structure Type	**Pond**	**Stream**	**Cliff**	**Upland**	**Total**
Closed	9	622	2,212	3,647	6,490
Open	309	1,531	2,727	10,254	14,821
Dwarf	3	90	421	1,426	1,940
Shrub	432	269	273	4,067	5,041
Water	267	135	1,966	2,175	4,543
Unclassified	3	87	13	342	445
Total	1,023	2,734	7,612	21,911	33,280

Table 5.2-1. Results of Building Searches for Artificial-Roost Surveys, 2013.

Site ID	Number of Structures Searched	Number of Structures with Roost Potential	Bat Sign Observed?
RS 01[1]	–	–	–
RS 02	1	0	No
RS 03	1	0	No
RS 04[2]	1	0	No
RS 05[1]	–	–	–
RS 06[1]	–	–	–
RS 07	1	0	No
RS 08	1	1	No
RS 09[2]	5	4	No
RS 10	4	2	No
RS 11[1]	–	–	–
RS 12	5	4	No
RS 13	5	3	No
RS 14	1	0	No
RS 15[1]	–	–	–
RS 16[3]	1	1	No
Total	26	15	

Notes:

1. Access permission not received.
2. Within Bat Study Area.
3. Searched in fall only.

10. FIGURES

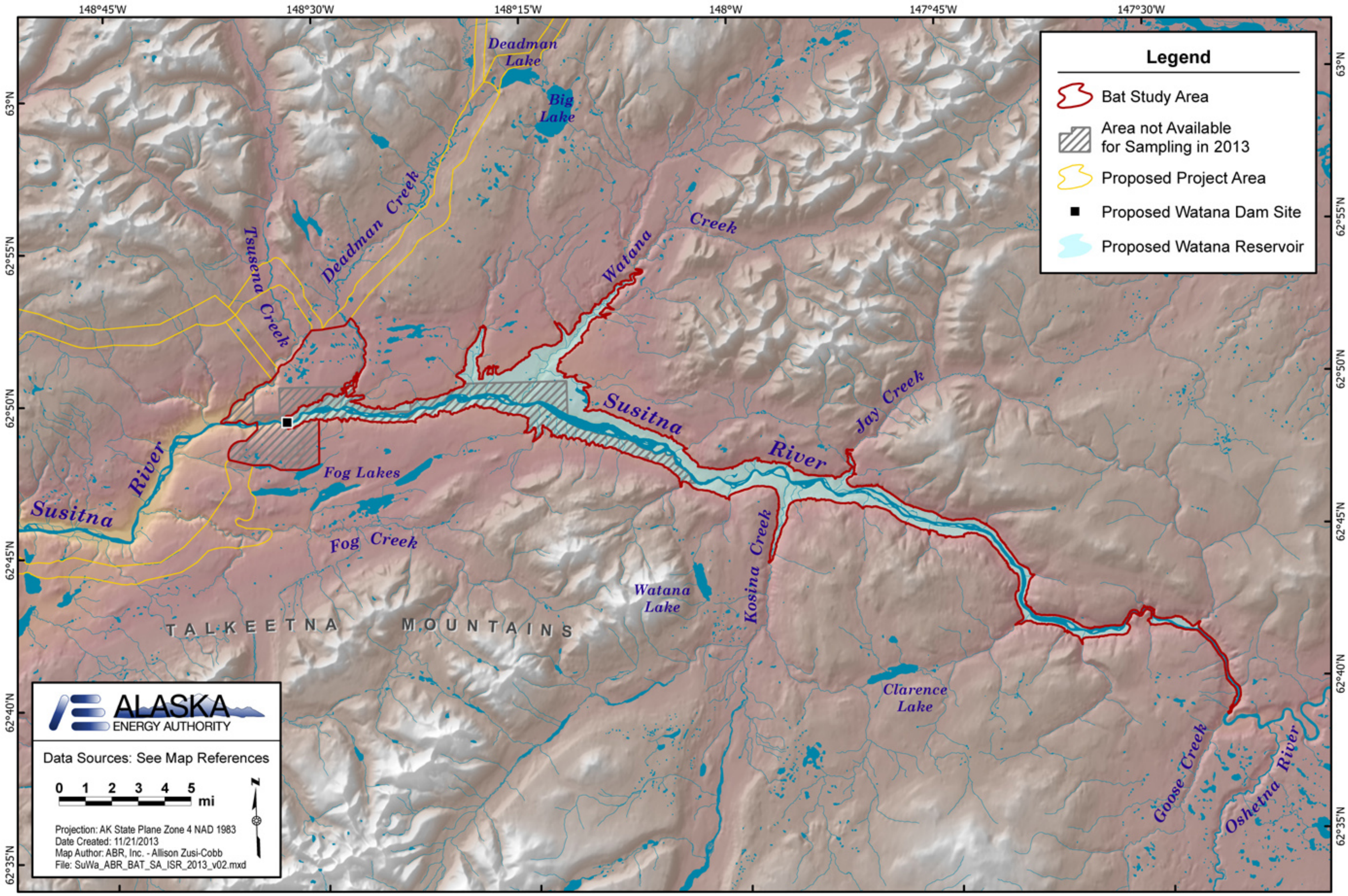

Figure 3-1. Bat Study Area for the Susitna–Watana Hydroelectric Project, 2013.

