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SUSITNA-WATANA HYDRO

Susitna–Watana Hydroelectric Project
(FERC No. 14241)

Bat Distribution and Habitat Use
Study Plan Section 10.13

Study Completion Report

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

October 2015

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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 Regional Working Group
FERC	Federal Energy Regulatory Commission
ft	feet
g	mass
GB	gravel bar
GIS	geographic information system
ILP	Integrated Licensing Process
ISR	Initial Study Report
km	kilometer
m	meter
mi	mile
mm	millimeter
ms	millisecond
NDVI	Normalized Difference Vegetation Index
Project	Susitna–Watana Hydroelectric Project
QA/QC	quality assurance and quality control
RSP	Revised Study Plan
SE	standard error
SPD	Study Plan Determination
WNS	White-nose Syndrome

1. INTRODUCTION

The Bat Distribution and Habitat Use Study (Bat Study, for short), Section 10.13 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 the occurrence of bats and the distribution of habitats in which bats were detected in the Project study area.

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 for Study 10.13 (ABR 2014a). 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 Bat Study. For example:

- Additional acoustic monitoring was conducted at 10 locations in 2014.
- A bat capture and radio telemetry effort was completed in summer and fall 2014.
- On October 21, 2014, AEA held an ISR meeting for the Bat Study.

In furtherance of the next round of ISR meetings and FERC's Study Plan Determination (SPD) expected in 2016, this report contains a comprehensive discussion of results of the Bat Study from the beginning of AEA's study program in 2013, through the end of calendar year 2014. It describes the methods and results of the Bat Study and explains how all Study Objectives set forth in the FERC-approved Study Plan have been met. Accordingly, with this report, AEA has now completed all field work, data collection, data analysis, and reporting for this study.

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) encompassed the proposed reservoir inundation zone, the proposed dam and powerhouse locations, and the associated camp facilities area, but not the various access-road and power transmission corridor alternatives.

4. METHODS AND VARIANCES

The methods for each component of the Bat Study are described in this section.

4.1. Acoustic Surveys

During the 2013 and 2014 study seasons, 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 (Anabat® SD1 broadband acoustic detectors; Titley Electronics, Ballina, New South Wales, Australia) to assess bat activity patterns and habitat associations across the study area by recording the ultrasonic sounds produced by echolocating bats. The study team deployed 20 detectors during May 25–October 7, 2013, and 10 detectors during May 15–October 11, 2014 (Table 4.1-1, Figure 4.1-1). The deployment of detectors in 2014 was described as a study plan modification in ISR 10.13 Part C, Section 7.1.2 (ABR 2014c), so more detail is provided under Section 4.1.1 below.

Scientists use acoustic detectors commonly for passive detection of free-ranging, echolocating bats (O'Farrell et al. 1999). Each detector had a minimum 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. Microphones were housed in waterproof "bat-hats" (EME Systems, Berkeley, California) and were secured to a section of rebar or tree, located approximately 1–1.5 m (3–5 ft) 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 from random points generated within the study area using 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). For each broad habitat type, the study team created 200-m (656-ft) buffers surrounding the features of interest (ponds, streams, and cliffs) and considered all remaining habitat as uplands. The Susitna River was included in the buffers for all habitat types, except for uplands. Sampling points were required to be within the 200-m (656-ft) buffer of each habitat type.

Non-pond habitat types were stratified further by vegetation structure (closed, open, and dwarf forests and shrub types; 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 yet available in 2013 or 2014. The vegetation structure types from the Kreig and Associates (1987) map were modified slightly by ABR (2013) to closely approximate the Level-III vegetation types of Viereck et al. (1992). The vegetation structure types used in this study were considered to be biologically relevant to bats because of the potential importance of structural complexity on bat activity. Closed forests have 60–100 percent canopy cover; open forests included open (25–60 percent) and woodland (10–25 percent) forest types; dwarf forests had at least 10 percent canopy cover of dwarf forest trees (under 5 m [16 ft] at maturity); and the shrub type comprised at least 25 percent shrub cover and <10 percent forest canopy cover. The shrub type also contained tiny proportions of wet graminoid meadow (0.31 percent of total) and barrens (0.28 percent of total). Within each broad habitat type, the study team tried to select one site in each of four vegetation structure types (closed, open, dwarf, shrub).

The area of each habitat and vegetation structure type was measured using a GIS. In 2013, the final sampling locations included eight pond sites, five upland sites, four stream, and three cliff sites. In 2014, the six sites that were resurveyed included three ponds, two cliffs, and one stream, and the four new stations on CIRWG lands included two cliff sites, one pond, and one stream. Upland habitat types were not surveyed in 2014 because of the extremely low levels of bat activity recorded in that habitat type in 2013. The vegetation structure classifications for non-pond sites in 2013 included three sites in each of the four classification types (open, closed, dwarf, and shrub). In 2014, the vegetation structure for the three non-pond sites that were resurveyed included one shrub type and two closed forest types. For the three new non-pond stations on CIRWG lands in 2014, the study team selected one closed and two open sites. The study team was unable to survey the dwarf forest type or to stratify the habitat types equally by vegetation structure in 2014 because of the limited overlap of habitat and vegetation structure conditions on CIRWG lands. Detector stations were placed as close as possible to the primary random sampling points. In several cases, alternative random points were used because of discrepancies between the vegetation type at the primary sampling point and the vegetation type identified on the 1980s vegetation map from the APA Project, which was used for sample allocation. Difficult helicopter access at several primary points also necessitated the use of alternative sampling locations.

At each station, 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 characteristics of the site. 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). Sunset times were calculated for each station's latitude, longitude, and elevation using the *PyEphem Python module 3.7.5.2* (Rhodes et al. 2013). Data were recorded on 1-GB compact flash (CF) data cards. The study team exchanged the CF cards and checked equipment approximately every 2 weeks. 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 implemented in 2013. However, the lack of ground access to Cook Inlet Regional Working Group (CIRWG) lands in the western portion of the study area in 2013 prevented acoustic sampling in some areas that would otherwise have been included in the random allocation of sampling points.

In 2014, the study team rectified that omission by establishing four new locations on CIRWG lands (Table 4.1-1). Six other sites that were surveyed in 2013 were resurveyed in 2014 to better understand annual variation and to monitor areas in which bat detections were recorded in 2013, to assist in targeting the mist-netting and telemetry effort in 2014. This additional sampling variance was presented as a modification to the Study Plan in ISR Part C Section 7.1.2.

4.2. Roost Surveys

In 2013, 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). The roost surveys were not repeated in 2014 because they were replaced by the bat capture and radio telemetry effort designed to locate specific bat roosts, as was described as a Study Plan modification in ISR Part C Section 7.1.2.

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 in 2013. 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 on 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 in 2013. No bridges were present in the study area, so the search concentrated on buildings. Before beginning the search, the study team requested permission from the landowners 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 focused on potential use of the structures as hibernation sites.

Both artificial roost searches included structures (19 in summer and 20 in fall) 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

In 2013, the study team opportunistically expanded roost searches to include nearby areas outside of the study area due to the scarcity of suitable roosting structures within the study area where permission was granted by property owners. The additional search effort expanded the scope proposed in the Study Plan and constituted a variance.

Access to CIRWG lands, which encompassed most of the western end of the study area, was not permitted in 2013. The lack of ground access to CIRWG lands prevented searches of potential natural roosting habitat 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. No artificial structures occur on CIRWG lands within the study area. In 2014, field effort was devoted to the targeted mist-netting and telemetry effort designed to locate specific bat roosts, which was added as a study plan modification for the second year of field surveys, as described in ISR 10.13 Part C, Section 7.1.2 (ABR 2014c).

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 at approximately 2-week intervals to minimize data loss from equipment failures or other factors, such as damage by animals (primarily bears). 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 were 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. For example, 10 bat passes may represent a single bat recorded 10 different times or may represent single passes by 10 different bats (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).

Echolocation sequences recorded by the detectors were processed using *Anabat CFC Read* software (version 4.4u) and were analyzed with *Kaleidoscope Pro* software (version 2.1, Wildlife Acoustics, Maynard, Massachusetts, USA) to detect and quantify bat passes. In addition, the study team visually inspected all spectrogram files using *AnalookW* software (version 4.1j; Corben 2011) to ensure proper species identification, based on characteristics reported by Ober (2006) and Lausen et al. (2014). A bat pass was defined as an echolocation sequence of ≥2 echolocation pulses with a minimum pass duration of 10 milliseconds (ms) (Gannon et al. 2003) and each sequence separated by 5 seconds. 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. Because so few calls were recorded in May and October, they were excluded from the hours-relative-to-sunset analysis.

In 2013, 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. In 2014, formal statistical analyses of the among-station, among-habitat, and among-vegetation structure data sets were not conducted because six of the sites in 2014 were not selected randomly. Monitoring of those six sites was continued in 2014 to test for annual variability and to track bat movements to assist with targeting areas for bat capture. A randomization test was used to look for differences between years for each of the six sites and among all six sites combined because the data were highly skewed, including many zeros and a small number of high values. For each simulation, the year values were randomized and the differences between nightly means for the two years were recalculated based on the randomized years. This process was repeated 5,000 times to generate 5,000 mean differences. The mean differences between years for each site and the overall mean were compared with the distribution of differences from the simulations. If the actual difference was more extreme than 95 percent of the simulated differences, then the differences between years were considered to be significant ($P < 0.05$). Only June–September data were used for monthly comparisons because of the short duration of sampling that was conducted in late May and early October. GIS software was used to measure the minimum distance from each detector station to seven landscape features: ponds, streams, rivers, any cliffs, and potential roosting cliffs of different value (roost quality index scores of 1, 2, and 3; see Section 5.2.1 below). Correlations between the mean number of bat passes and the minimum distances to these landscape features were tested using Spearman's rank correlation. SPSS version 18.0 analytical software was used for all statistical comparisons, assuming statistical significance at $P = 0.05$ (SPSS 2009).

4.3.1. Variances

No variances from the data management and analysis methods described in the Study Plan were necessary in 2013 or 2014.

4.4. Bat Capture and Radio Telemetry

Using the methods described in the Study Plan, the study team was unable to document roost locations (maternity colonies, hibernacula) of bats (objective 3 above). The results of the acoustic monitoring study documented widespread bat use of the study area, however, demonstrating that bats roost within the study area. Little brown bats typically forage less than 3 km (1.9 mi) from roost sites (Henry et al. 2002), similar to other bats of the family *Vespertilionidae* (Brigham et al. 1997b; Campbell et al. 1996), bolstering support for the presence of bat roosts in the study area. The most efficient method for locating bat roost sites is radio telemetry. Hence, the study team used radio telemetry to try to identify roosting locations of bats in the study area. This Study Plan modification was presented in ISR 10.13 Part C, Section 7.1.2 (ABR 2014c).

During July 14–26 and September 19–30, 2014, the study team deployed mist nets to capture bats and equip them with tiny radio transmitters to determine roosting locations of bats in the Project area (under ADFG Permit #14-153 and ADFG IACUC Protocol #2014-12). Although the capture and handling equipment came from states in which White-nose Syndrome (WNS) had not been detected (Montana and Oregon), the study team decontaminated all equipment according to the latest WNS protocol (version 6.25.2012; USFWS 2015) before transporting it to Alaska. All equipment and clothing also were decontaminated, following the same protocol, before moving to another capture site. The start time for each mist-net session began at sunset and the session continued until sunrise in the summer or for 5–7 hours in the fall, depending on air temperatures. Capture efforts were suspended when air temperatures dropped below 25º F. Mist nets were monitored continuously for the duration of each nightly trapping session, with a maximum duration of 10 minutes between net checks. The study team used the network of acoustic detectors at which bat activity was detected to target sites for mist netting, as well as identifying other potential mist-netting areas while in transit between sampling sites. Not all mist-netting sites were located near cliff sections of high suitability.

After removal from mist nets, captured bats were placed into a paper holding bag, which were protected from rain and cold weather. The following data were collected for each captured bat: forearm length (mm); mass (g); sex; age (adult or juvenile, following Anthony 1988); reproductive condition (pregnant, lactating, or scrotal); and species. The radio transmitter used was the smallest available (Type LB-2X, mass = 0.27 g; Holohil Systems Ltd., Carp, Ontario, Canada). The transmitter was attached to the inter-scapular area after clipping fur and applying Perma-type surgical adhesive (Perma-Type Company Incorporated, Plainville, Connecticut). Only bats weighing at least 6 g were candidates for transmitter attachment, for which the transmitter and glue would represent ≤5 percent of a bat's total mass, following standard guidelines (Aldridge and Brigham 1988, Neubam et al. 2005). The holding time for captured bats was no more than 1 hour, including 20 minutes of adhesive drying time after transmitter attachment.

The study team tracked radio-tagged bats using a Telonics TR-2 receiver and H-antennas mounted on a Robinson R-44 helicopter to identify, to the maximal extent possible, exact roost locations using unaided vision or binoculars. Bats were tracked to rock and/or cliff faces used as day-roosting substrates. After a cliff roost was identified, the exact location was recorded with a GPS receiver, close-up and wide-angle photographs of the site were taken, and descriptive data were collected, including estimated cliff height (m), estimated cliff length (m), estimated height of roost above ground (m), approximate depth of roost location (cm), approximate crack or crevice length of roost location (m), estimated distance to nearest water source (m), and roost aspect.

Several biological samples were opportunistically gathered from captured bats to provide data for an unrelated study being conducted by David Tessler (ADF&G wildlife biologist). The study team collected tissue samples from the wing membrane with a 2-mm biopsy punch for genetic analysis. The team also collected additional samples noninvasively for disease surveillance of bat-borne pathogens by gently wiping a sterile cotton swab across the body, wings, and nose of each bat.

