Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Waterbird Migration, Breeding, and Habitat Use
Study Plan Section 10.15

Initial Study Report

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

LIST OF ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

Abbreviation	Definition
ABR	ABR, Inc.—Environmental Research & Services
ADF&G	Alaska Department of Fish and Game
agl	above ground level
AEA	Alaska Energy Authority
ANOVA	Analysis of Variance
AOU	American Ornithologists' Union
APA	Alaska Power Authority
CIRWG	Cook Inlet Regional Working Group
CSD	circular standard deviation
CUROL	Clemson University Radar Ornithology Lab
CWS	Canadian Wildlife Service
ESM1	Watana Camp Meteorological Station
df	degrees of freedom
FERC	Federal Energy Regulatory Commission
ft	foot, feet
GHz	gigahertz
GIS	Geographic Information System
GPS	Global Positioning System
GVEA	Golden Valley Electric Association
h	hour
ha	hectares
ILP	Integrated Licensing Process
ISR	Initial Study Report
km	kilometer

Abbreviation	Definition
kt	knots
kW	kilowatt
m	meter
µsec	microsecond
mi	mile
min	minute
mi/h	miles per hour
m/s	meters per second
PAD	Pre-application Document
PRM	Project River Mile
Project	Susitna-Watana Hydroelectric Project
QA/QC	Quality Assurance/Quality Control
r	mean vector length
RSP	Revised Study Plan
SE	Standard Error
SPD	Study Plan Determination
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
V	volts

EXECUTIVE SUMMARY

Waterbird Migration, Breeding, and Habitat Use 10.15	
Purpose	The goal of the Waterbird Migration, Breeding, and Habitat Use Study is to collect baseline data on waterbirds migrating through and breeding in the Project area to enable assessment of the potential impacts of the Project and to inform the development of appropriate protection, mitigation, and enhancement measures.
Status	The first year of data collection and analysis was completed successfully in 2013.
Study Components	This multi-year study consists of the following components: 1. Aerial surveys of water bodies during the spring and fall migration periods throughout a large study area; 2. Ground-based visual and radar surveys of diurnal and nocturnal avian migration at a sampling site near the proposed Watana dam location; 3. Aerial surveys for breeding waterfowl; 4. Aerial stream surveys for Harlequin Ducks during the pre-nesting and brood-rearing periods; 5. Aerial brood-rearing surveys for other waterbirds; and 6. Collection of tissue samples for laboratory analysis of mercury levels.
2013 Variances	For aerial surveys, the number of surveys flown during migration was reduced by three surveys during spring and two surveys during fall to maintain a 5-day interval between surveys, each of which typically required more than one day to complete (RSP Section 10.15.4.1.1). The “breeding-pair survey” proposed in the Study Plan (RSP Section 10.15.4.2.1) was replaced with “breeding population survey,” which is a more inclusive survey method. Harlequin Duck surveys were restricted to 10 river miles beyond the study area buffer due to logistical constraints (RSP Section 10.15.4.2.2). After further clarification of the scope, objectives, limitations, and historical justification of the ground-based visual and radar methodologies proposed in the Study Plan, USFWS dropped its recommendation (which was accepted by FERC in the February 1 Study Plan Determination) for use of four observers for visual surveys during migration studies, so visual surveys were conducted using a single observer, as originally described in RSP Section 10.15.4.1.2.

	The Study Plan study objective for acquiring tissue samples of piscivorous waterbirds for laboratory analysis of mercury levels, which was based on opportunistically finding nests during breeding aerial surveys and visiting those nests after the nesting season to collect feather samples (RSP Section 10.15.4.3), was not met during the 2013 study season. Fewer nests of piscivorous waterbirds were found than expected during breeding aerial surveys in 2013.
Steps to Complete the Study	As explained in the cover letter to this draft ISR, AEA's plan for completing this study will be included in the final ISR filed with FERC on June 3, 2014.
Highlighted Results and Achievements	Distribution, abundance, relative use of water bodies, and timing of arrival, nesting and departure were documented for waterbirds in the study area in 2013. Overall movement rates as well as those of focal species groups were moderate-to-low relative to those reported for other migration studies in the region.