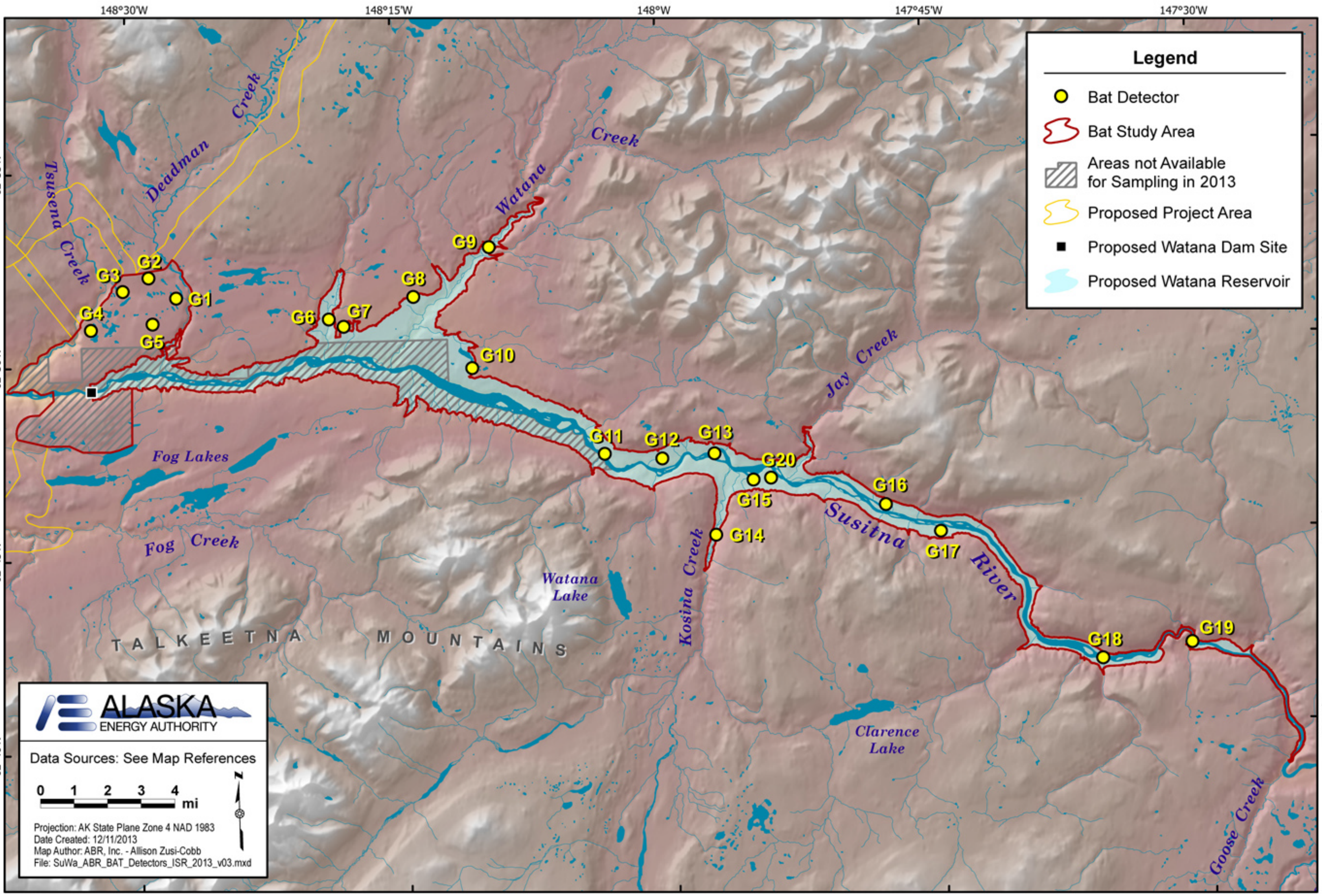

Figure 4.1-1. Acoustic Detector Sites Monitored for the Bat Study in 2013.

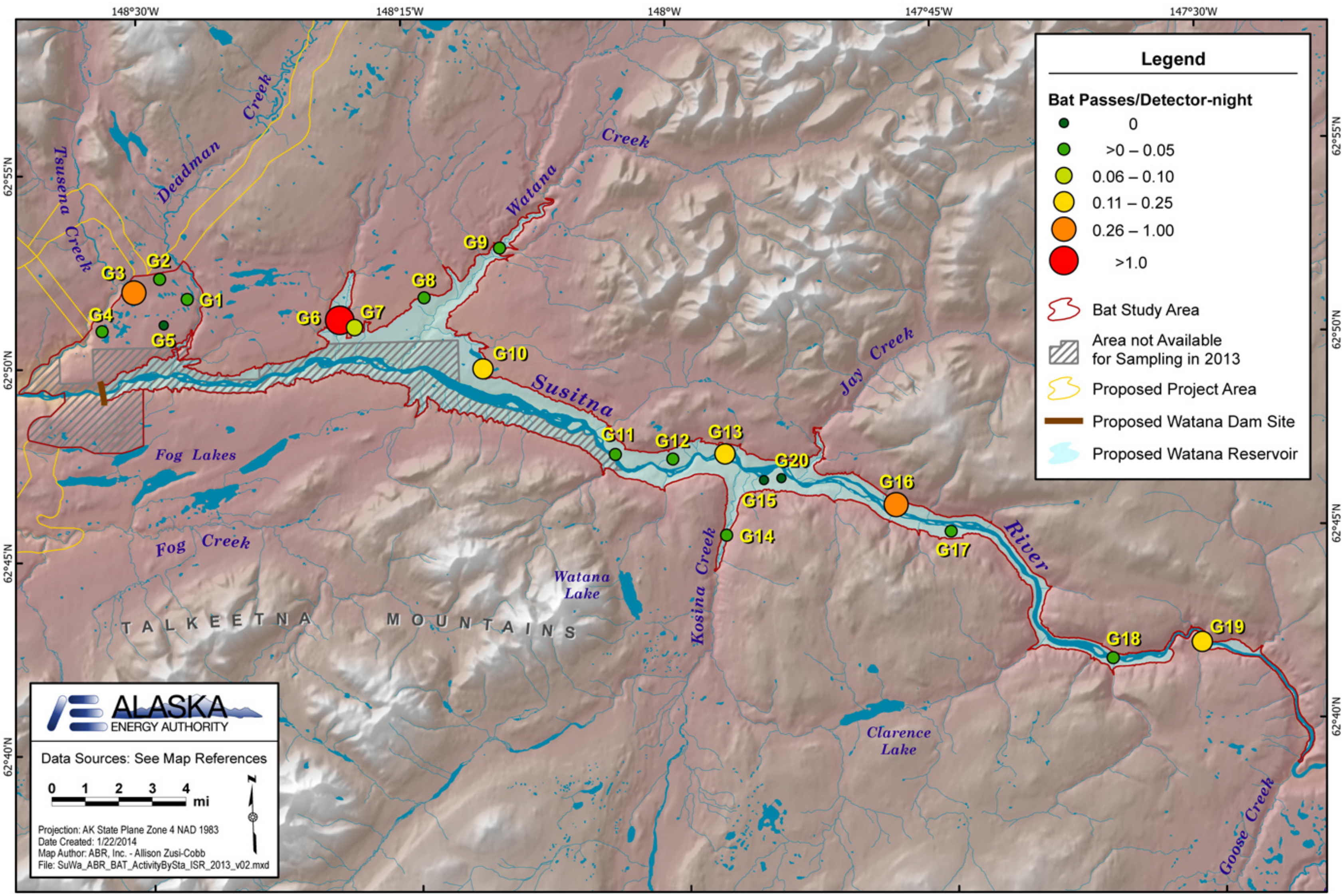

Figure 5.1-1. Distribution of Bat Activity Among Acoustic Detector Stations, 2013.