5. RESULTS

Cumulative data developed in support of the Study Completion Report are available for download at http://gis.suhydro.org/reports/SIR:

- BAT_10_13_Acoustic_and_Habitat_2013_2014_ABR.xlsx;
- BAT_10_13_Acoustic_Monitoring_2013_2014_ABR.xlsx;
- BAT_10_13_Photo_Delivery_Table_2013_2014_ABR.xlsx;
- BAT_10_13_Telemetry_Roost_2014_ABR.xlsx;
- BAT_10_13_Data_2013_2014_ABR.gdb/BAT_2013_2014_AcousticMonitors;
- BAT_10_13_Data_2013_2014_ABR.gdb/BAT_2013_2014_Habitat_ForestStructure;
- BAT_10_13_Data_2013_2014_ABR.gdb/BAT_2013_2014_StudyArea;
- BAT_10_13_Data_2013_2014_ABR.gdb/BAT_2014_Mist_Net_Capture;

- BAT_10_13_Data_2013_2014_ABR.gdb/BAT_2014_Mist_Net_Survey;
- BAT_10_13_Data_2013_2014_ABR.gdb/BAT_Cliff_Habitat_Quality.

5.1. Acoustic Surveys

5.1.1. General Bat Activity

5.1.1.1. 2013 Sampling

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) and 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 break-up 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 the acoustic characteristics (Figure 5.1-2) described by Ober (2006) and Lausen et al. (2014). Activity across all stations and seasons averaged 0.23 ± 0.04 (mean ± SE) bat passes/detector-night (Table 5.1-2).

5.1.1.2. 2014 Sampling

In 2014, acoustic monitoring at all 10 detector stations resulted in a total of 1,428 potential detector-nights (Table 5.1-1) and usable data were recorded on 1,370 detector-nights (96.0 percent). Data losses resulted from unidentified CF card or detector problems (C21, June 27–July 7 and August 12–24; C22, September 16–26; C24, July 14–25 and September 16–26).

Bat activity was detected at all 10 locations sampled (Figure 5.1-3). Overall, 631 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 matched those described by Ober (2006) and Lausen et al. (2014). Activity across all stations and seasons averaged 0.46 ± 0.09 (mean ± SE) bat passes/detector-night (Table 5.1-3).

Differences in bat activity between years were examined for the six sites surveyed in 2013 and 2014. All of the stations except G3 recorded fewer bat passes in 2014 than in 2013. Three of the stations (G10, G19, and G3) showed significant differences ($P < 0.05$) in mean bat passes/night between years, but the overall difference among all detector stations was not significantly different.

5.1.2. Temporal Comparisons

5.1.2.1. Seasonal Activity

5.1.2.1.1. 2013 Sampling

Bat activity varied substantially throughout the sampling period (Figure 5.1-4; 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).

5.1.2.1.2. 2014 Sampling

Bat activity again varied substantially throughout the sampling period (Figure 5.1-5; Table 5.1-3) and differed significantly among months (June–September; H = 75.0; df = 3; $P < 0.001$). On May 20, two bat passes were recorded at station G6, which were the bat activity recorded from deployment of the detector stations until July 8 (50 nights later), after which activity became more consistent. The greatest single-night activity rates occurred in July, but the average activity rates in July (0.88 ± 0.36 mean passes/detector-night; Table 5.1-3) and August (0.87 ± 0.17 mean passes/detector-night) were essentially identical. September bat activity (0.41 ± 0.08 mean passes/detector-night) was consistent, but only at approximately half of the activity levels seen in July and August. No bat passes were recorded in June or October. Most stations recorded the greatest amount of activity in August (7 of 10 stations; 70 percent), followed by July (2 of 10 stations; 20 percent) and September (1 of 10 stations; 10 percent). The spatial distribution of bat activity (number of stations with any activity across the study area) by month followed a similar trend, with the most widespread detections occurring in July (10 of 10 stations; 100 percent) and August (10 of 10 stations; 100 percent), followed by September (6 of 10 stations; 60 percent) and then May (1 of 10 stations; 10 percent).

5.1.2.2. Nightly Activity

5.1.2.2.1. 2013 Sampling

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 5.1-6), with peak activity generally occurring 1–3 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; $P < 0.05$).

5.1.2.2.2. 2014 Sampling

As in 2013, bat activity within nights varied substantially among hours of the night during all months (Figure 5.1-7), with peak activity generally occurring 1–3 hours after sunset. No bat activity was recorded in the hour before sunset or the hour after sunrise. In July, activity peaked 2–3 hours after sunset, with significantly more activity occurring during this time period (mean passes/station/hour = 0.68; $P < 0.01$), and significantly less activity in the first hour after sunset (mean passes/station/hour = 0; $P < 0.05$). Similarly, activity in August also peaked 2–3 hours after sunset (mean passes/station/hour = 0.37; $P < 0.01$) and significantly less activity occurred in the hour after sunset (mean passes/station/hour = 0; $P < 0.05$). In September, activity appeared to be the inverse of July and August, with little activity occurring within 2–3 hours after sunset and the greatest activity occurring later in the night within 3–5 hours after sunset. Significantly more activity occurred during those periods (3–4 hours after sunset mean passes/station/hour = 0.13, $P < 0.01$; 4–5 hours after sunset mean passes/station/hour = 0.14, $P < 0.01$), and significantly less activity 1–2 hours after sunset (mean passes/station/hour = 0; $P < 0.05$).

5.1.3. Spatial Comparisons

5.1.3.1. Activity Among Stations

5.1.3.1.1. 2013 Sampling

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, at 0.78 ± 0.38 mean passes/detector-night, and G16, at 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 5.1-8).

The elevation of detector stations above sea level ranged from 1,680 ft to 2,425 ft (Table 5.1-4). Overall bat activity was not correlated with elevation (Spearman's $\rho = -0.008$, P = 0.972), although bat activity tended to peak at higher elevations later in the sampling period (Spearman's $\rho = 0.474$, P = 0.054).

5.1.3.1.2. 2014 Sampling

Bat activity varied among sampling stations (Figure 5.1-9). Stations G6 and C22 recorded the greatest rates of activity, at 1.93 ± 0.73 mean passes/detector-night and 1.21 ± 0.31 mean passes/detector-night, respectively. The activity rates at those stations were 2–13 times greater than were those recorded at the next most active stations (G3, at 0.45 ± 0.13 mean passes/detector-night; G13, at 0.25 ± 0.10 mean passes/detector-night; C23, at 0.20 ± 0.06 mean passes/detector-night; and G16, at 0.15 ± 0.09 mean passes/detector-night; Table 5.1-3). Four of the 10 stations (C21, G10, C24, G19) recorded 0.1 bat passes/detector-night or less.

The elevation of detector stations above sea level ranged from 1,450 ft to 2,375 ft (Table 5.1-5) and bat activity was not correlated with elevation (Spearman's $\rho = -0.236$, $P = 0.511$). The activity at most stations peaked in August but, contrary to the results in 2013, bat activity did not tend to peak at higher elevations later in the sampling period.

5.1.3.2. Activity in Relation to Habitat and Vegetation Structure

5.1.3.2.1. 2013 Sampling

Bat activity varied significantly among the four broad habitat types sampled (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 5.1-6), 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 5.1-10).

Bat activity did not differ among the four types of vegetation structure sampled (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 5.1-7), followed by the shrub (0.08 ± 0.02 mean passes/detector-night), open (0.03 ± 0.01 mean passes/detector-night), and dwarf structure types (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 5.1-11).

The bat study area totaled 33,124 acres (Table 5.1-8). Stratified according to the broad habitat types sampled, the study area comprised these proportions: upland = 59.4 percent; cliff = 23.0 percent; stream = 8.0 percent; pond = 3.0 percent; and Susitna River = 6.6 (Figure 5.1-12). Stratified by vegetation-structure type, the non-water-body portion of the study area comprised these proportions: open = 51.5 percent; closed = 22.7 percent; shrub = 17.6 percent; dwarf = 6.8 percent and unclassified = 1.4 percent (Figure 5.1-13).

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 5.1-4) were significantly correlated with mean bat passes per detector-night (Spearman's ρ; $P > 0.05$).

5.1.3.2.2. 2014 Sampling

Statistical analyses of bat activity rates and habitats (pond, stream, and cliff) were not conducted in 2014, as was explained above in Section 4.3. Detector stations in stream habitats recorded the greatest level of activity (1.15 ± 0.42 mean passes/detector-night; Table 5.1-9), followed by cliff habitats (0.39 ± 0.08 mean passes/detector-night) and pond habitats (0.21 ± 0.04 mean passes/detector-night). Bat activity at stream sites peaked in July, whereas activity at cliff sites peaked in September (Figure 5.1-14). Activity at pond sites remained relatively low throughout the study period with the greatest amount of activity occurring in September.

Similarly, statistical analyses on bat activity rates and vegetation types (open, closed, and shrub) were not conducted in 2014. Detector stations in closed forest-structure types recorded the greatest level of activity (1.13 ± 0.28 mean passes/detector-night; Table 5.1-10), followed by the open (0.15 ± 0.04 mean passes/detector-night) and shrub types (0.04 ± 0.02 mean passes/detector-night). Activity levels in the closed type peaked in July, whereas activity in open and shrub types remained consistently low during the entire study (Figure 5.1-15).

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 5.1-5) 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 aerial survey on June 28–30, 2013: 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, but no suitable roosts were found. 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 roost search in August 2013 and to 11 sites during the search in October 2013, 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.

5.3. Bat Capture and Radio Telemetry

During the summer capture effort in 2014, the study team deployed mist nets for 304.5 mist-net-hours (8,267 m^2 mist-net-hours) during 13 nights at seven different locations. During the fall capture effort, the team deployed mist nets for 457.1 mist-net-hours (11,946 m^2 mist-net-hours) during 12 nights at two locations. Despite these intensive mist-netting efforts, only a single little brown bat was captured. An adult male weighing 9.1 g was captured at 03:15 on July 18 at site G6, along a slow moving, unnamed tributary of the Susitna River, just west of Watana Creek. After the transmitter was attached successfully, the bat was released and was tracked to day roosts over the next 10 days.

On the first day following release, the bat roosted in a small cliff complex near the mouth of the unnamed tributary, approximately 457 m (1,500 ft) downstream of the capture site. All but one subsequent roost locations were in the same large cliff complex on the north side of the Susitna River near between Project River Miles 193.7 and 195 (Figure 5.2-1). The other roost location was occupied on the third day of tracking, 0.4 mi southeast of the large cluster of roost locations. All roost locations were in cliff faces above a stream or river. The majority of the roost locations (80 percent) were in a cliff section identified as having high suitability during the cliff roost quality survey in 2013. The cliff section used on the day following release was identified as having low suitability and the roost used on the third day of tracking was classified as having moderate suitability. The cliff faces used for roosting by the tagged bat varied in elevation from approximately 1,655 ft to 1,730 ft above sea level (160–330 ft in height).

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

This study revealed that activity by 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 upstream to Goose Creek, near the eastern edge of the proposed reservoir inundation zone. Seventeen of the 20 detector stations in the study area recorded bat activity between late May and early October in 2013 and all 10 detector stations recorded bat activity during the same time period in 2014. Nearly the same number of bat passes were recorded in each year, but only half as many detectors were deployed in 2014 as in 2013, contributing to a higher mean activity rate in the second year of study. The 2014 rate was likely inflated by the fact that the six stations that were resurveyed were those at which the greatest activity levels were recorded in 2013. Those six sites were resurveyed to elucidate annual variation in bat activity and to target reliable sites for the mist netting and telemetry effort. Five of the six resurveyed sites actually recorded less activity in 2014 than in 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 comparable 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 area, and habitat differences between the coastal forests of Southeast Alaska and the interior forest and shrublands in this study area.

Lausen et al. (2014) conducted similar 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; six 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 12 bat passes per detector- night over the duration of that study was derived from their data (Table 3 in Lausen et al. 2014). Assuming that each of the seven 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 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 in 2013 and 83 bat passes in 2014, both recorded at station G6.

6.1.1. Temporal Comparisons

6.1.1.1. Seasonal Activity

Bats were detected during every month of the study period (late May to early October) in 2013, but were not recorded in June or October in 2014. Parker et al. (1997) observed similar first and last observations of the year (May and October) of bat activity near Fairbanks and suggested that bats in Interior Alaska may not travel far to hibernate. In both years of this study, substantial variability was evident in the monthly activity rates, but those differences were statistically significant only in 2014. In 2013, more stations peaked in July than in any other month and overall bat activity level in that month was roughly twice that detected in August and 1.5 times that in September. In 2014, most stations peaked later in the year (August), although mean activity rates across all detector stations were nearly identical in July and August. Similarly, Tessler et al. (2014) also reported peaks of activity in July and August, based on the information gathered in their "citizen-science" observational study. Increases in activity during these periods may be due to increases in prey abundance or the appearance of volant (flying) juveniles. The lack of consistent bat activity in the study area in May and early June suggests that, although bats may be present, foraging conditions may not be favorable until late June or July. Alternatively, the lack of consistent activity until late June and July may reflect the arrival of migrant bats. Paradoxically, consistent bat activity was detected earlier in the late spring of 2013, when snow and ice cover persisted into June, than in 2014, when the Project area was free of snow and ice at a much earlier date.

In 2013, mean activity rates tended to peak later in the year at higher elevation sites. For instance, activity peaked in September at four stations that were located at some of the highest elevations sampled. In 2014, this pattern was less apparent. In both years, a pulse of activity occurred near the end of September and in early October, after which no bats were recorded for the remainder of the study. Those pulses of activity may indicate prehibernation behavior (McGuire and Guglielmo 2009), premigratory behavior, or migrating bats moving through the study area. Station G3 experienced peak activity levels in September in both 2013 (103 bat passes) and 2014 (48 bat passes). 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. In the Northwest Territories, Lausen et al. (2014) found the greatest species diversity and capture success at the lowest elevation site (820 ft), in contrast to reduced bat activity and capture success at higher elevation sites (>1,968 ft). The effect of elevation on bat distribution is more pronounced at high-latitude locations such as Alaska (Parker et al. 1997); hence, the relatively high elevation of the sites sampled in this study (1,450–2,375 ft) may have contributed to low bat activity rates and capture success.