1. INTRODUCTION

On December 14, 2012, the Alaska Energy Authority (AEA) filed with the Federal Energy Regulatory Commission (FERC or Commission) its Revised Study Plan (RSP) for the Susitna-Watana Hydroelectric Project No. 14241 (Project), which included 58 individual study plans (AEA 2012). Section 10.15 of the RSP described the Waterbird Migration, Breeding, and Habitat Use Study (Waterbird Study). This study focuses on aerial surveys of water bodies during spring and fall migration, surveys of diurnal and nocturnal migration using visual and radar sampling, breeding waterfowl population surveys, stream surveys for Harlequin Ducks, and brood-rearing surveys. RSP Section 10.15 described the goals, objectives, and methods proposed for data collection on waterbirds.

On February 1, 2013, FERC staff issued its study plan determination (February 1 SPD) for 44 of the 58 studies, approving 31 studies as filed and 13 with modifications. RSP Section 10.15 was one of the 13 studies approved with modifications. In its February 1 SPD, FERC recommended the following:

> *FWS recommends that the study be modified to clarify that visual observation (both diurnal and nocturnal) to be conducted along each of the four transects would done by a separate observer during each sampling session. In other words, four observers would be used to collect data during each sampling session. FWS also recommends that the study be modified to clarify that the maximum number of possible 1-hour radar sampling sessions would be conducted each night because the start and stop time is not currently specified in the study plan.*
>
> *AEA states in the study plan that the migration study (which also will provide data for the Landbird and Shorebird Migration, Breeding and Habitat Use Study [study10.16]) would require a crew of four biologists working day and night shifts over a period of 120 days in 2013. While AEA's study plan suggests that it plans to conduct the study as recommended by FWS, the plan is not explicit. Using four biologists to concurrently document birds observed in each direction would ensure better correlation and interpretation of visual observations with radar data. Although the study plan does not explicitly state the start and stop times for radar sampling sessions, the plan is clear as to the sampling framework and that efforts are intended to maximize sampling sessions.*
>
> *We recommend that AEA implement the study with FWS' proposed modification for clarifying the use of four observers during visual observations. No modification of the study plan is needed regarding maximizing the number of radar sessions because AEA's study plan already provides for maximizing the number of radar sessions.*

As described below under the radar and visual migration sampling task (see Section 4.1.2.1), following the February 1 SPD AEA's study team engaged in further consultation with the U.S. Fish and Wildlife Service (USFWS) regarding FERC staff's recommendation. This consultation resulted in USFWS vacating its original recommendation that was adopted by FERC staff (see Appendix A). As a result, the visual migration observations were conducted as originally described in the RSP (Section 10.15.4.1.2).

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 Waterbird 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").

Following the standard practice of the American Ornithologists' Union (AOU 1998), the names of bird species are capitalized throughout this report.

2. STUDY OBJECTIVES

The goal of the Waterbird Study is to collect baseline data on waterbirds migrating through and breeding in the Project area and surrounding study area to enable assessment of the potential impacts of the Project and to inform the development of appropriate protection, mitigation, and enhancement measures. As used here, "waterbirds" is applied broadly to include swans, geese, ducks, loons, grebes, cranes, cormorants, herons, gulls, and terns. Shorebirds frequently are included in the general category of waterbirds, but they are addressed separately for this Project under the Landbird and Shorebird Migration, Breeding, and Habitat Use Study (Study 10.16) because the ground-based survey methods for shorebirds are similar to those used for landbirds. The Study Plan for the Waterbird Study includes breeding surveys for the Harlequin Duck, a species of conservation concern that requires specific stream-survey techniques.

This study has three objectives, as established in RSP Section 10.15.1:

- Document the occurrence, distribution, abundance, habitat use, and seasonal timing of waterbirds migrating through the Project area in spring and fall.
- Document the occurrence, distribution, abundance, productivity, and habitat use of waterbirds breeding in the Project area.
- Review available information to characterize food habits and diets of piscivorous waterbirds documented in the study area as background for the Mercury Assessment and Potential for Bioaccumulation Study (Study 5.7).

The information gained from this study will be used to evaluate waterbird habitat loss and alteration quantitatively, in conjunction with the separate Vegetation and Wildlife Habitat Mapping Study and the Evaluation of Wildlife Habitat Use Study (see Studies 11.5 and 10.19, respectively), and to estimate the number of migrating and breeding waterbirds that may be affected by the Project.