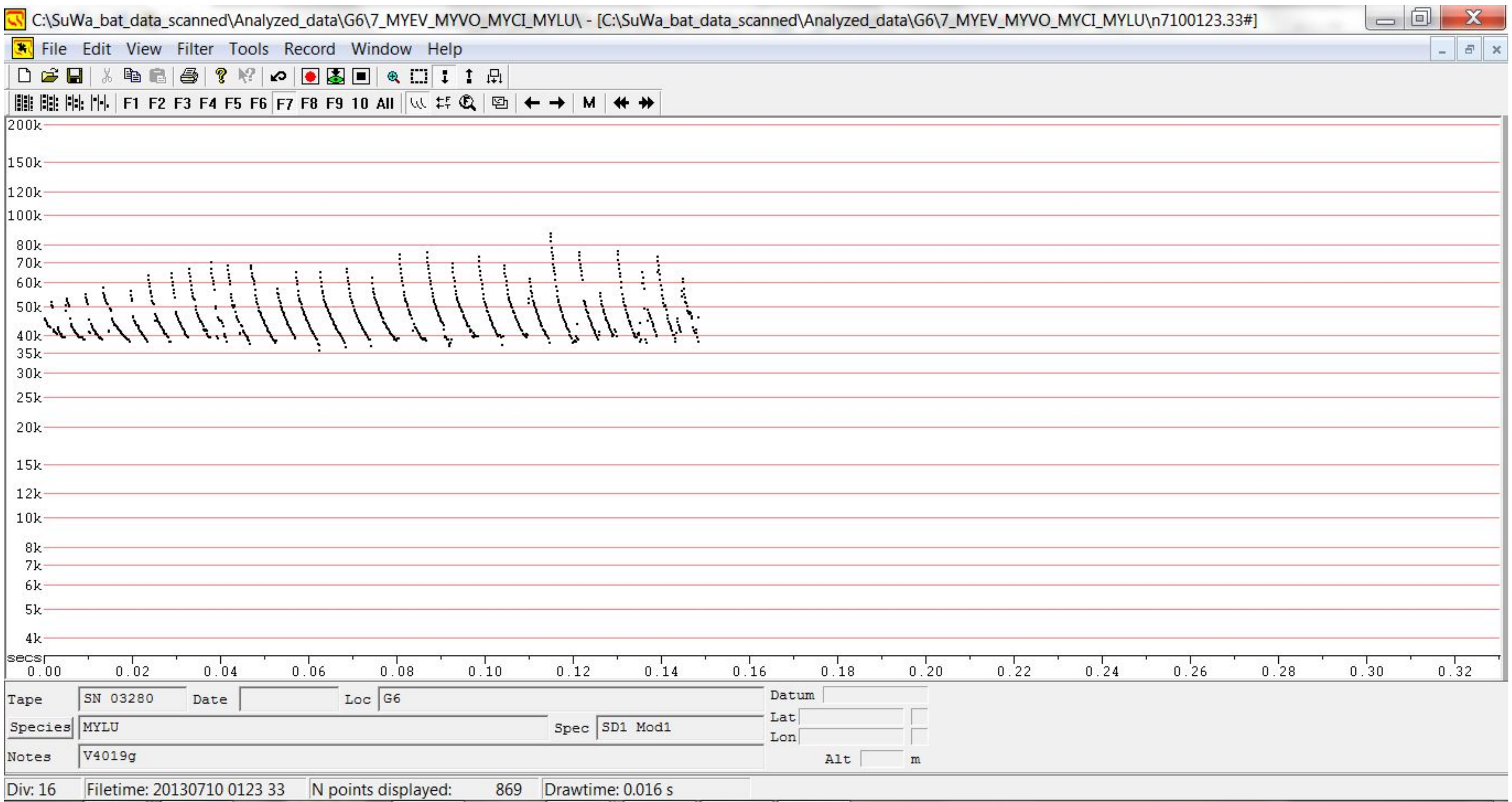

Figure 5.1-2. Representative Sonogram from Little Brown Bat Recorded during Current Study, 2013.