6.1.1.2. Nightly Activity

Bat activity was recorded only between sunset and sunrise, despite beginning sampling 1 hour before sunset and ending 1 hour after sunrise. Most of the activity probably occurred during periods of low light or of 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, among the darkest hours of the night, for most (June–August) of the months sampled. Outside of these months, when more hours of darkness were available, bats were not necessarily most active during the darkest periods of the night. 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 risk from avian predators (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, which also suggested avoidance of foraging during relatively light periods, similar to another study in southeast Alaska (Loeb et al. 2014). With increasing hours available for foraging in September, a bimodal distribution (two peaks) in the pattern of activity became evident, as has been documented in other studies (Kunz 1973, Erkert 1982, Taylor and O'Neil 1988, Maier 1992, Hayes 1997).

6.1.2. Spatial Comparisons

6.1.2.1. Activity Among Stations

Bat activity varied considerably among the detector stations. In both years, station G6 recorded 1.5 to 2 times more activity than the next most active stations (G3 in 2013 and C22 in 2014). 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 habitat for bats. In addition, Station G6 was located approximately 1 mile upstream from a "highly suitable" section of cliff, where the male bat radio-tagged in July 2014 roosted consistently. Some of the metrics generated from this study were certainly affected by the large number of bat calls recorded at Station G6, but this single station did not exert undue influence on the overall trends observed across the remaining detector stations, with one exception. The results of the habitat and vegetation structure analyses in 2013 appeared to have been driven primarily by Station G6.

6.1.2.2. Activity in Relation to Habitat and Vegetation Structure

Bat activity rates varied among habitat types between years, but most habitat types (pond, stream, cliff) had at least one station with substantial activity. The greatest amount of bat activity occurred in habitat types associated with water (streams and ponds). Similarly, the cliff habitat station that recorded the second greatest activity rate during this study also was associated with water, being located on the Susitna River. Association of bats with water has been widely documented. Slough and Jung (2008) recorded the highest activity rates in riparian and lacustrine habitats in the Yukon and Loeb et al. (2014) found a similar result in Southeast Alaska. 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 because of 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 and 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 in the study area.

The mean activity levels of bats detected among the habitat types sampled in this study were inversely proportional to their spatial extent on the landscape. Pond and stream habitats composed only 11.5 percent of the total acreage of the study area, but represented 84.3 percent of all recorded bat activity in 2013. Most of the remaining activity (15.2 percent) in 2013 occurred in cliff habitats, which constituted 19.7 percent of the study area acreage. It is inappropriate to compare habitats or vegetation structure types in 2014 because the six sites that were resurveyed in that year were not selected randomly.

The mean activity rates of the little brown bats detected in this study were not influenced significantly by vegetation 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 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. (1997a) 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 Sleep and Brigham (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. Loeb et al. (2014) found a similar trend in Southeast Alaska and speculated that denser canopies may offer less light penetration and more darkness, which may provide more protection from predators. The activity rate in the closed forest structure type in this study was driven largely by the single station that recorded the most bat activity during the entire study (G6). Despite the high acreage of the open forest structure type (51.5 percent) in the study area, detectors located in open forests recorded only 3.4 percent of the overall bat activity in 2013. Dwarf forest provided few resources needed by bats in the study area, in view of the fact that the lowest activity rate detected among all habitat and vegetation structure types in 2013 was recorded in that structure type.

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 that the study team mapped in 2013 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) elsewhere in North America. 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). Randall et al. (2014) tracked three adult male little brown bats to mostly natural roosts (cliffs and trees), in contrast to females, which only roosted in buildings. Other studies suggest that female bats use natural roosts (mostly in the form of trees) in northwestern Canada (Crampton and Barclay 1998, Olson and Barclay 2013). Few trees were found in the study area in 2013 that were considered suitable as 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. The preliminary geologic map produced for the Project (see ISR Study 4.5, Geology and Soils Study) details the presence of some limestone in the bat study area, but no caves were discovered by the Geology team (M. Bruen, Geology and Soils Study Lead, personal communication).

6.2.2. Artificial Roosts

The human-made 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). Randall et al. (2014) observed female bats roosting solely in artificial structures while males used mostly natural structures (trees and cliffs), likely due to the rigid temperature requirements for females during pregnancy and lactation. 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.

6.3. Bat Capture and Radio Telemetry

Despite concerted efforts by the study team to capture bats with mist nets during summer and fall 2014, only a single male bat was captured and radio-tagged. That bat yielded 10 days of roosting information for midsummer. The first roost location used after the bat was released was in a cliff section just downstream of the capture location. That cliff section was mapped as having low suitability in the 2013 cliff survey. The bat may have roosted in that location because of the close proximity to the capture site and the lack of darkness to find more appropriate roost sites farther from the capture site. All subsequent relocations of the bat were in cliff sections above the Susitna River about 1 mile from the capture site. This result supports other studies documenting that little brown bats typically forage less than 3 km (1.9 mi) from roost sites (Henry et al. 2002), similar to other vespertilionid bats (Brigham et al. 1997b; Campbell et al. 1996). The majority (90 percent) of relocations occurred in a cliff section classified as having high suitability in the 2013 cliff survey, whereas the remaining 10 percent were in a cliff classified as having moderate suitability. Cliffs identified as high suitability contained more vertical and horizontal cracks and greater depth of cracks than did cliffs classified as moderate suitability. Even though the study team was unable to identify the exact roosting locations of the tagged bat, it was possible to detect general changes in roost-site locations within the cliff sections by radio-tracking from a helicopter.

In general, the study area offers very little roosting habitat in the form of tree roosts and human-made structures. The study team was unable to locate any bats roosting in trees or human-made structures in the study area. After expending considerable effort attempting to document roost sites in the study area, the study team confirmed that the cliffs above the Susitna River offered the most likely roosting locations for little brown bats. This information will be valuable for assessing potential impacts in the Project license application. The relatively high elevation of the study area may have contributed to the low capture success (Lausen et al. 2014) in this investigation. Despite the limited success of the capture efforts in 2014, this effort was the first of its kind to occur in Interior Alaska (D. Tessler, ADF&G, personal communication) and provides useful information for bat management in Alaska.

7. CONCLUSIONS

In 2013 and 2014, AEA completed two years of acoustic monitoring to document bat use of the study area and surveyed the study area for bat roosts. The field work, data collection, data analysis, and reporting for the Bat Study successfully met all study objectives in the FERC-approved Study Plan. The results of the Bat Study are reported herein and earlier by AEA in ISR 10.13 Parts A, B, and C (ABR 2014a, 2014b, 2014c). With this report, AEA has now completed the Bat Distribution and Habitat Use Study.

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9. TABLES

Table 4.1-1. Categorization of Acoustic Detector Stations by Habitat and Forest Structure Types, 2013–2014.

Station	Habitat Type	Forest Structure Type	Year Surveyed
G1	Pond	–	2013
G2	Pond	–	2013
G3	Pond	–	2013, 2014
G4	Pond	–	2013
G5	Upland	Shrub	2013
G6	Stream	Closed	2013, 2014
G7	Pond	–	2013
G8	Upland	Dwarf	2013
G9	Stream	Open	2013
G10	Pond	–	2013, 2014
G11	Upland	Open	2013
G12	Pond	–	2013
G13	Cliff	Closed	2013, 2014
G14	Cliff	Open	2013
G15	Upland	Dwarf	2013
G16	Pond	–	2013, 2014
G17	Upland	Closed	2013
G18	Stream	Shrub	2013
G19	Cliff	Shrub	2013, 2014
G20	Stream	Dwarf	2013
C21	Pond	–	2014
C22	Cliff	Closed	2014
C23	Cliff	Open	2014

Station	Habitat Type	Forest Structure Type	Year Surveyed
C24	Stream	Open	2014

Table 4.2-1.Quality Scores for Potential Cliff-Roosting Habitat, 2013.

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 5.1-1. Number and Percentage of Nights Surveyed by Acoustic Detector Stations in 2013, and 2014.

	2013			2014		
Station	Number of Nights in Sampling Period	Number of Nights Actually Surveyed	Percentage of Nights Surveyed	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	150	150	100
G4	139	139	100	–	–	–
G5	139	139	100	–	–	–
G6	142	142	100	150	150	100

	2013			2014		
Station	**Number of Nights in Sampling Period**	**Number of Nights Actually Surveyed**	**Percentage of Nights Surveyed**	**Number of Nights in Sampling Period**	**Number of Nights Actually Surveyed**	**Percentage of Nights Surveyed**
G7	136	101	74.3	–	–	–
G8	140	140	100	–	–	–
G9	137	113	82.5	–	–	–
G10	140	140	100	149	149	100
G11	138	138	100	–	–	–
G12	140	140	100	–	–	–
G13	140	140	100	149	149	100
G14	139	139	100	–	–	–
G15	140	131	93.6	–	–	–
G16	136	136	100	149	149	100
G17	136	136	100	–	–	–
G18	136	112	82.4	–	–	–
G19	136	127	93.4	149	149	100
G20	136	136	100	–	–	–
C21	-	-	-	133	109	82.0
C22	-	-	-	132	121	91.7
C23	-	-	-	134	134	100
C24	-	-	-	133	110	82.7
Total	2,767	2,660	96.1	1,428	1,370	95.9

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 6.31-3. Bat Activity (Bat Passes per Detector-Night) by Station and Month, 2014.

	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]
G3	0	-	17	0	-	30	0.06	0.04	31	0.58	0.18	31	1.60	0.57	30	0	-	11	0.45	0.13	150
G6	0.12	0.12	17	0	-	30	5.77	3.27	31	2.68	1.08	31	0.87	0.28	30	0	-	11	1.93	0.73	150
G10	0	-	17	0	-	30	0.03	0.03	31	0.39	0.10	31	0	-	30	0	-	10	0.09	0.03	149
G13	0	-	17	0	-	30	0.45	0.16	31	0.77	0.47	31	0	-	30	0	-	10	0.26	0.10	149
G16	0	-	17	0	-	30	0.42	0.42	31	0.13	0.06	31	0.20	0.14	30	0	-	10	0.15	0.09	149
G19	0	-	17	0	-	30	0.06	0.04	31	0.13	0.06	31	0	-	30	0	-	10	0.04	0.02	149
C21	0	-	1	0	-	26	0.17	0.08	24	0.28	0.11	18	0.07	0.05	30	0	-	10	0.10	0.03	109
C22	0	-	0	0	-	30	1.10	0.45	31	2.84	1.03	31	1.26	0.42	19	0	-	10	1.21	0.31	121
C23	0	-	1	0	-	30	0.16	0.09	31	0.42	0.14	31	0.30	0.17	30	0	-	11	0.20	0.06	134
C24	0	-	1	0	-	30	0.11	0.11	19	0.23	0.14	31	0	-	19	0	-	10	0.08	0.04	110
Total	0.02	0.02	105	0	-	296	0.88	0.36	291	0.87	0.17	297	0.41	0.08	278	0	0	103	0.46	0.09	1,370

Notes:

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

Table 5.1-4. 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 5.1-5. Elevation and Minimum Distances to Water Bodies and Cliffs, by Station, 2014.

		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]
G3	2,242	140	1,589	3,568	8,961	12,198	8,961	10,364
G6	1,829	2,899	12	5,906	1,417	1,417	7,380	6,910
G10	2,031	0	3,542	3,276	2,903	2,903	10,371	8,622
G13	1,680	6,523	1,688	210	603	3,231	603	7,594
G16	1,751	33	232	724	5,267	5,267	6,112	17,729
G19	1,968	9,331	72	131	336	25,377	14,501	336
C21	2,375	0	2,953	4,261	5,125	5,765	5,125	5,813
C22	1,450	4,461	5,151	0	58	249	58	3,306
C23	1,528	6,700	4,357	0	431	3,165	4,719	431
C24	1,588	2,089	73	502	900	900	16,394	1,307

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 5.1-6. 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 5.1-7. 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 5.1-8. Acreage of Habitat and Vegetation Structure Types in Bat Study Area, 2013 and 2014.

	Habitat Type					
Vegetation Structure Type	Pond	Stream	Cliff	Upland	Susitna River	Total
Closed	9	612	2,212	3,642	–	6,475
Open	309	1,472	2,720	10,213	–	14,714
Dwarf	3	90	421	1,426	–	1,939
Shrub	432	269	273	4,067	–	5,042
Water	272	133	1,962	0	2,169	4,536
Unclassified	3	77	13	326	–	419
Total	1,027	2,653	7,601	19,674	–	33,124

Table 6.3. Bat Activity (Bat Passes per Detector-Night) by Month and Habitat Type, 2014.

	Pond			Stream			Cliff			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]
May	0	–	52	0.11	0.11	18	0	–	35	0.02	0.02	105
June	0	–	116	0	–	60	0	–	120	0	–	296
July	0.17	0.11	117	3.62	2.06	50	0.44	0.13	124	0.88	0.36	291
August	0.35	0.07	111	1.45	0.56	62	1.04	0.30	124	0.87	0.17	297
September	0.47	0.16	120	0.53	0.18	49	0.30	0.10	109	0.41	0.08	278
October	0	–	41	0	–	21	0	–	41	0	–	103
Total	0.21	0.04	557	1.15	0.42	260	0.39	0.07	553	0.46	0.09	1370

Notes:

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

Table 5.1-10. Bat Activity (Bat Passes per Detector-Night) by Month and Vegetation Structure Type for Non-Pond Habitats, 2014.