3. STUDY AREA

As established in RSP Section 10.15.3, the study area for waterbirds encompasses lakes, ponds, rivers, streams, and flooded wetlands within a 3-mi (4.8-km) buffer area around the proposed Watana reservoir, the Watana Dam Site and Camp Facilities Area, and the alignments of the three road and transmission corridors (Figure 3-1). The 3-mi buffer includes nearly all of the water bodies surveyed in the 1980s for the Alaska Power Authority (APA) Susitna Hydroelectric Project (Kessel et al. 1982), most of which occur in relatively discrete groupings (e.g., see Pre-Application Document [PAD] Figure 4.6-16; AEA 2011). The study area boundary extends beyond 3 mi in several places to include other water bodies surveyed by Kessel et al. (1982), such as Stephan Lake, Murder Lake, Clarence Lake, and other unnamed water bodies south of the Susitna River between Kosina Creek and the Oshetna River, but six large lakes (Kessel's numbers 131–136) between the mouths of the Tyone and Maclaren rivers are not included in the study area because they are located well upstream from the area that may be affected by the Project.

4. METHODS AND VARIANCES IN 2013

The methods of data collection and analysis described in RSP Section 10.15.4 were followed during the spring, summer, and fall field surveys in 2013, although some variances from the methods proposed in the Study Plan were necessary because of survey logistics and further consultation with the USFWS after the Commission's February 1 SPD. The methods, variances and justification for variances from the Study Plan are described in each relevant subsection below.

4.1. Spring and Fall Migration

4.1.1. Aerial Surveys

AEA implemented the methods described in the Study Plan, with the exception of variances explained below (Section 4.1.1.1).

Waterbirds use a broad range of lakes, ponds, rivers, creeks, and flooded wetlands throughout the study area during migration. The most effective means of assessing the distribution and abundance of waterbirds over such a large area is by aerial survey. Waterbirds often use rivers and streams for staging during early spring when water bodies are covered by ice, so spring surveys were flown parallel to river and stream courses, in addition to covering lakes and ponds. In contrast, fall migration surveys included only lakes, ponds, and flooded wetlands. Because of the distribution of water bodies in relatively discrete, irregularly spaced groupings in most of the study area, a lake-to-lake survey pattern was the most efficient survey approach, in which the survey path either circled or bisected each water body to allow survey personnel to count waterbirds in the water and on the shore.

Rather than specifying a minimum water body size to be surveyed for the lake-to-lake surveys, the survey team delineated an efficient flight path through and among water-body groups to maximize the number of water bodies covered within the 3-mi buffer of the study area. A route covering all water bodies in a lake group was repeated on each migration survey using Global Positioning System (GPS) navigation. The survey route was developed by reviewing U.S. Geological Survey (USGS) 1:63,360-scale topographic maps and high-resolution aerial or satellite imagery. Most water bodies 5 acres (2 ha) or more in size were surveyed, as well as many smaller ponds located between larger water bodies. This approach provided more complete survey coverage than would have resulted from selection of a random sample of water bodies in the study area.

Before field surveys began, large lakes (>50 acres) and groups of smaller lakes (<50 acres each) were allocated among various lake-survey groups and sections of rivers were assigned unique identification numbers (Figures 4.1-1, 4.1-2, and 4.1-3). The centroids of lakes and lake groups and the end points of river sections were used as waypoints and were loaded into a global positioning system (GPS) receiver to aid the pilot in navigating to survey locations. The survey team created field maps showing survey lakes and rivers on a topographic base layer and used them, together with the GPS, to visually navigate to survey locations. Flight lines on each survey were recorded on a GPS receiver.

To characterize the period of migration adequately and avoid missing migration peaks for various species and species-groups of waterbirds, surveys were conducted at five-day intervals during the spring (late April to late May) and fall (mid-August to mid-October) migration periods, resulting in 7 surveys in spring and 11 surveys in fall (Table 4.1-1). Each survey took one to three days to complete, depending on weather conditions and, during spring, on the extent of open water. The first fall migration survey was combined with the second Harlequin Duck brood-rearing survey; together, those two surveys took five days to complete. The spring migration surveys transitioned directly into the waterfowl breeding population surveys with no break in timing, as is described below (Section 4.2.1).

The aircraft used on all aerial surveys was a small, piston-engine helicopter (Robinson R-44). Surveys were flown at 125–200 ft above ground level and a speed of 20–45 kt when observing waterbirds. An experienced biologist recorded all data on a hand-held digital recorder, including GPS waypoint number; lake group or river identification number; and the number, species, and sex of birds. Nests and broods were recorded whenever encountered. After each survey, the observation recordings were either transferred directly into a digital database or were transcribed onto data sheets for later entry into the database. Observation recordings were reviewed a second time and compared with the digital database during quality assurance/quality control (QA/QC) review. Data were summarized by species, species group, location (water body or stream), date of survey, and survey area. Species-groups used for data summaries included waterfowl (geese, swans, dabbling ducks, and diving ducks), loons, grebes, cranes, gulls, terns, and jaegers. Some closely related waterfowl species that are difficult to differentiate during aerial surveys (e.g., Lesser vs. Greater scaup, Common vs. Barrow's goldeneyes) were recorded to the lowest taxonomic level of identification possible.