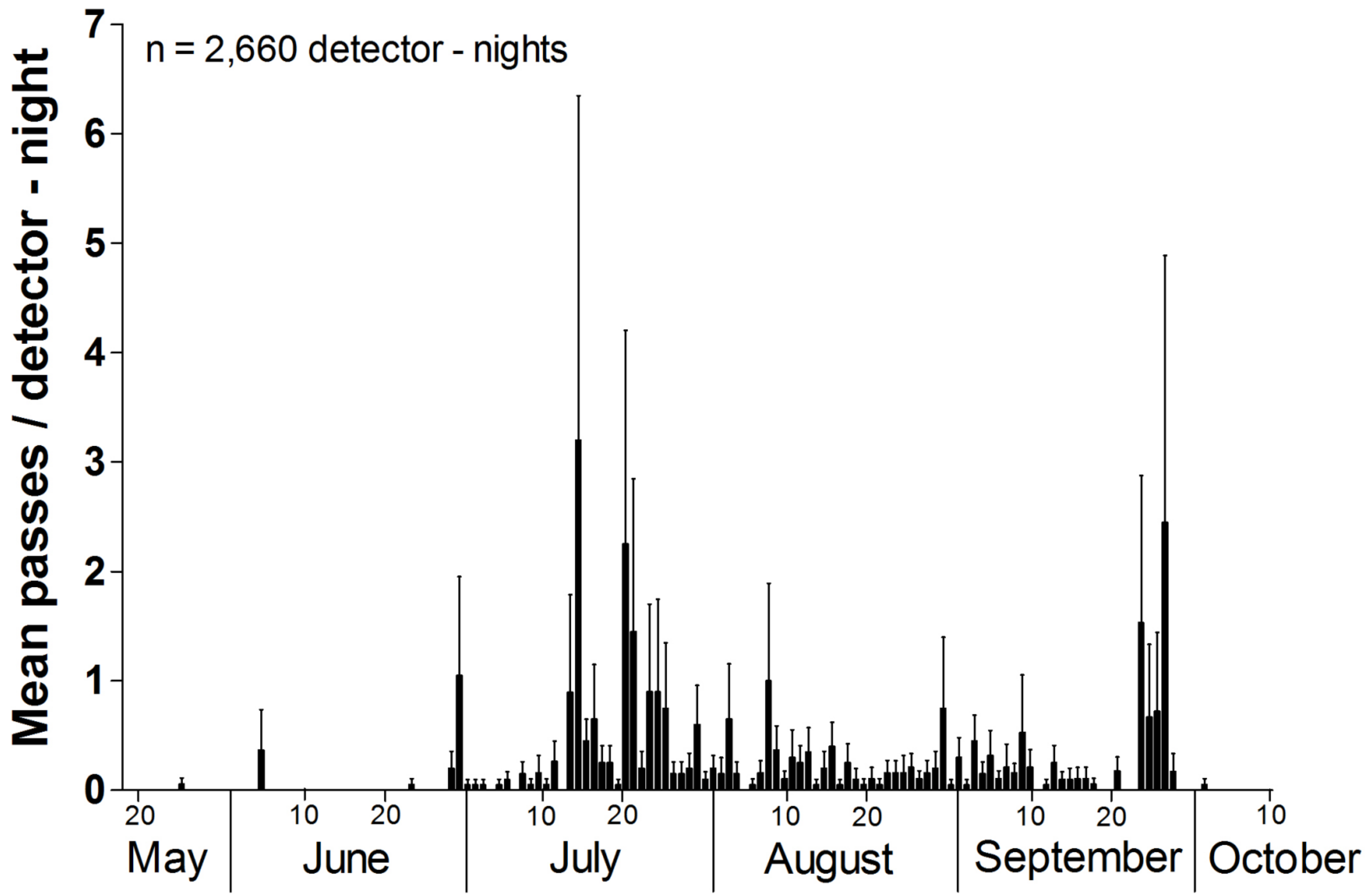

Figure 5.1-3. Bat Activity by Date, 2013 (error bars indicate SE).

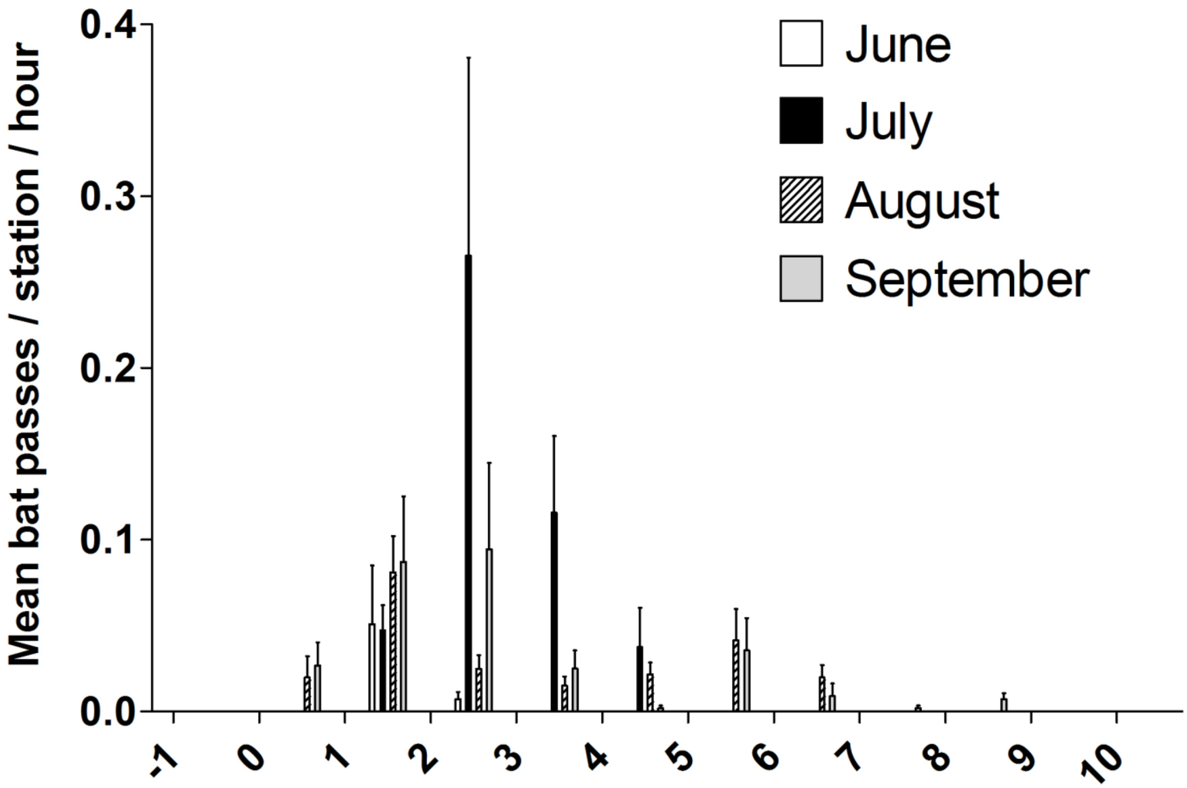

Figure 5.1-4. Bat Activity by Hour in Relation to Sunset, 2013 (error bars indicate SE).