	Open			Closed			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]
May	0	–	2	0.06	0.06	34	0	–	17	0.04	0.04	53
June	0	–	60	0	–	90	0	–	30	0	–	180
July	0.14	0.07	50	2.44	1.12	93	0.06	0.04	31	1.36	0.60	174
August	0.32	0.10	62	2.10	0.53	93	0.13	0.06	31	1.18	0.27	186
September	0.18	0.11	49	0.63	0.16	79	0	–	30	0.37	0.09	158
October	0	–	21	0	–	31	0	–	10	0	–	62
Total	0.15	0.04	244	1.13	0.28	420	0.04	0.02	149	0.63	0.15	813

Notes:

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

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

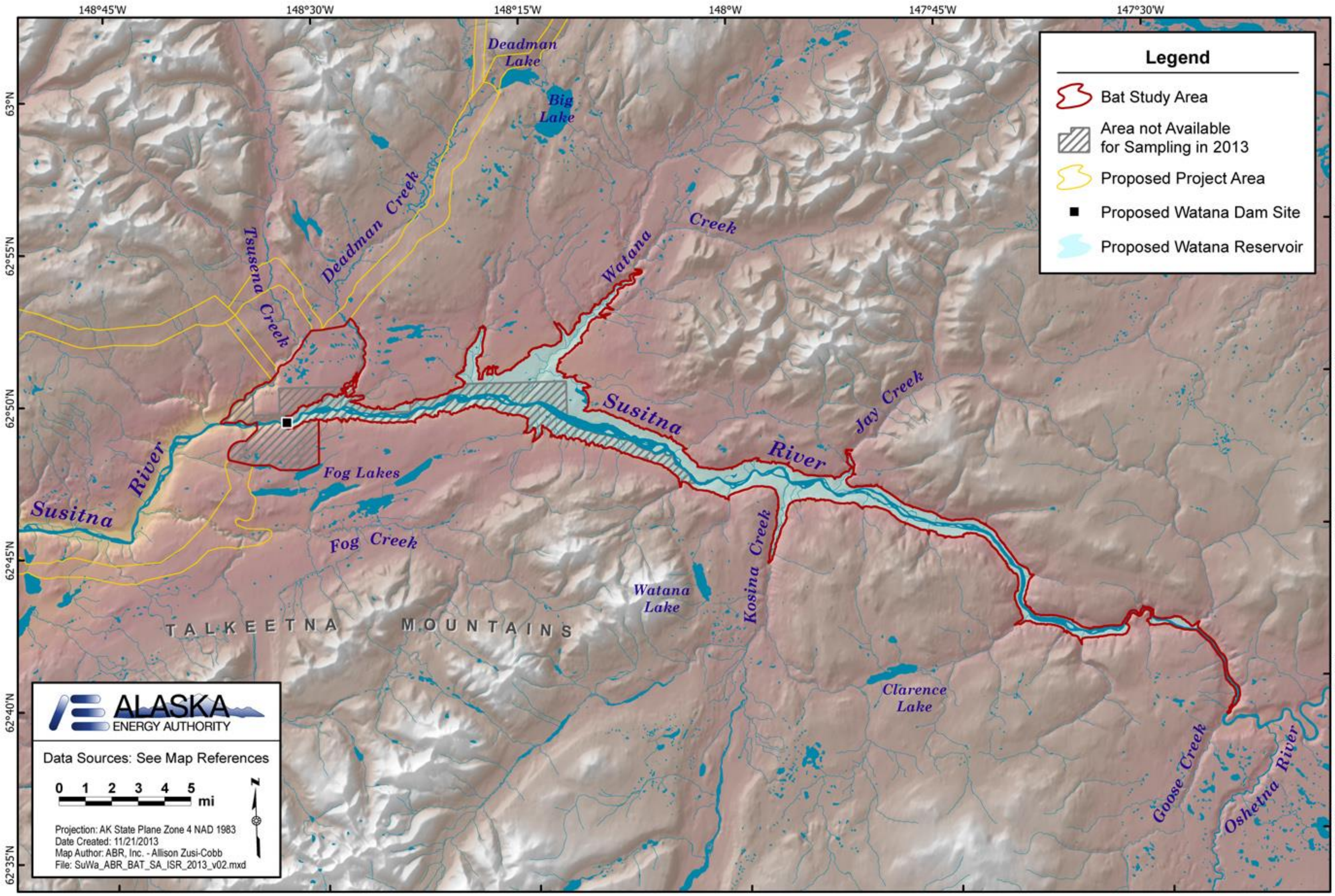

Figure 3-1. Bat Study Area for the Susitna–Watana Hydroelectric Project, 2013 and 2014.

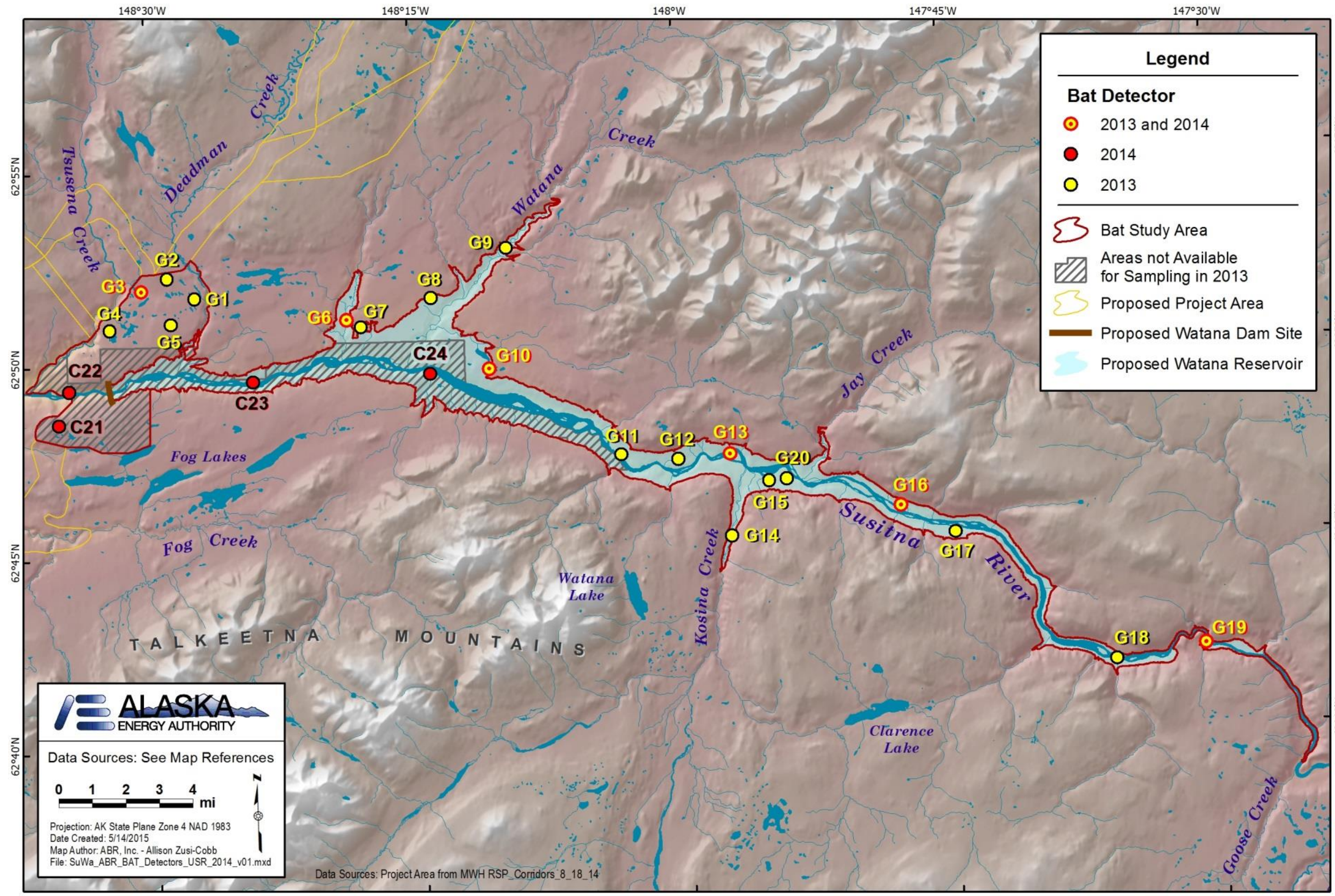

Figure 4.1-1. Acoustic Detector Sites Monitored for the Bat Study in 2013 and 2014.

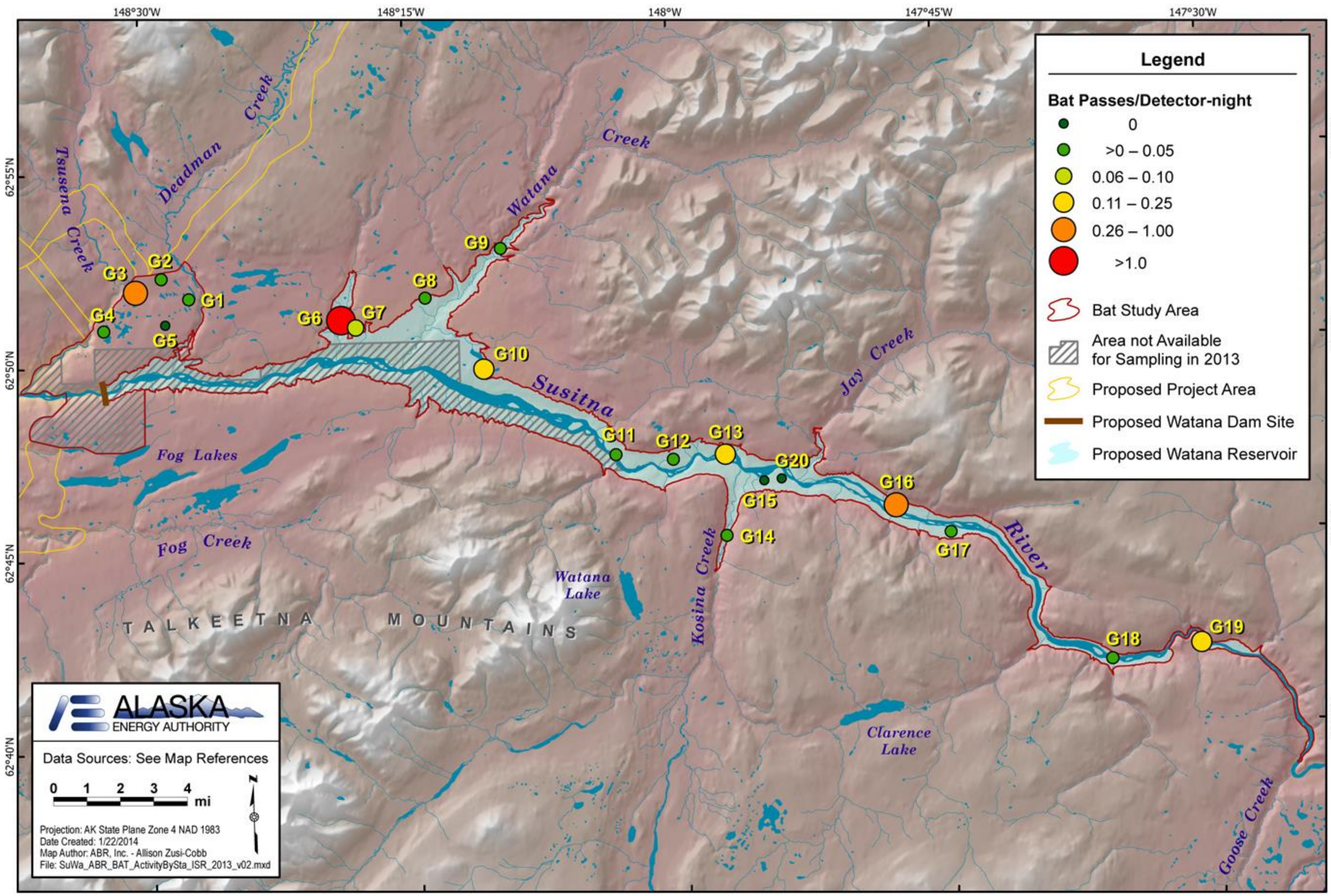

Figure 5.1-1. Distribution of Bat Activity Among Acoustic Detector Stations, 2013.

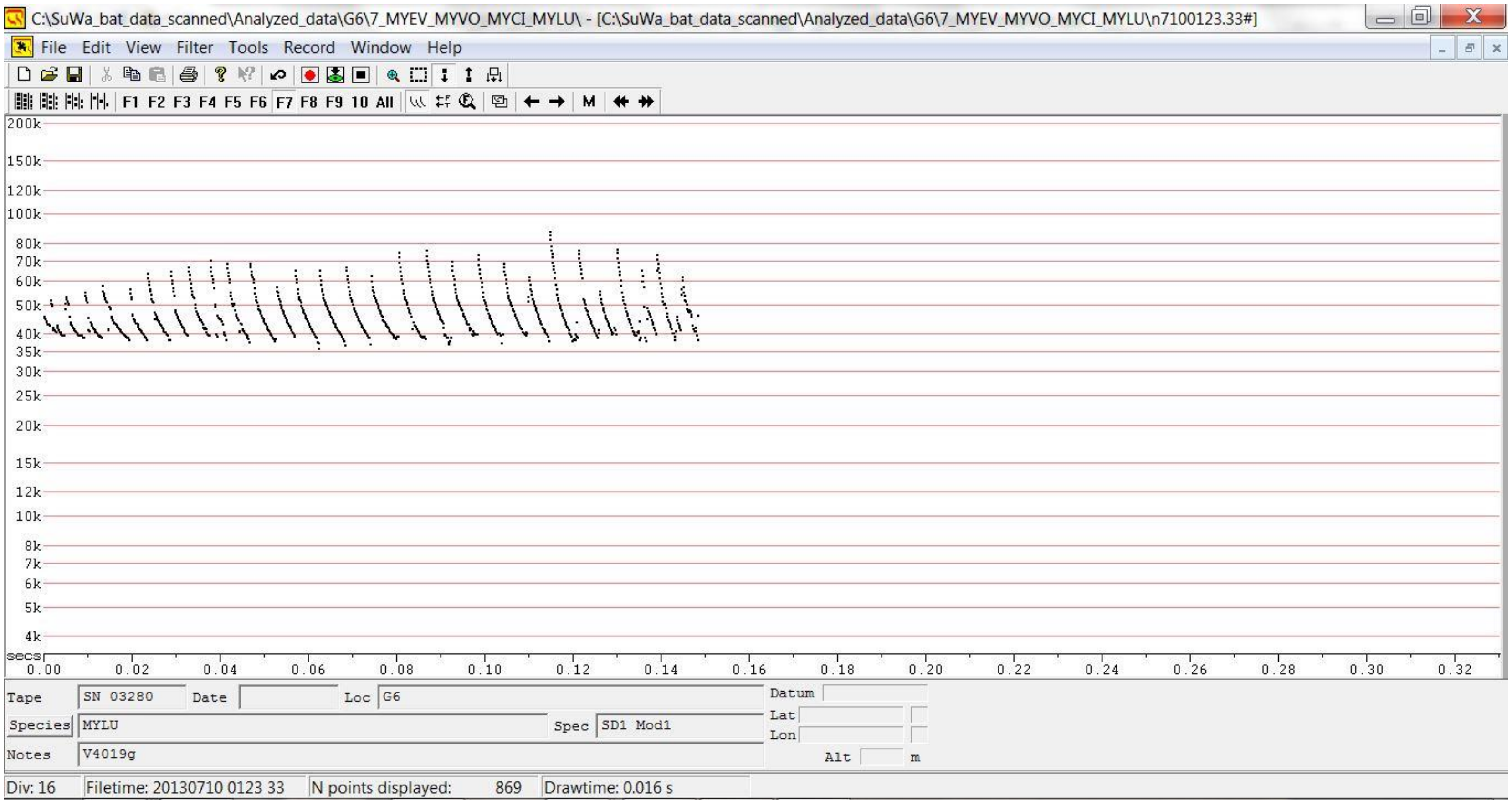

Figure 6.31-2. Representative Sonogram from Little Brown Bat Recorded during the Bat Study, 2013 and 2014.