During data analysis, the study team compiled data on species composition, summarized the timing of migration, and identified water bodies that were important to migrating waterbirds. For the latter task, the team followed the approach used to analyze migration data for the 1980s APA Susitna Hydroelectric Project (Kessel et al.1982): a "relative importance value" was calculated for a specific subset of water bodies to evaluate their use by waterbirds during spring and fall migration. First, the area of water bodies sampled was measured using a geographic information system (GIS). Next, the relative importance value of each lake was calculated as the sum of the relative mean abundance (number of birds) from the spring or fall surveys, the relative mean density (birds/km^2), and the relative mean species richness (number of species). For the subset of water bodies that were sampled in both studies, the relative importance values from the 2013 surveys were compared with those reported by Kessel et al. (1982).

4.1.1.1. Variances

Fewer migration surveys were conducted during spring and fall in 2013 than were described in RSP Section 10.15.4.1.1. A five-day interval was scheduled between successive surveys, as stated in the RSP. However, when surveys took two or more days to complete, the five-day interval between surveys was calculated from the ending day of one survey to the first day of the next survey, rather than from the start of one survey to the start of the subsequent survey, as had been done when estimating the number of surveys for the RSP. This adjustment in temporal spacing resulted in fewer surveys. Despite this adjustment, peak movements of waterbird species were successfully documented, and study objectives were met in 2013.

4.1.2. Ground-based Surveys

AEA implemented the methods described in the Study Plan, with the exception of variances explained below (Section 4.1.2.1).

To obtain information on the volume and flight directions of birds migrating through the study area near the proposed dam site, the study team conducted intensive, ground-based surveys of bird migration in spring and fall by using a combination of visual observations and radar monitoring. The sampling site and associated field camp for the migration surveys were established at the peak elevation (709 m [2,325 ft]) of the benchland northwest of the proposed Watana dam site (Figure 4.1-4). Although this study component is reported here in the Waterbird Study ISR (ISR Study 10.15), it is important to note that the sampling design also provided migration data on landbirds, shorebirds, and raptors, which are included in this report for convenience, rather than being split up among this ISR and those for Studies 10.14, Surveys of Eagles and Other Raptors, and 10.16, Landbird and Shorebird Migration, Breeding, and Habitat Use.

Diurnal visual observations were conducted during daylight hours (sunrise to sunset) from April 20 to June 3 (spring migration) and from August 16 to October15 (fall migration) in 2013. Using binoculars and spotting scopes, individual observers recorded data from an observation point adjacent to the Watana Camp Meteorological Station (ESM1) during 25-minute sampling sessions, separated by 5-minute break periods during which weather data were recorded. Data recorded for each bird observation included date, time, species (or taxon), flock size, transect crossed (four transect lines, oriented in each of the cardinal directions—north, east, south, west), distance crossed (distance from observer), flight direction, flight behavior, and an estimate of minimal flight altitude above the ground.

Nocturnal audiovisual surveys were conducted during the first 2–3 h of nocturnal radar sampling in both spring and fall to supplement radar data with identification of taxa composing radar targets. These surveys consisted of 50-min sessions of visual sampling by a single observer, concurrent with hourly radar sampling. The timing of the visual sampling period was adjusted as day length changed during the migration periods. Observers used binoculars during crepuscular (twilight) periods and night-vision goggles, aided by infrared spotlights to illuminate targets flying overhead, during dark periods. For each bird or flock of birds detected, observers collected the following data: species or taxon, flight direction, flight altitude, flight behavior, and transect (north, east, south, or west). Weather data recorded during each visual and/or radar sampling session included wind direction, average wind speed, cloud cover, ceiling height, light conditions, precipitation, air temperature, and barometric pressure. These weather data supplemented hourly weather data summaries collected by the ESM1 station.