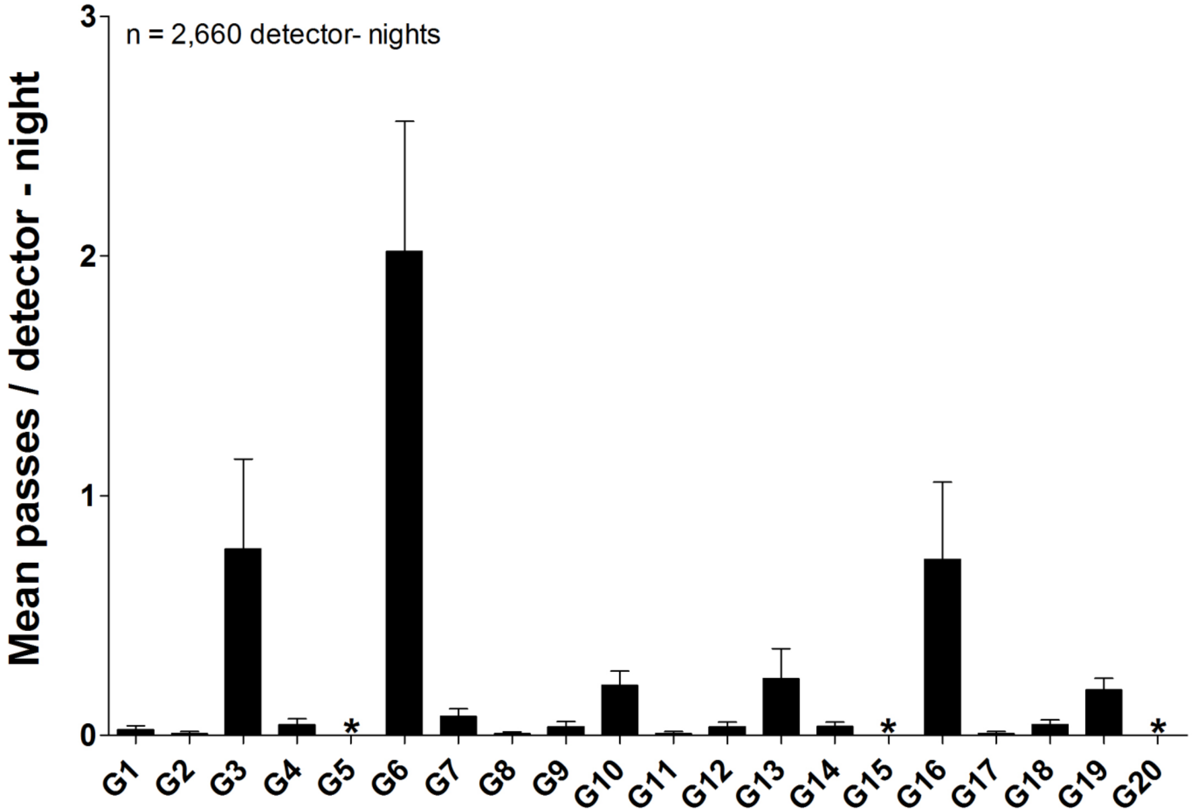

Figure 5.1-5. Bat Activity by Station in 2013 (error bars indicate SE; asterisks indicate that no bats were detected).

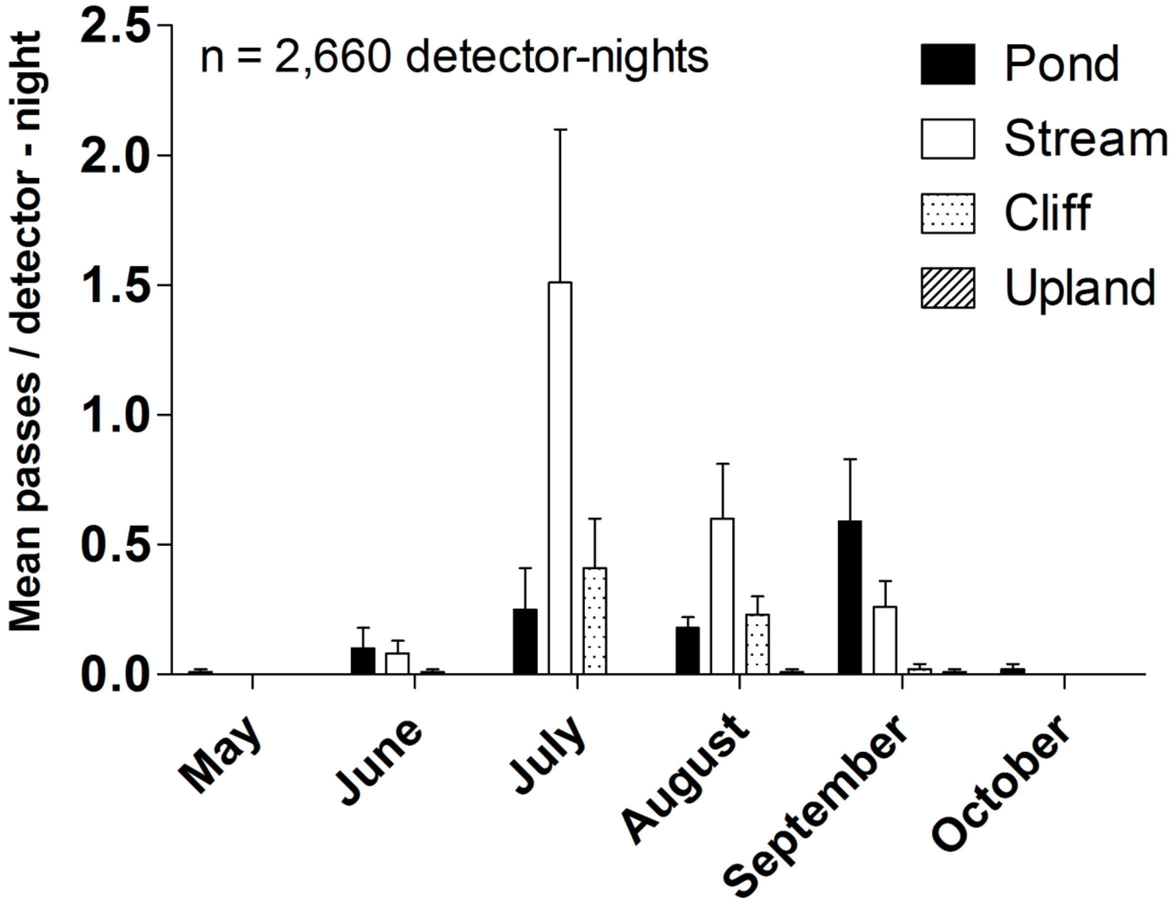

Figure 5.1-6. Bat Activity by Month and Habitat Type, 2013 (error bars indicate SE).