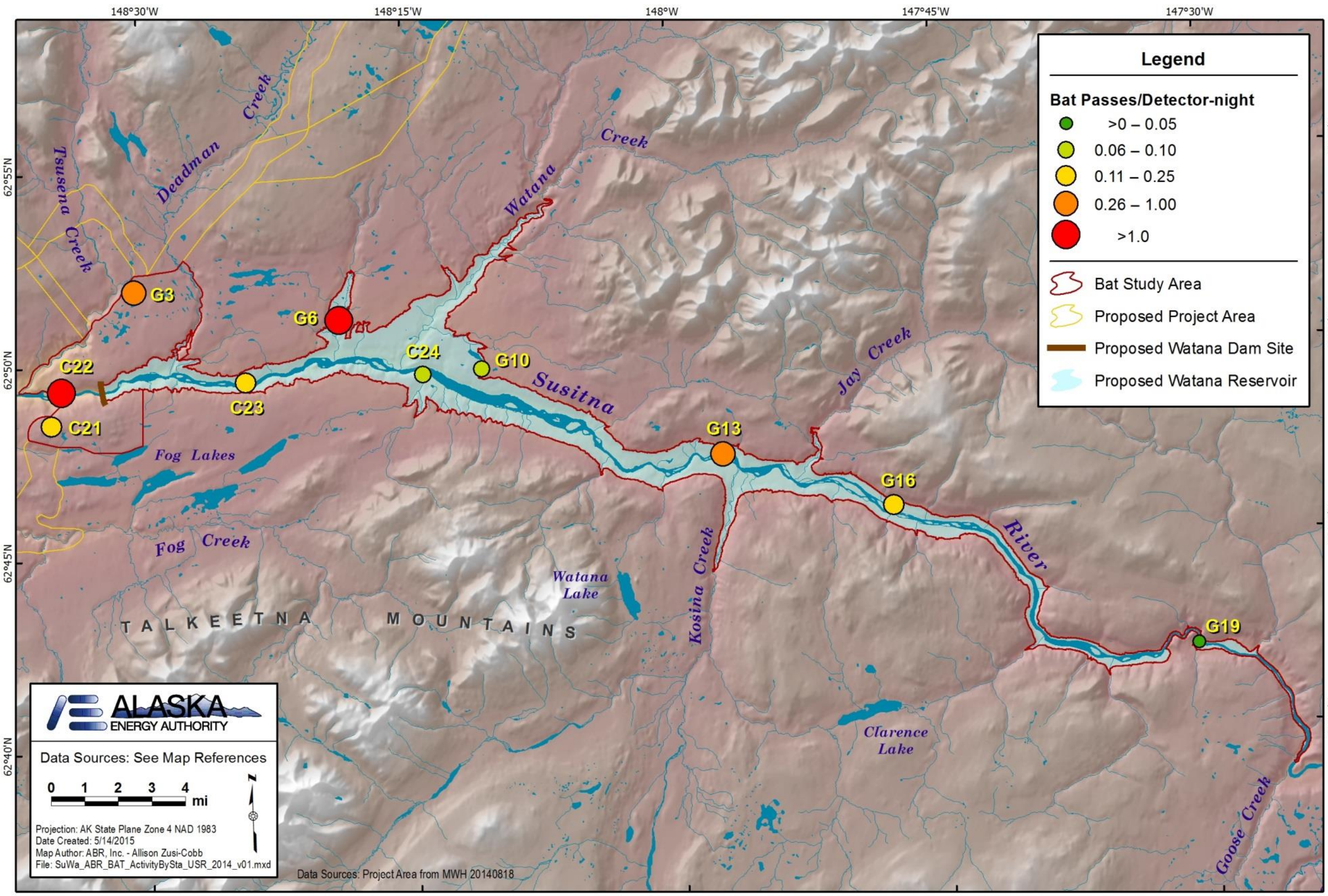

Figure 5.1-3. Distribution of Bat Activity Among Acoustic Detector Stations, 2014.

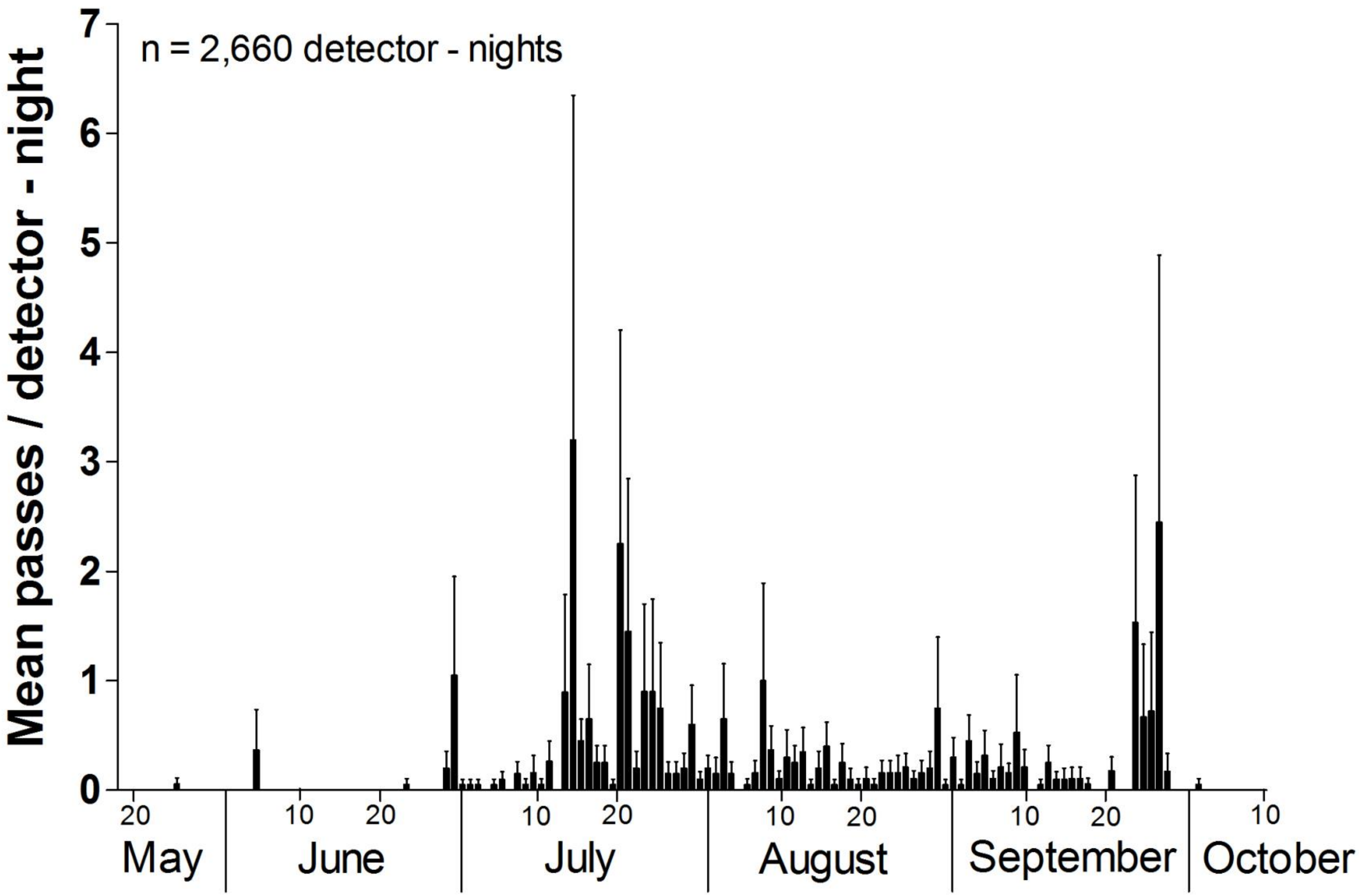

Figure 5.1-4. Bat Activity by Date, 2013 (error bars indicate SE).

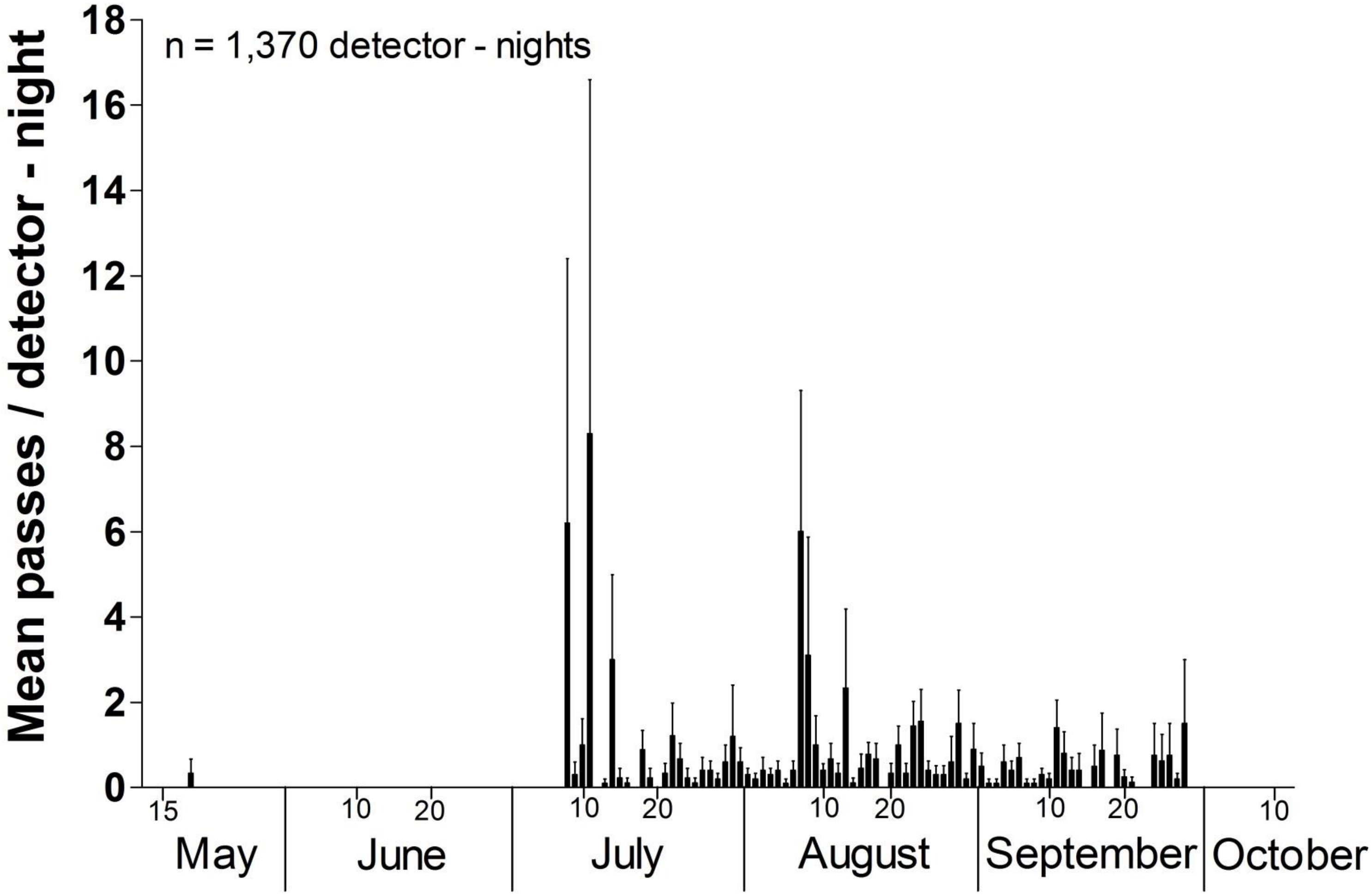

Figure 6.31-5. Bat Activity by Date, 2014 (error bars indicate SE). Note different scale than for 2013 figure.