For radar monitoring of flight activity, the survey team set up a portable marine radar, which functioned in both surveillance and vertical modes, near the field camp, approximately 120 m (400 ft) north–northwest of the visual observation point. The radar was powered by a portable generator and two 12V batteries. The radar (Furuno Model FR-1510 MKIII; Furuno Electric Company, Nishinomiya, Japan) is a standard X-band marine radar transmitting at 9.410 GHz through a 2-m-long slotted wave guide (antenna), with a peak power output of 12 kW. The antenna has a beam width of 1.23° (horizontal) × 25° (vertical) and a side lobe of ±10–20°. Range accuracy is 1 percent of the maximal range of the scale in use or 30 m (whichever is greater) and bearing accuracy is ±1°. A pulse length of 0.07 μsec was used while operating at the 1.5-km (0.9-mi) range to sample the flight activity of small-bodied birds, such as songbirds. A longer pulse length (0.5 μsec) was used while operating at the 6-km (3.7-mi) range to sample the flight activity of large-bodied birds, such as waterfowl, cranes, and raptors. At shorter pulse lengths, echo resolution is improved (giving more accurate information on target identification, location, and distance), whereas at longer pulse lengths, echo detection is improved (increasing the probability of detecting a target). An echo is a picture of a target on the radar monitor and a target is one or more birds (or bats) that are flying so close together that the radar displays them as one echo on the display monitor. The radar has a digital color display with several useful features, including true north correction for the display screen (to evaluate flight directions), color-coded echoes (to differentiate the strength of return signals), and on-screen plotting of a sequence of echoes (to depict flight paths). Because targets are plotted with every sweep of the antenna (2.5-sec intervals) and because groundspeed is directly proportional to the distance between consecutive echoes, a hand-held scale was used to estimate ground speeds of plotted targets to the nearest 5 km/h (3.1 mi/h) when operating at the 1.5-km range and to the nearest 20 km/h (12 mi/h) during operation at the 6-km range.

Radar data were collected in 1-h sampling sessions throughout each night (from shortly after sunset to just before sunrise) and in 3-h blocks during the day (between sunrise and sunset). Diurnal sampling blocks varied each day to maximize evenness of sampling effort for each hour across the season. Each 1-h radar sampling session consisted of (1) one 10-min period to collect weather data and adjust the radar to surveillance mode; (2) one 10-min period with the radar in surveillance mode (1.5-km range) to collect information on migration passage rates of small-bodied birds (e.g., passerines, shorebirds); (3) one 10-min period with the radar in surveillance mode (1.5-km range) to collect information about flights of small-bodied birds, including groundspeed, flight direction, tangential range (minimal perpendicular distance to the radar laboratory), transect crossed (north, south, east, and west), and the number of individuals (if known); (4) one 10-min period with the radar in surveillance mode (6-km range) to collect information on both passage rates of large-bodied birds and information on their groundspeed, flight direction, tangential range (minimal perpendicular distance to the radar), transect crossed (north, south, east, and west), and the number of individuals (if known); (5) one 5-min period to adjust the radar to vertical mode; and (5) one 15-min period with the radar in vertical mode (1.5-km range) to collect information on flight altitudes and flight behavior. All hours of radar data were recorded using an automated image frame-recording device (Model VGA2USB, Epiphan Systems Inc., Ottawa, Ontario), which enabled continuous collection of a record of high-quality lossless radar images, with a resolution identical to that of the radar monitor.

Data collected in this study on flight volume, altitudes, and directions among all species and taxa were summarized for comparison with the results of similar studies conducted in Alaska at Tok, in the upper Tanana River valley, and Gakona, in the Copper River valley (Cooper et al. 1991a, 1991b; Cooper and Ritchie 1995);the Tanana Flats and Alaska Range foothills near Healy (Day et al. 2007; Shook et al. 2006, 2011);and Fire Island in upper Cook Inlet (Day et al. 2005).Visual observation analyses were differentiated among species-groups and subgroups of particular interest (swans, cranes, and eagles). Common Ravens were excluded from analyses of passerine species because of differences in their flight behaviors and the range of detectability for both horizontal distances and flight altitudes. In the radar data, targets observed >1.5 km from the radar represented larger bird species, composed primarily of raptors, cranes, and waterfowl during diurnal sessions and waterfowl during nocturnal hours.

Data from diurnal visual surveys during spring and fall were used to calculate movement rates based on the number of birds observed in flight from the visual observation station. Daily visual movement rates are reported as the mean number of birds/h ±1 standard error (SE) and are not adjusted for detectability of different size-classes of birds by distance. Flocks are used as the summary unit for flight direction and flight altitude. When summarizing flight direction, only birds exhibiting straight-line flight for a distance of at least 100 m were included, and directions are reported as medians for categories of cardinal and intermediate directions (e.g. north, northeast, east, southeast, south, southwest, west, northwest). The minimum flight altitude observed for each individual or flock was reported. Because of limitations in the accuracy of altitude estimates at greater distances, flight altitudes were analyzed only for those flocks observed within 1 km (horizontal distance) of the visual observation station.