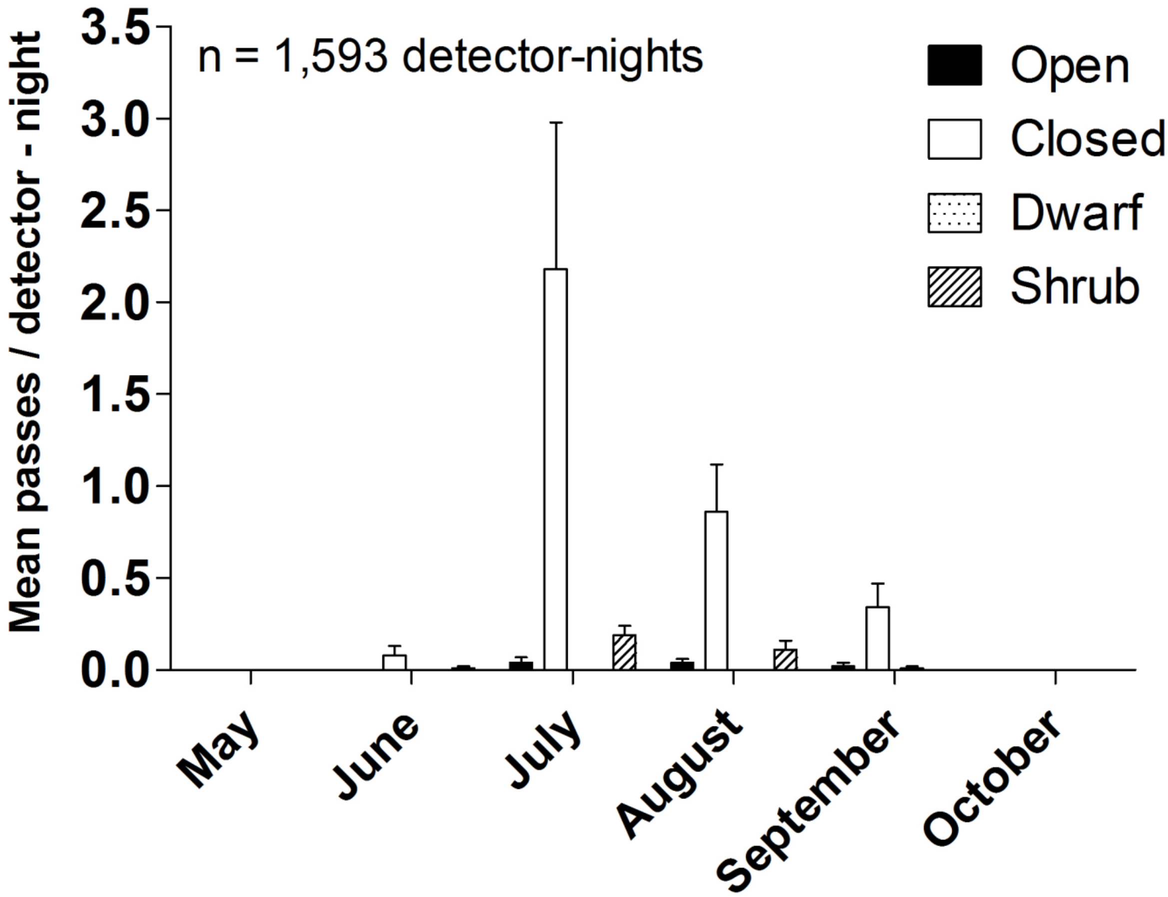

Figure 5.1-7. Bat Activity by Month and Forest Structure Type for Non-Pond Habitats, 2013 (error bars indicate SE).

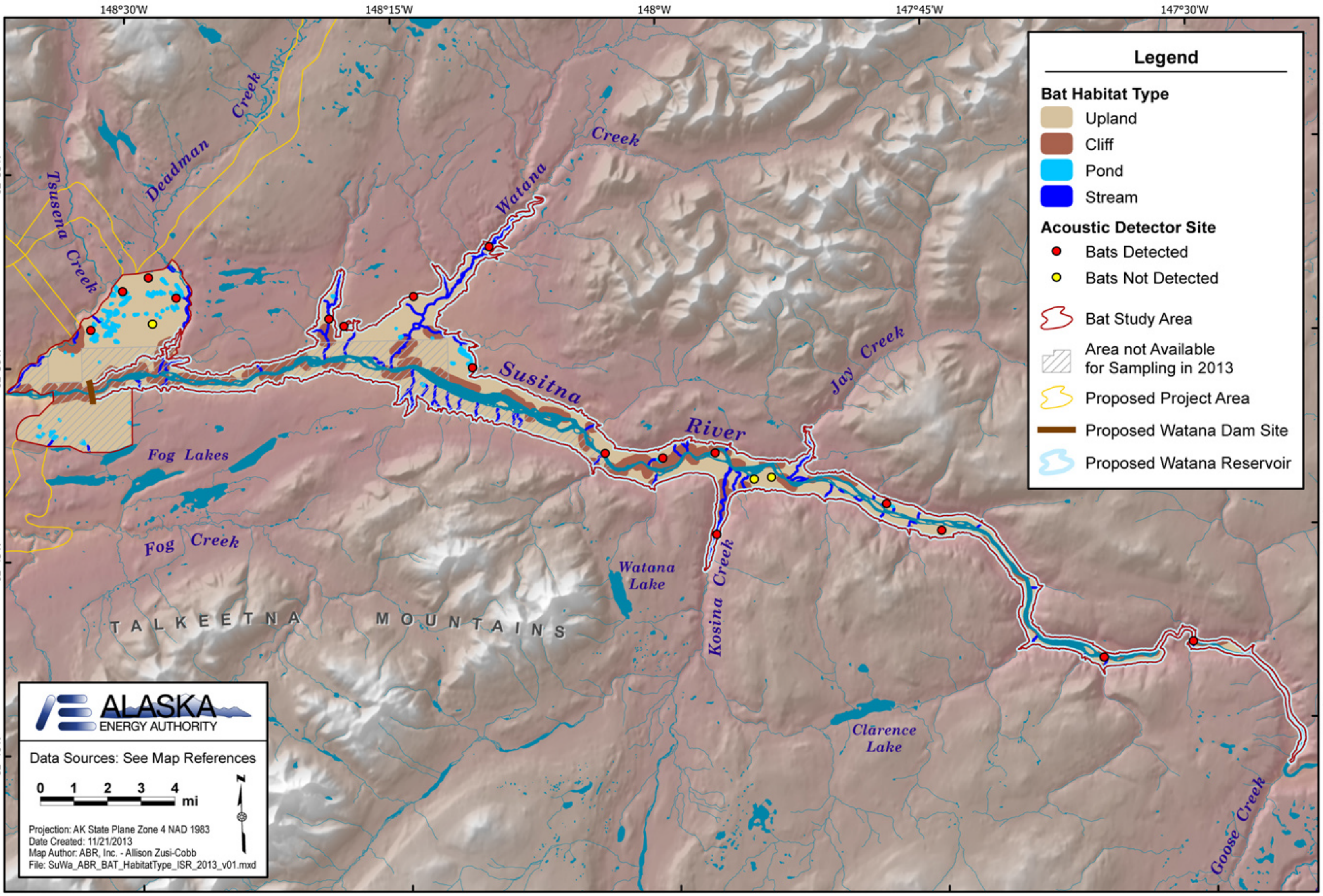

Figure 5.1-8. Distribution of Habitat Types in Bat Study Area, in Relation to Acoustic Detector Sites, 2013.