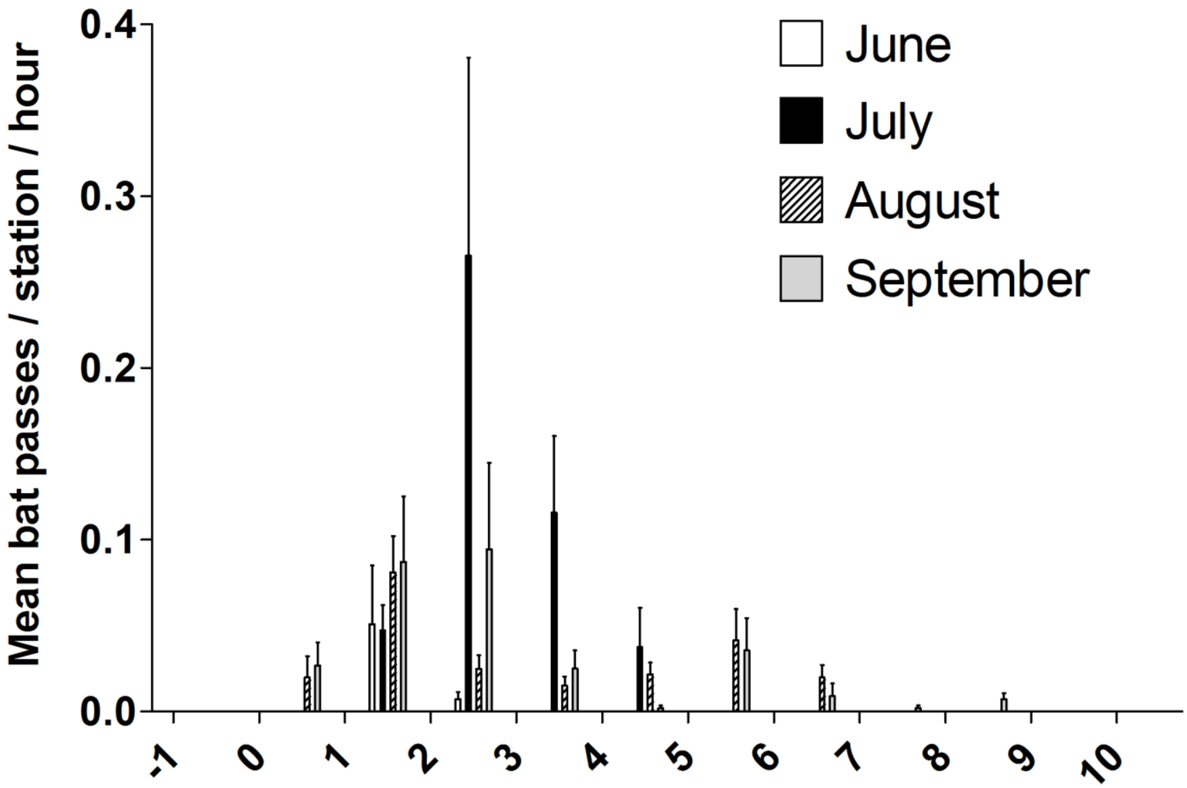

Figure 6.31-6. Bat Activity by Hour in Relation to Sunset, 2013 (error bars indicate SE).

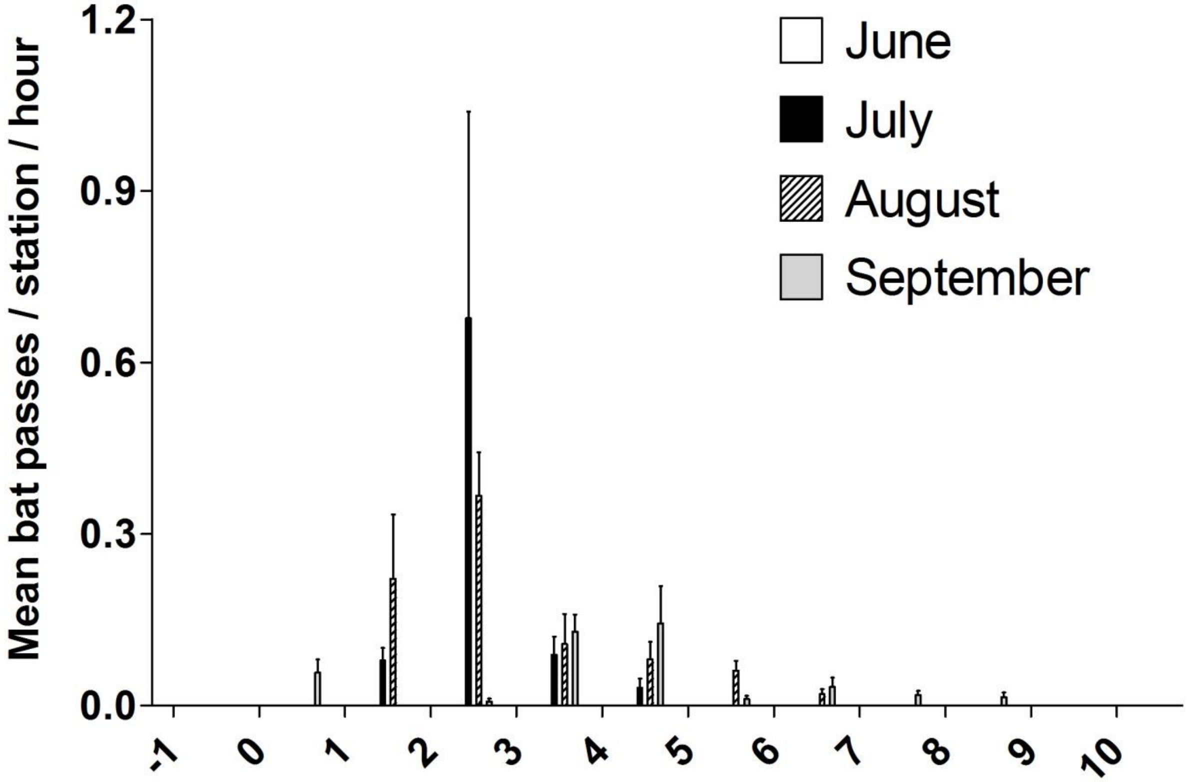

Figure 6.31-7. Bat Activity by Hour in Relation to Sunset, 2014 (error bars indicate SE; note different vertical scale than in 2013 figure).

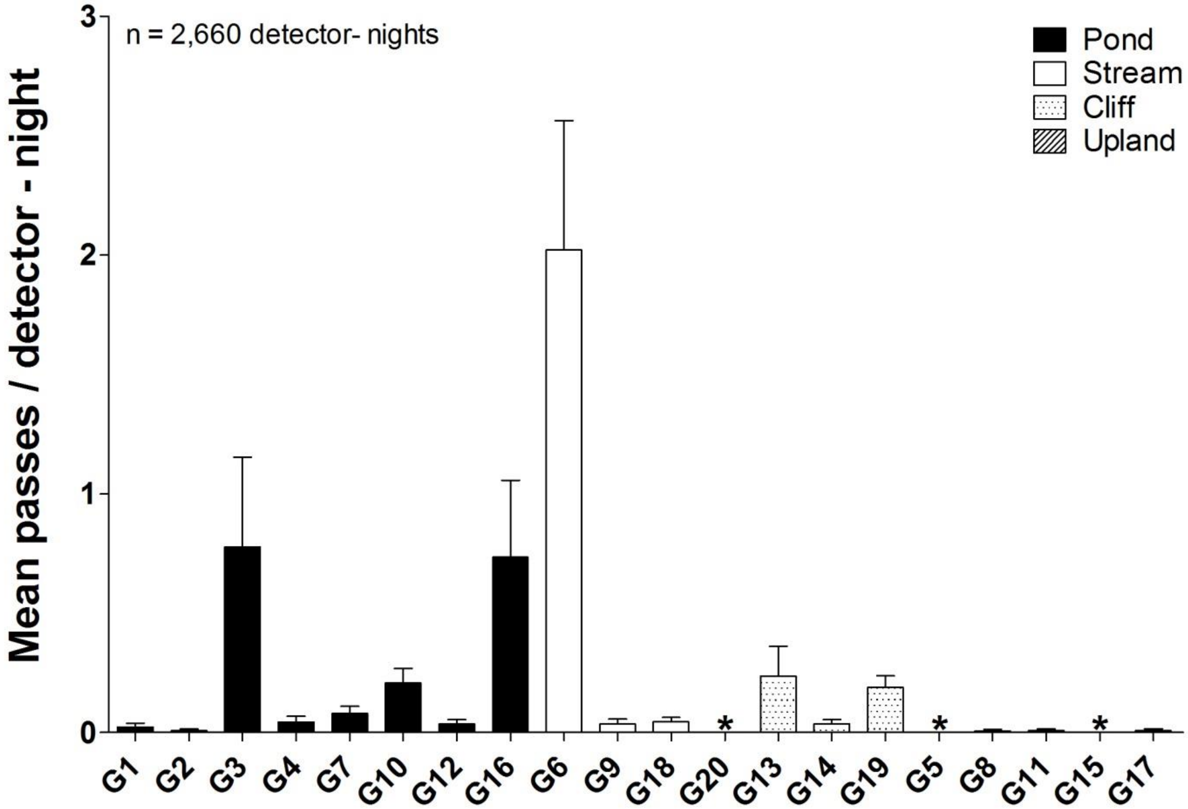

Figure 6.31-8. Bat Activity by Station by Habitat Type (Pond: G1, G2, G3, G4, G7, G10, G12, G16; Stream: G6, G9, G18, G20; Cliff: G13, G14, G19; Upland: G5, G8, G11, G15, G17) in 2013 (error bars indicate SE and asterisks indicate that no bats were detected).

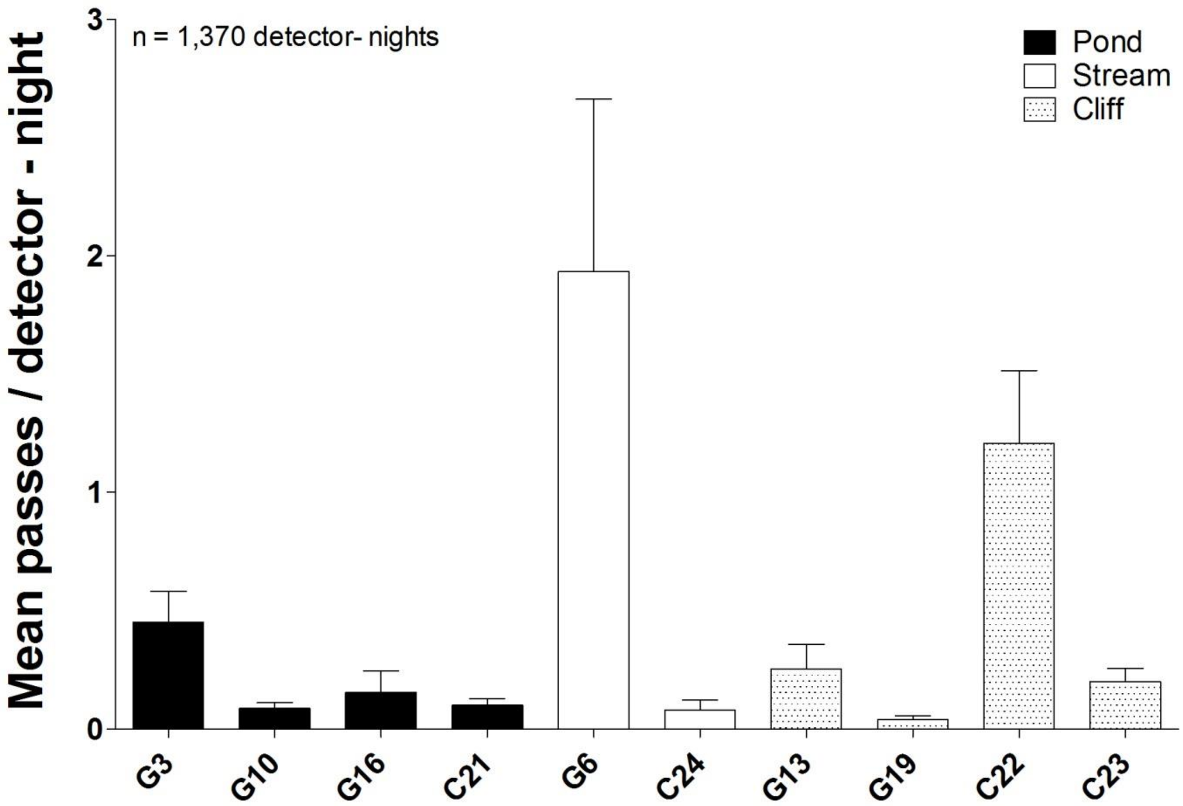

Figure 5.1-9. Bat Activity by Station in 2014 (error bars indicate SE).