Based on previous studies, the primary axis of migration in the region was presumed to be east–west. The cross-sectional distribution of migration across the basin was assessed by comparing movement rates of birds crossing transect lines extending north and south of the visual observation station. For birds with directional flight that were not observed crossing a transect, transect crossings were estimated by extrapolating flight lines. In cases where multiple cardinal transects were crossed, targets were assigned to a primary transect (north or south) line. To determine if differences in movement rates north and south of the station resulted from birds preferentially following the Susitna River channel, the numbers of flocks crossing a 1.5-km transect line due south of the observation station (extending the full width of the river channel at the site) were compared with the numbers crossing a 1.5-km transect line extending due north (away from the channel).

Of primary importance in radar target identification is the elimination of insect targets. Insect contamination was reduced by (1) omitting small targets (the size of gain specks) that only appeared within ~500 m of the radar, as well as targets with poor reflectivity (e.g., targets that plotted erratically or inconsistently in locations having good radar coverage); and (2) editing data before analysis by omitting targets with corrected airspeeds <6 m/s (<13.4 mi/h). This threshold was based on radar studies that determined that most insects have airspeeds of <6 m/s, whereas those of birds and bats usually are >6 m/s (Tuttle 1988, Larkin 1991, Bruderer and Boldt 2001, Kunz and Fenton 2003). Airspeeds of surveillance-radar targets were calculated using ground speed and flight direction, corrected for concurrent wind velocity and wind direction obtained from the ESM1 station (see Mabee et al. 2006). Targets that had corrected airspeeds <6 m/s were omitted from all analyses of surveillance radar. Use of the radar in vertical mode to obtain flight altitude data results in a tradeoff between maximizing sample sizes and maximizing the number of targets for which actual ground speeds can be discerned. To obtain adequate sample sizes for analysis of flight altitudes, the threshold airspeed criterion was used for targets only on dates when insects or insect-like radar targets were detected, under the assumption that all targets were birds on dates with no insects or insect-like targets were observed.

Unlike movement rates based on visual observations of all birds observed in flight, radar passage rates provide an index of migration densities and are reported as the mean number ± 1 SE of targets passing along 1 km of migratory front per hour. All radar flight-altitude data are reported in meters above ground level (m agl) relative to a horizontal plane passing through the radar-sampling station. Actual mean altitudes may be higher than those reported because an unknown number of birds fly above the 1.5-km range limit of the radar (Mabee and Cooper 2004). Flight-direction data were analyzed following procedures for circular statistics with Oriana software version 3.1 (Kovach 2009). Mean and median flight directions of radar targets were calculated, as well as the circular standard deviation (CSD) and the mean vector length (r) to describe the dispersion of flight directions. Mean flight directions coupled with high r values (maximum = 1) indicate strong patterns in flight orientation, whereas mean flight directions coupled with low r values (minimum = 0) indicate weak or no directionality in flight movements.

To assess daily patterns in migration passage rates and flight altitudes, the study team assumed that a day began at sunrise, so that sampling nights were not split between two dates. For both radar and visual studies, diurnal sampling periods were categorized as morning (sessions starting <4 h post-sunrise), late afternoon (sessions starting <4 h pre-sunset), and mid-day (all other sessions). Differences among time periods in passage rates (radar and visual) and flight altitudes (radar only) were analyzed using one-way analysis of variance (ANOVA; SPSS 2010). For radar surveys, one-way ANOVA also was used to examine differences among passage rates and flight altitudes of targets during sessions occurring within 1 h after sunset and 1 h before dawn, and during the nocturnal hours between these crepuscular hours. Repeated-measures ANOVAs, incorporating the Greenhouse–Geisser epsilon adjustment for degrees of freedom (SPSS 2010), were used to compare passage rates among hours during night when data were collected in the first 4 h after sunset in the spring and the first 7 h after sunset in the fall, due to differences in the minimum number of nocturnal hours during of each season.