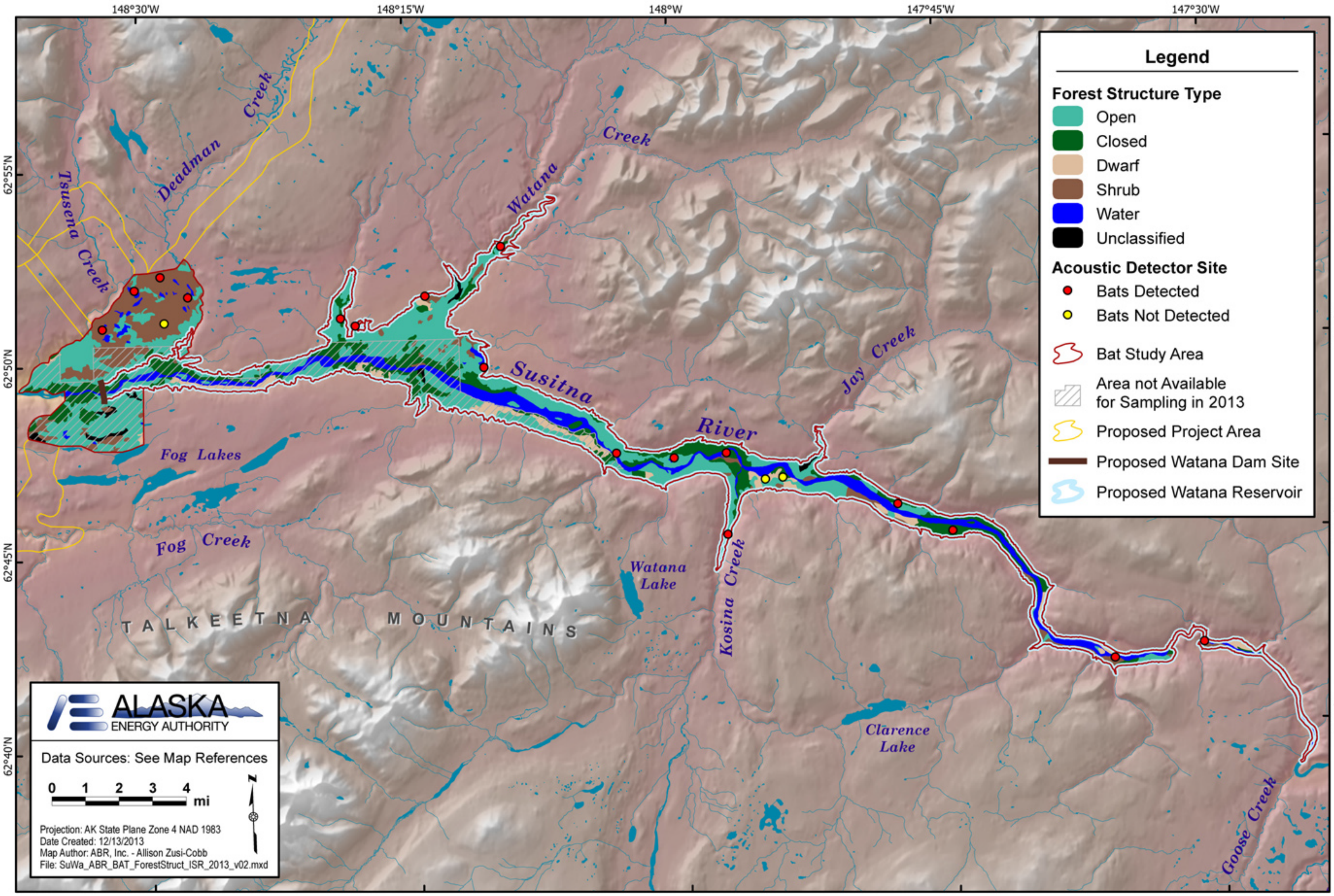

Figure 5.1- 9. Distribution of Forest Structure Types in Bat Study Area, in Relation to Acoustic Detector Sites, 2013.