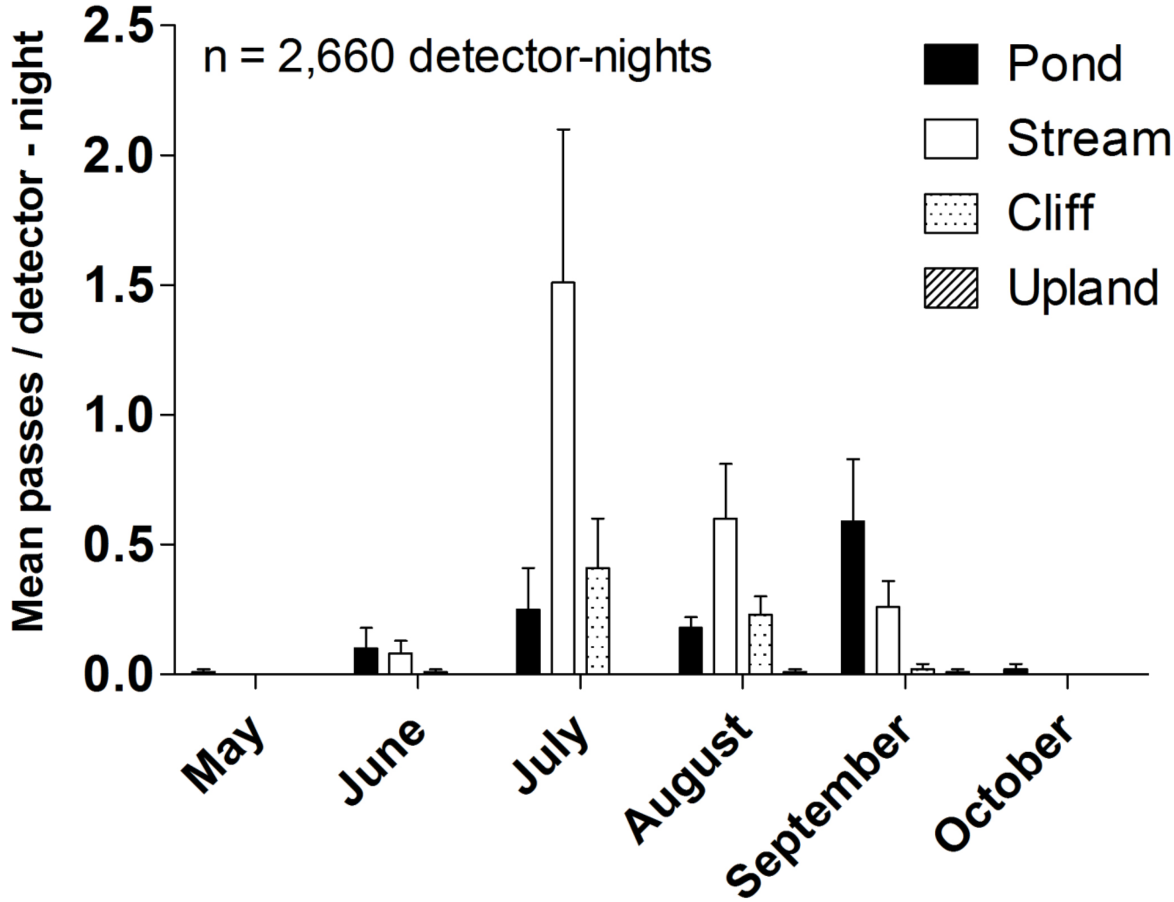

Figure 6.31-10. Bat Activity by Month and Habitat Type, 2013 (error bars indicate SE).

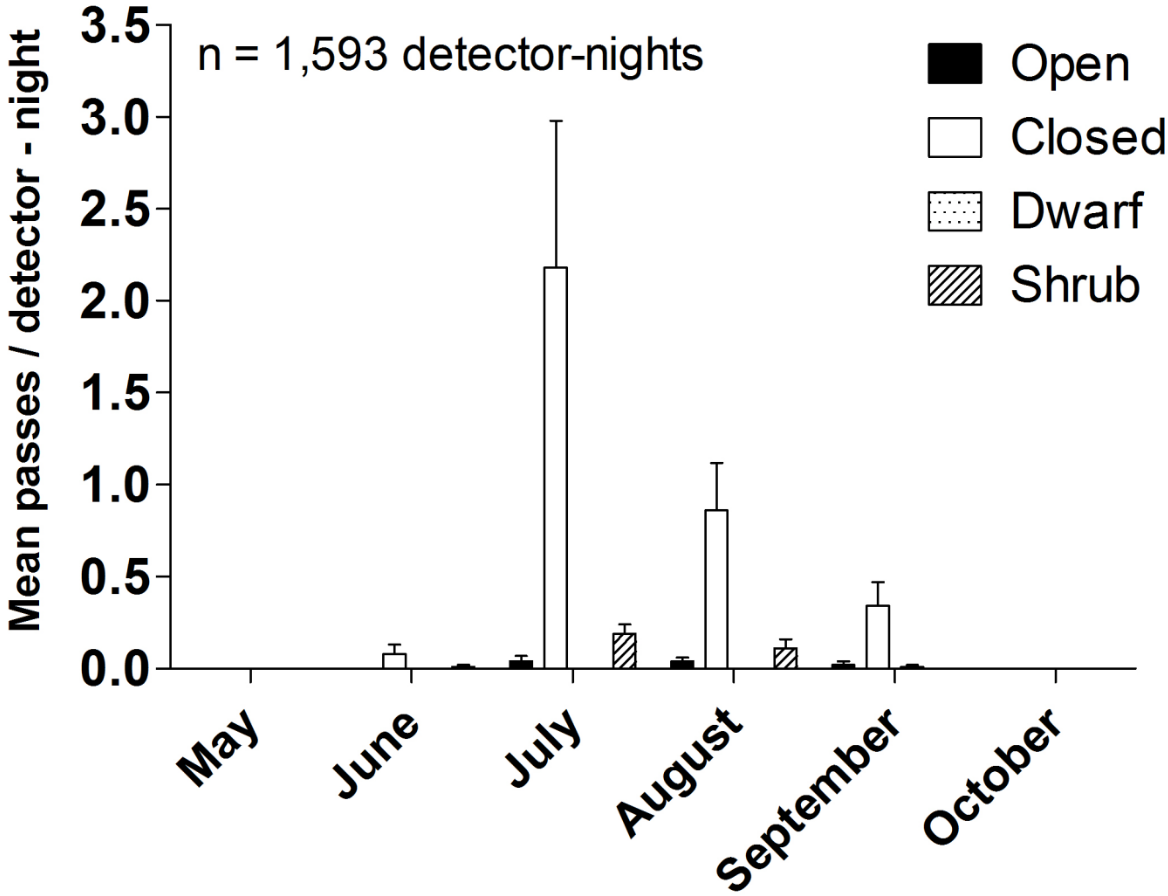

Figure 5.1-11. Bat Activity by Month and Forest Structure Type for Non-Pond Habitats, 2013 (error bars indicate SE).

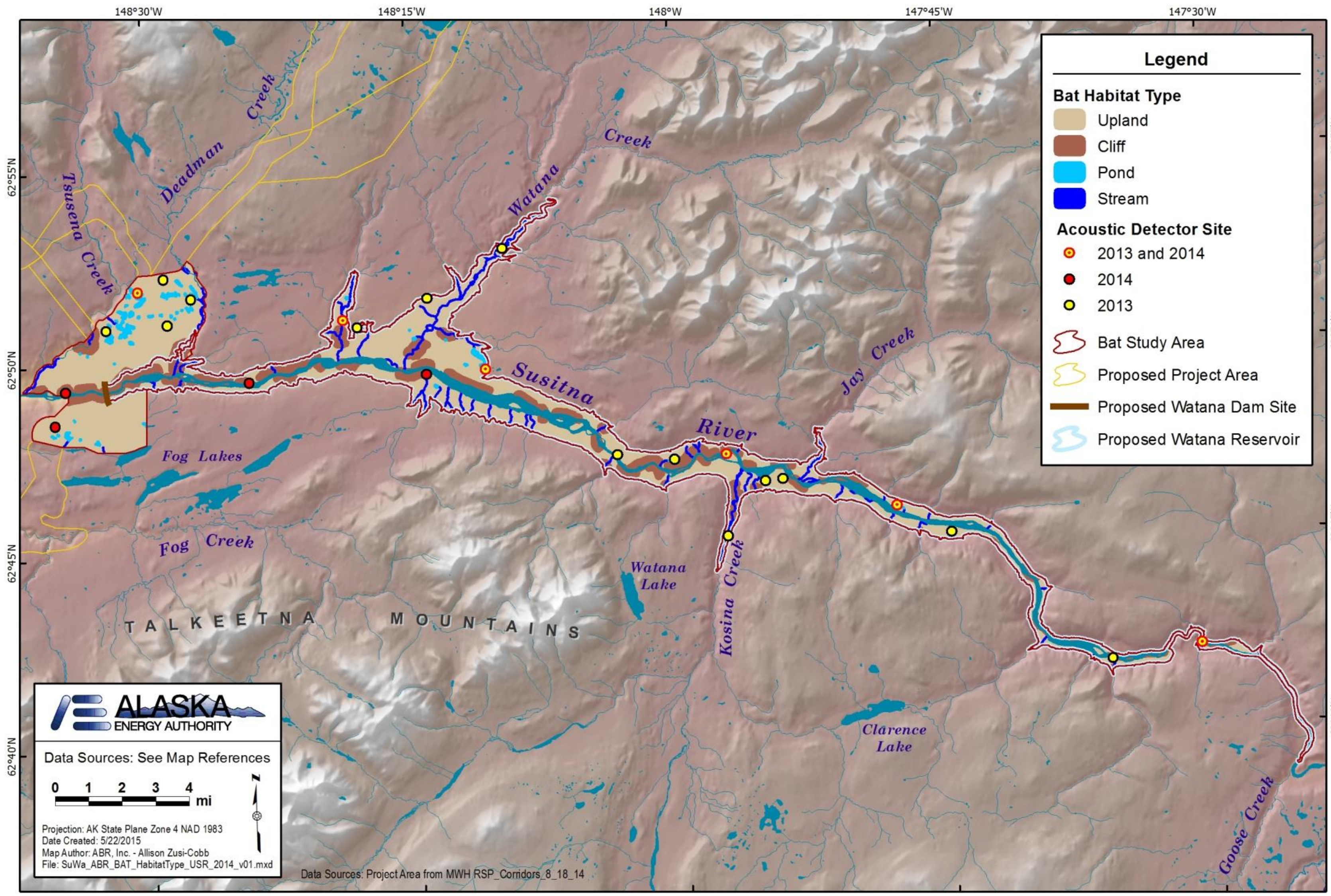

Figure 5.1-12. Distribution of Habitat Types in Bat Study Area, in Relation to Acoustic Detector Sites, 2013 and 2014.

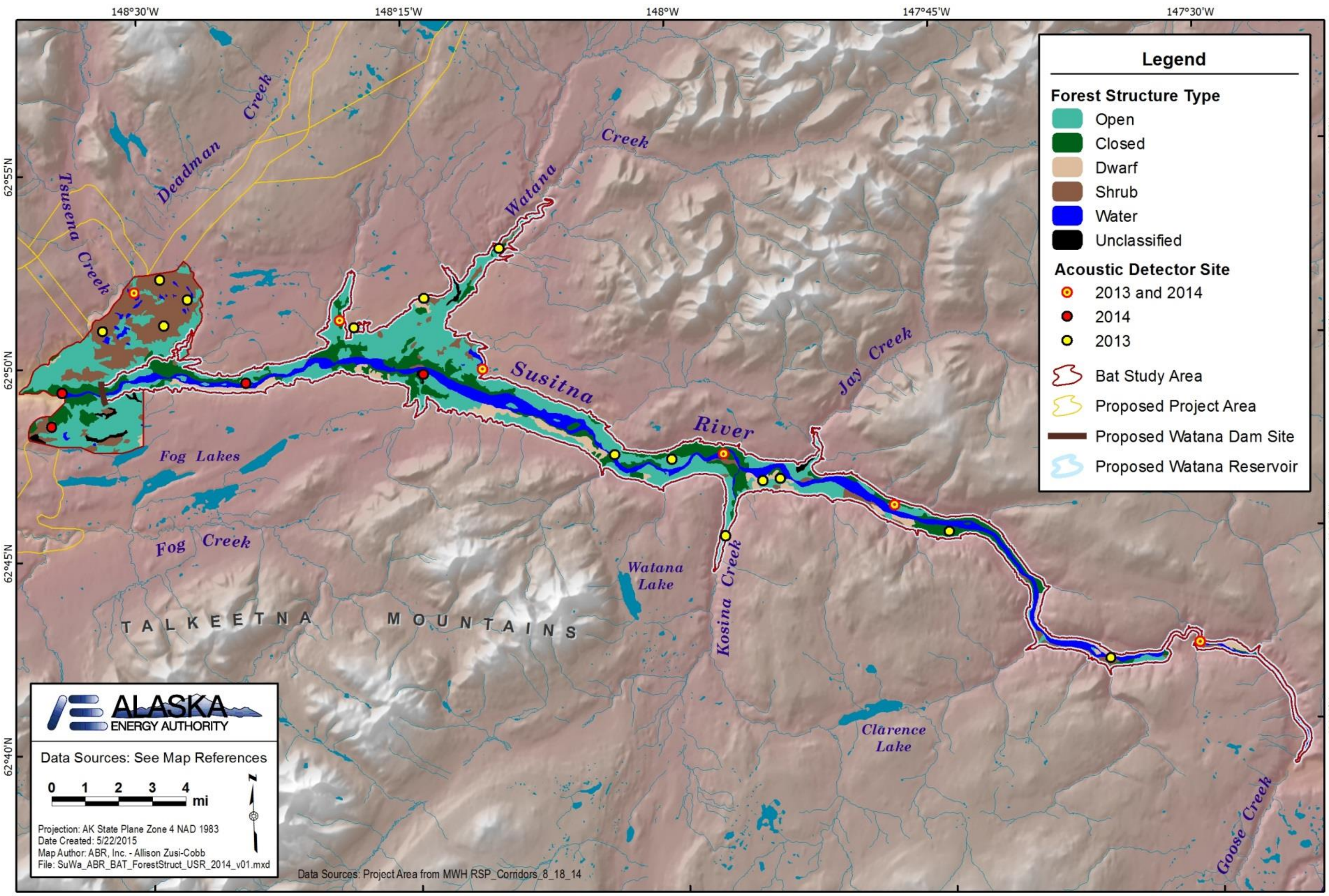

Figure 5.1- 13. Distribution of Vegetation Structure Types in Bat Study Area, in Relation to Acoustic Detector Sites, 2013 and 2014.