In the diurnal visual surveys, the cross-sectional distribution of migration across the basin was assessed by comparing passage rates of targets crossing transect lines north and south of the radar sampling station. When necessary, transect crossings were assigned to targets with short, unidirectional flight paths by extrapolating flight paths across transects. In cases where multiple transects were crossed, targets were assigned to a primary transect (north or south) line. For targets observed during sampling at the 1.5-km range, passage rates of targets north and south of the station were compared using paired t-tests (SPSS 2010); the distributions of targets observed crossing the north and south transects >1.5 km from the radar also were compared from sampling at the 6-km range.

Factors that decreased sample sizes of the various summaries and analyses of radar data included insect contamination, precipitation, logistical issues, and variable numbers of hours of darkness across the season. Therefore, sample sizes sometimes differ among summaries and analyses.

4.1.2.1. Variances

Following a meeting on March 1, 2013, the USFWS reversed its recommendation for modification of the RSP, which had been accepted by FERC in the February 1 SPD. The suggested modification called for the use of four visual observers during both diurnal and nocturnal sampling periods, rather than the single observer proposed in the RSP. Through further consultation with USFWS on March 1, however, the AEA study team provided clarification of the scope, objectives, limitations, and historical justification of the visual and radar methodologies proposed, as well as contingencies for alternative methods to be used in case individual observers determined that conditions warranted modifications to increase sampling efficiency. USFWS deemed this additional information sufficient to drop its recommendation for four simultaneous visual observers (M. DeZeeuw, USFWS Acting CPA/Energy Coordinator, email communication, March 22, 2013; Appendix A) and the study was conducted, meeting all objectives, using single visual observers as originally proposed in RSP Section 10.15.4.1.2.

4.2. Breeding Season

4.2.1. Breeding Population Surveys

AEA implemented the methods described in the Study Plan, with the exception of variances explained below (Section 4.2.1.1).

The survey team used two different survey approaches for breeding population surveys in the study area, depending on the location of the water bodies being surveyed. In most of the study area, the same lake-to-lake survey approach used for the migration surveys was used for the breeding surveys, with no break in timing between the spring migration and breeding survey periods. To increase survey efficiency, the survey effort was focused on lake groups where lakes were tightly clustered (Figures 4.1-5, 4.1-6, and 4.1-7). A rectangular area (7×11 mi) was delineated east of the upper end of the reservoir inundation zone ("transect block" in Figure 3-1) in an area of low topographic relief with a high density of water bodies. The transect block was sampled during breeding waterfowl population surveys using a transect sampling approach, rather than attempting to cover all of the water bodies completely in a lake-to-lake pattern. The survey team recorded data in 0.25-mi (400-m) strips along transect lines spaced at 1-mi intervals, providing sample coverage of approximately 25 percent of the survey block.

Surveys for breeding waterfowl in the transect-survey block followed standard USFWS protocols (USFWS 1987, USFWS and Canadian Wildlife Service [CWS] 1987). The survey team arranged parallel survey lines to cover the greatest possible number of water bodies and wetlands. The placement of the transect lines, which were oriented systematically along the long axis of the survey block, was done before the field season, using USGS topographic maps and

GIS. Waypoints were calculated at transect endpoints and at 1-mi intervals along each of the seven transects and a GPS route file using those waypoints was created for navigation during the survey.

As in the migration surveys, a Robinson R-44 helicopter was used as the survey platform for the breeding surveys. Flight altitude was low (125–200 ft agl), with the lower altitude being used for the transect surveys) to permit observation of birds without having to rely on binoculars, although binoculars were used where necessary to confirm species identification. Transect surveys were flown at a constant speed of 45 kt and lake-to-lake surveys at a speed of 20–45 kt.

During the lake-to-lake surveys, a single observer recorded data for the entire surface area of the water bodies surveyed. In the transect surveys, each of two observers searched for waterbirds in a 0.125-mi (~200 m) strip on each side of the aircraft, for a total strip width of 0.25 mi (~400 m) while the pilot navigated along the transect lines using a GPS receiver. Data collection followed standard USFWS protocols, grouping observations into five categories: (1) lone drake; (2) flocked drakes (2–4 males in close association); (3) pair (male and female in close association); (4) group (≥3 mixed-sex birds of the same species in close association which cannot be separated into singles and pairs or ≥5 flocked males of the same species); and (5) nests. Data recorded for each observation included a GPS waypoint number and the lake group, river, or transect number. Observations were recorded on hand-held digital voice recorders for later transcription and transfer to a digital database for final QA/QC and analysis.