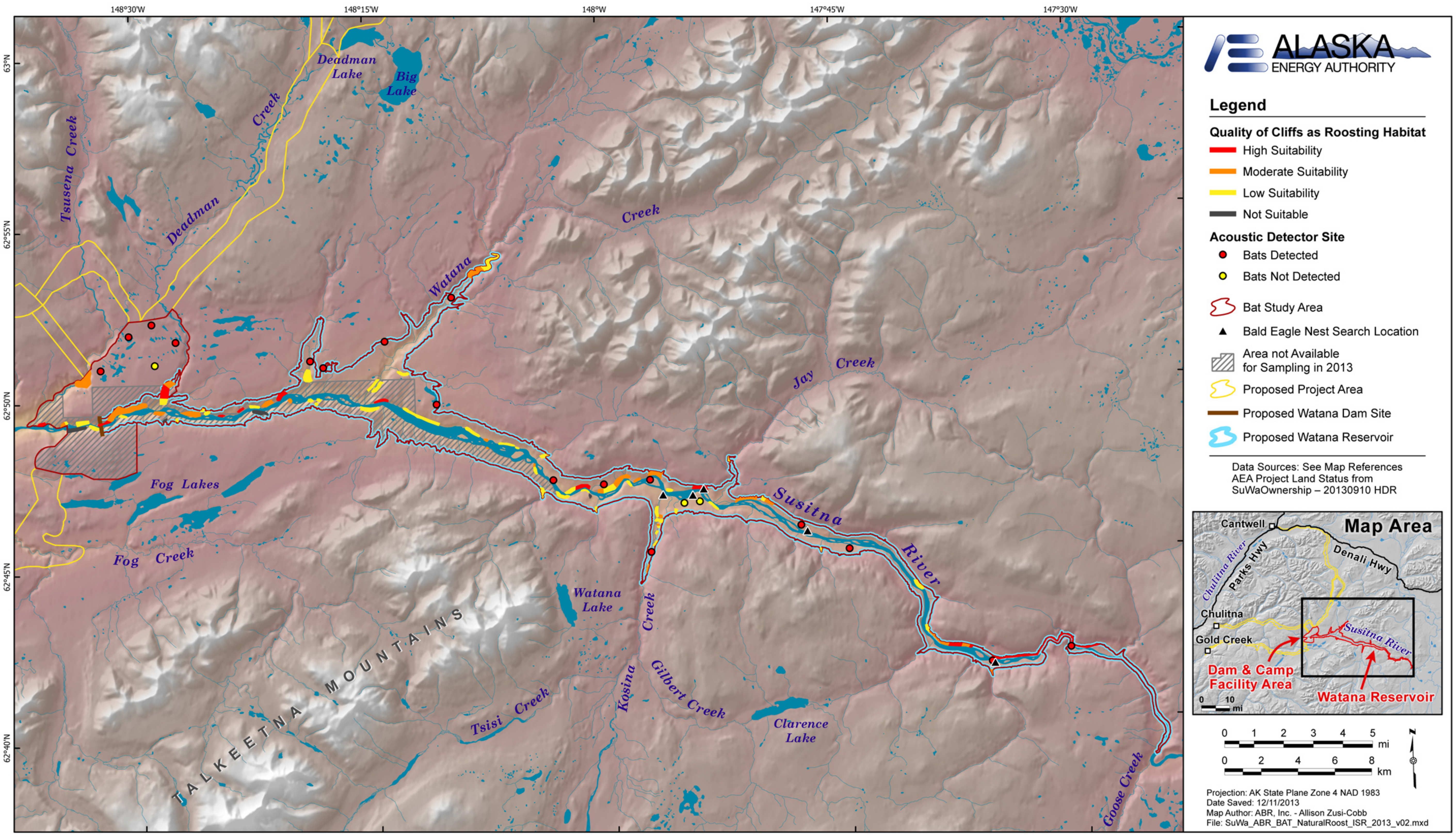

Figure 5.2-1. Cliff Habitats Surveyed in Bat Study Area, in Relation to Acoustic Detector Sites, 2013.

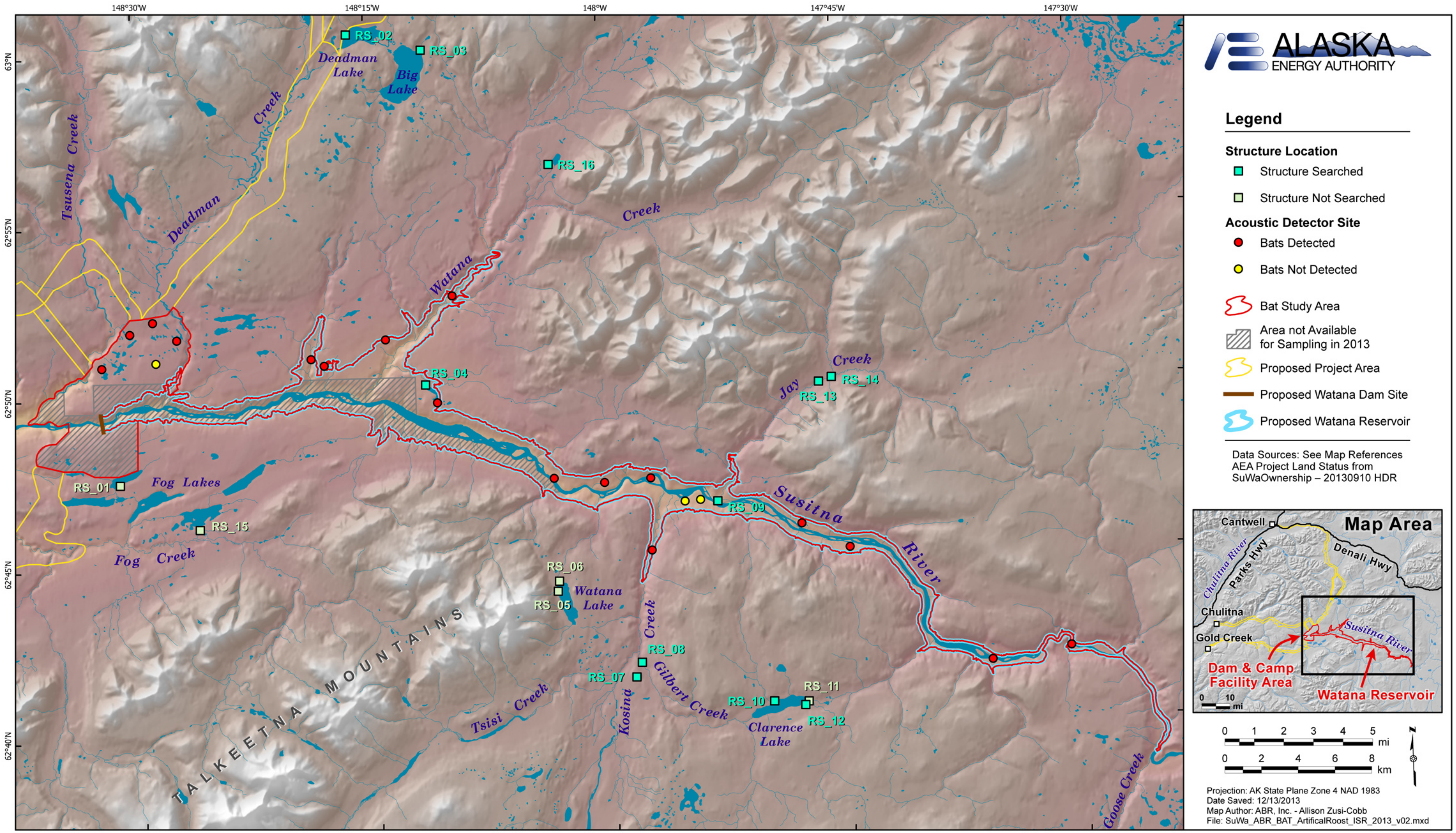

Figure 5.2-2. Locations of Buildings Searched on Artificial-Roost Surveys, in Relation to Acoustic Detector Sites, 2013.