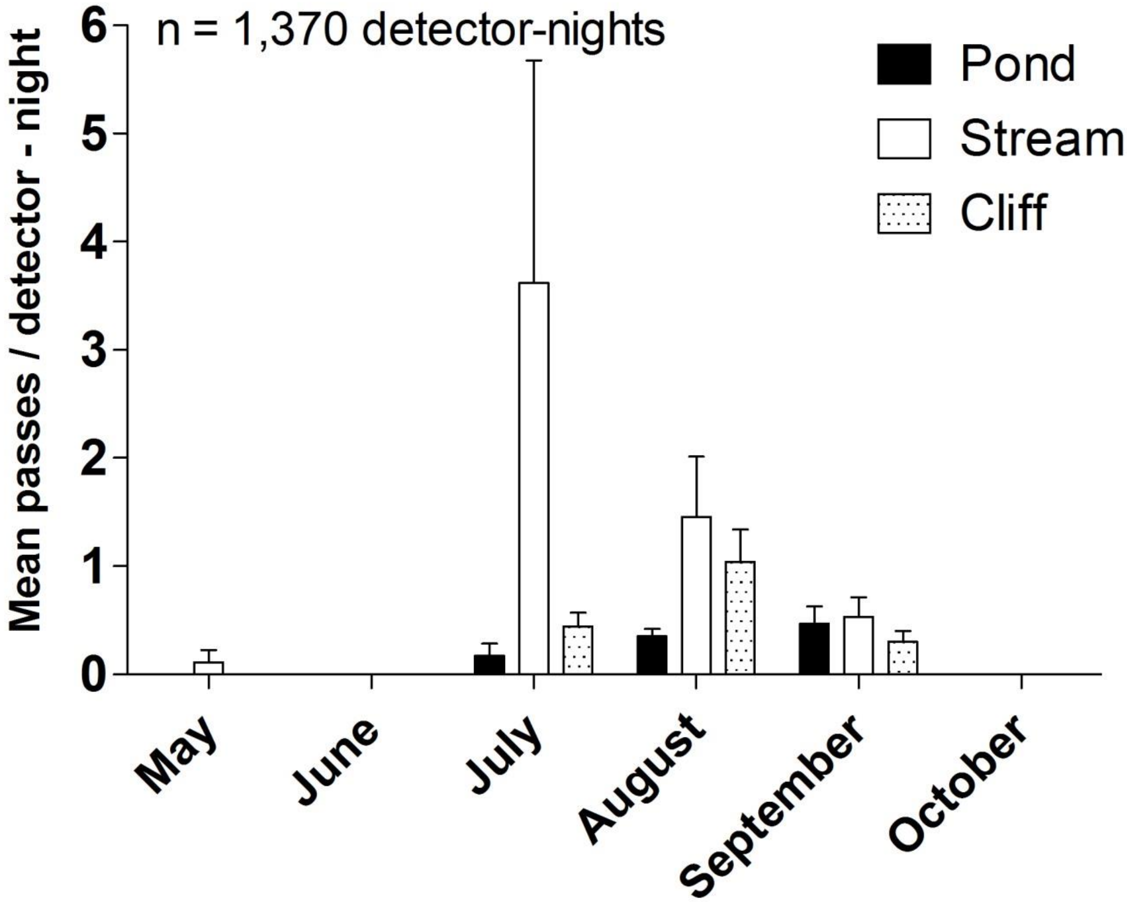

Figure 6.31-14. Bat Activity by Month and Habitat Type, 2014 (error bars indicate SE). Note different scale than for 2013 data.

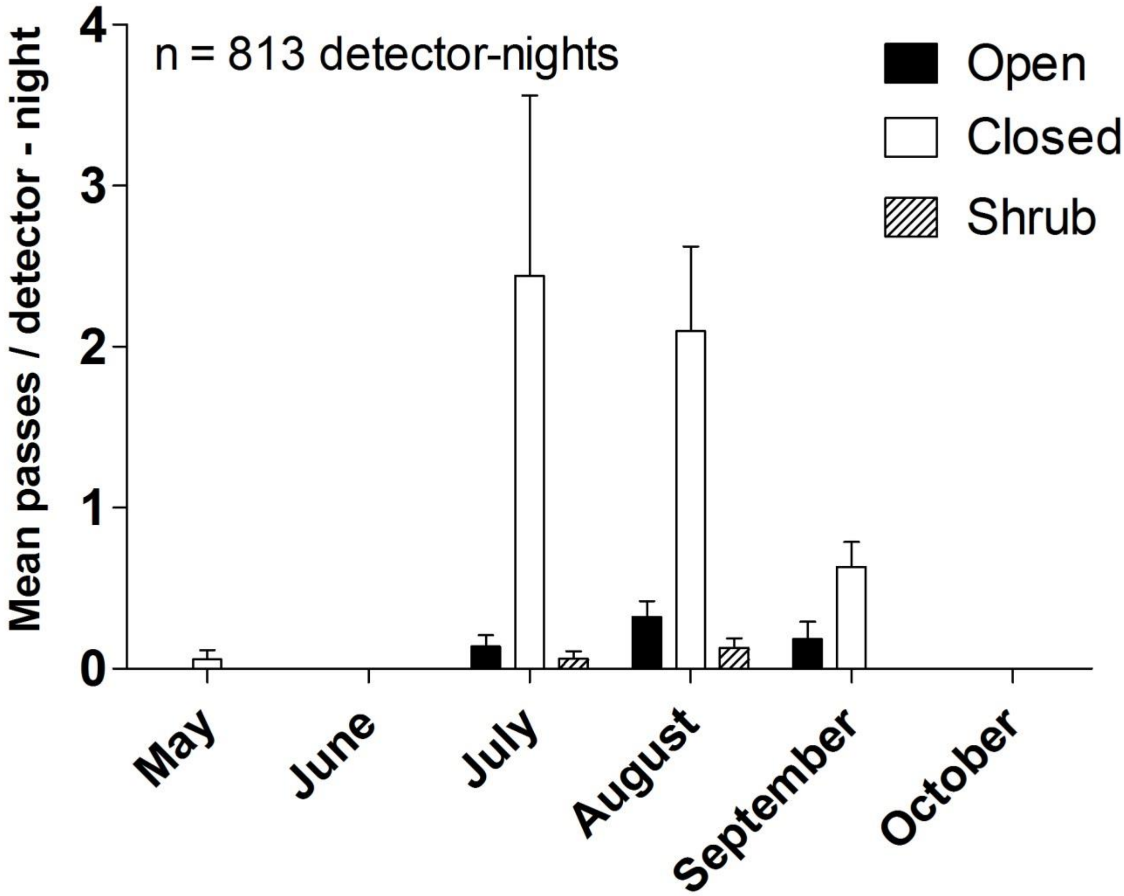

Figure 5.1-15. Bat Activity by Month and Vegetation Structure Type for Non-Pond Habitats, 2014 (error bars indicate SE). Note different scale than for 2013 figure.

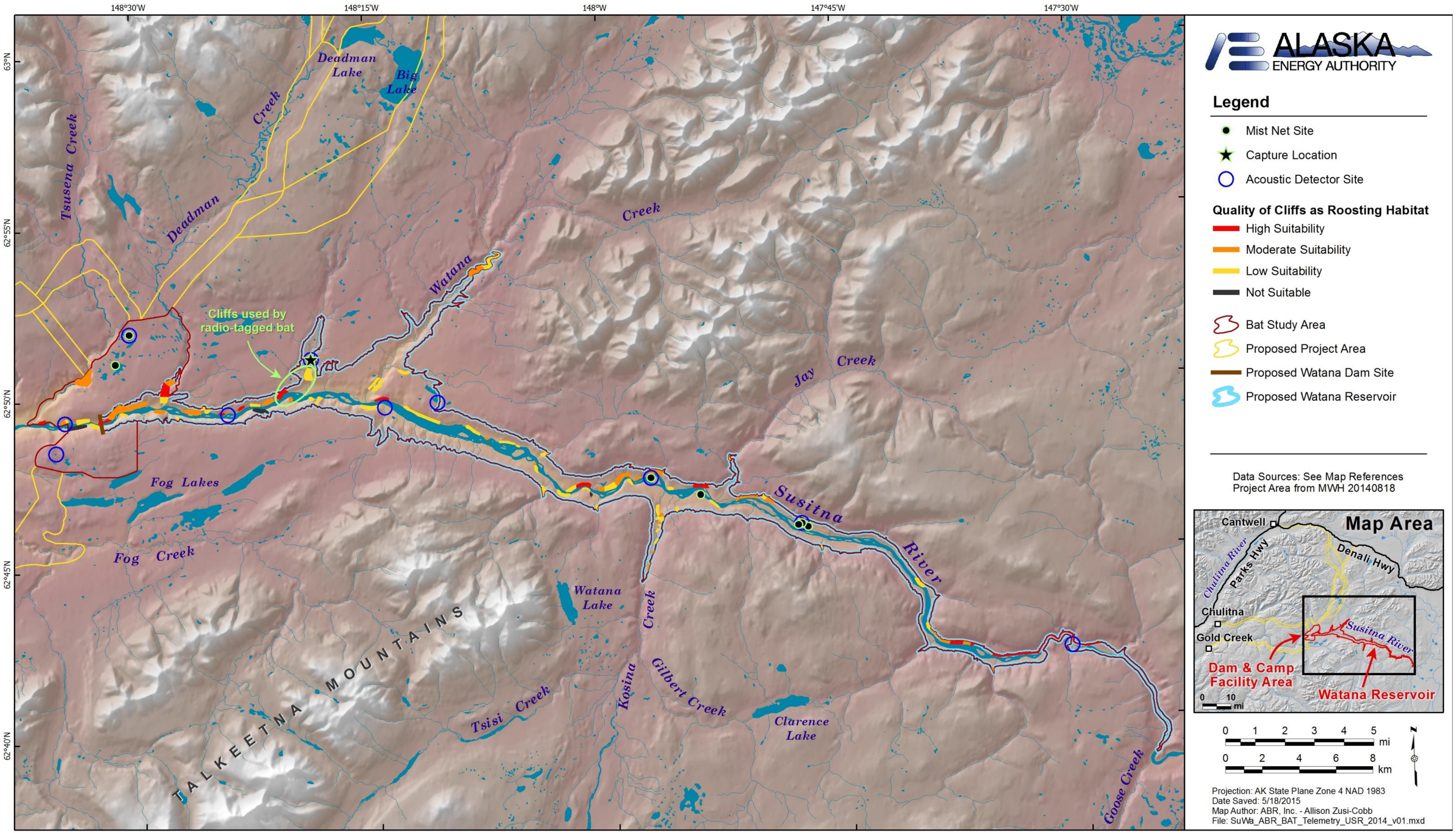

Figure 5.2-1. Mist-Net Sites in 2014 and Cliffs used by Radio-tagged Bat in 2014, in Relation to Cliff Habitats Surveyed in 2013.

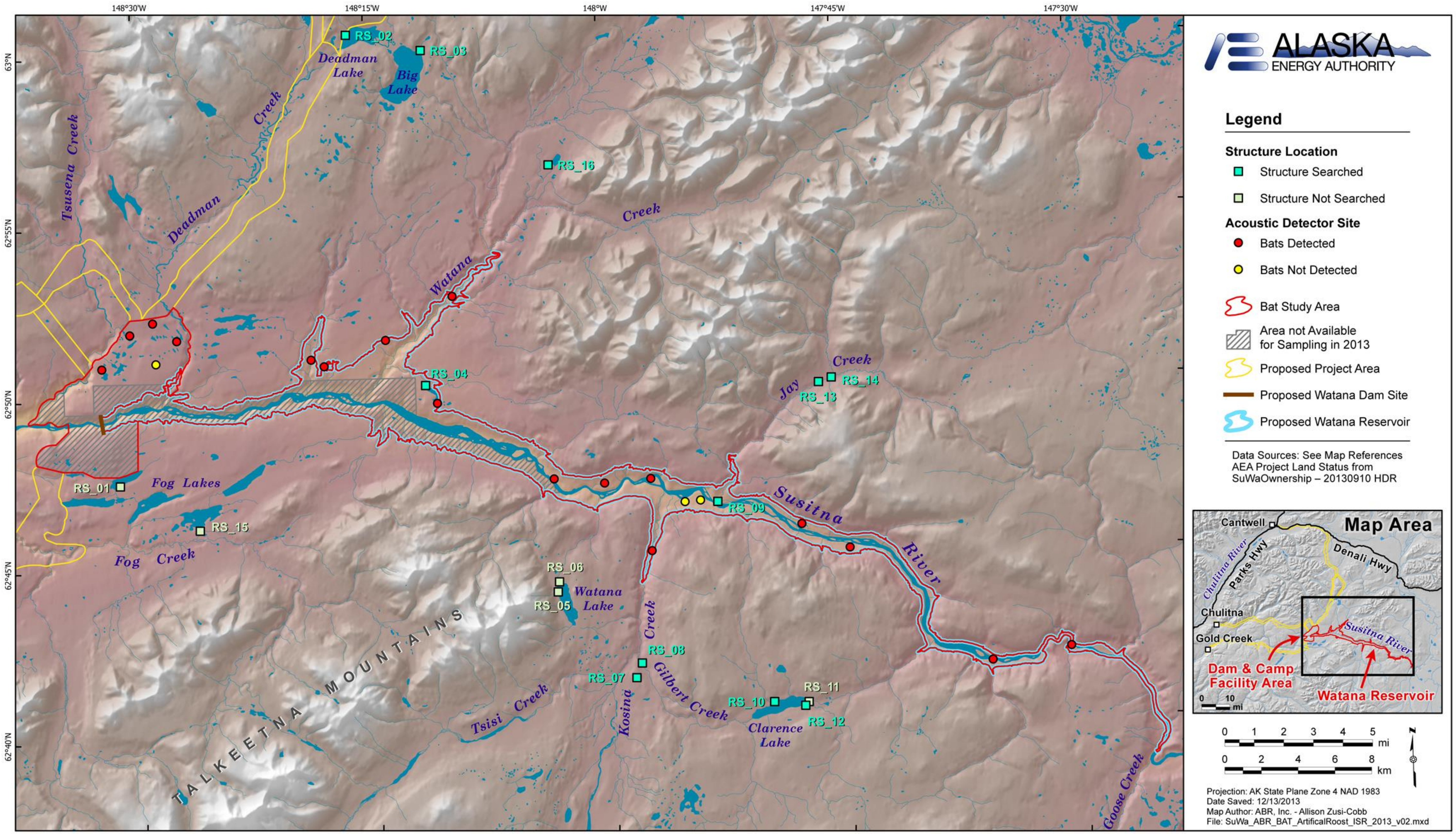

Figure 5.2-2. Locations of Buildings Searched on Artificial-Roost Surveys, in Relation to Acoustic Detector Sites, 2013. While CIRWG lands were not accessed in 2013, there are no known structures on CIRWG lands within the study area.