The timing of the breeding waterfowl population surveys was scheduled by evaluating the chronology of spring break-up and snow- and ice-melt in 2013, which were monitored throughout the spring migration surveys. Breeding waterfowl population surveys typically are flown in late May or early June, depending on location and elevation, when pairs are present on territories but females are not yet spending time on nests. Survey timing can affect results because the nesting phenology of dabbling ducks is generally earlier than that of most diving ducks, and some dabbling duck species can be missed if the survey occurs too late, after the cryptically colored females are on nests and the more brightly colored males have left the area.

To account for this variability among species-groups, two surveys were flown, spaced 10 days apart (Table 4.1-1), to target the expected peak presence of pairs and males of dabbling ducks and diving ducks, respectively, which differ in migratory timing. Each survey was conducted during the same periods as the pre-nesting Harlequin Duck surveys, taking four to five days to complete. Weather and visibility conditions during surveys were recorded to assess the quality of data collection.

Survey data were used to calculate the estimated densities of each species of waterfowl and to identify areas important to breeding waterfowl, following standard protocols (USFWS and CWS 1987, Smith 1995) to convert raw survey counts to indicated total population indices. Species-specific correction factors (when available) were applied to the indices to derive population estimates of each species detected in the transect-survey block.

4.2.1.1. Variances

The term "breeding-pair survey" proposed in the Study Plan (RSP Section 10.15.4.2.1) was replaced here with "breeding population survey," which is a more inclusive survey method. The breeding-pair survey is designed to estimate the number of breeding pairs in an area based on counts of single drakes and pairs of waterfowl, whereas the breeding population survey is designed to estimate not only the number of breeding pairs in an area but also includes grouped birds to derive a breeding population estimate for the area. The term "breeding population survey" accurately describes the results reported in this document on breeding waterfowl densities and population indices in the study area. Hence, more information was gathered than was described in the Study Plan, meeting Study Plan objectives.

4.2.2. Harlequin Duck Surveys

AEA implemented the methods described in the Study Plan, with the exception of variances explained below (Section 4.2.2.1).

In inland areas of Alaska, Harlequin Ducks predominantly forage in mountain streams and nest in adjacent shoreline habitats. Male Harlequin Ducks are only present on breeding streams during a short period in spring while courting females. Accordingly, pre-nesting surveys must be conducted in that short timing window to quantify the number of nesting pairs occupying a stream. After hatching, successful females are visible on streams with their broods, and failed breeders often group together.

All rivers and streams flowing through the study area buffer were surveyed for breeding Harlequin Ducks. These stream surveys extended outside the 3-mi study-area buffer where necessary to include suitable habitats farther upstream. The survey team flew surveys for pre-nesting and brood-rearing Harlequin Ducks in a Robinson R-44 helicopter, using two observers seated on the same side of the aircraft. Surveys proceeded in both upriver and downriver directions, with the helicopter positioned over one bank to provide an unobstructed view of the entire width of the water course. Survey altitude was 100–150 ft agl and survey speed was 20–35 kt. Surveys covered primary and secondary tributary streams within the 3-mi study area buffer and extended up to 10 mi beyond the buffer to include contiguous suitable nesting habitat (Figures 4.1-5, 4.1-6, and 4.1-7). The extent of suitable nesting habitat was assessed initially during the last migration survey before the first Harlequin Duck pre-nesting survey and was continually reassessed on each Harlequin Duck survey. Observers recorded sex of individuals, counts of adults, and counts of young on hand-held digital recorders and marked GPS waypoints for later transcription and transfer to a digital database for analysis. Data were summarized as the number of pairs, males, females, and young and identified streams used by breeding Harlequin Ducks.

To account for variability in the occurrence of peak numbers of breeding pairs and brood-rearing females on a stream, the survey team flew two pre-nesting surveys and two brood-rearing surveys, with 10 days intervening between each pair of surveys (Table 4.1-1). The survey timing was adjusted to the environmental conditions and breeding phenology observed in 2013.

4.2.2.1. Variances

Although the extent of suitable nesting habitat extended >10 mi beyond the 3-mi study area buffer on some of the major tributaries of the Susitna River, it was not logistically feasible to follow the entire length of tributary streams as was proposed in the Study Plan (RSP Section 10.15.4.2.2). For tributaries that had suitable habitat well beyond the 3-mi study area buffer, a survey end point was established at 10 mi beyond the buffer. That distance was based on the linear home range of Harlequin Ducks during the pre-nesting and brood-rearing periods (Robertson and Goudie 1999). Calculation of linear densities of Harlequin Ducks along breeding streams was not feasible in 2013 because of differences in the upstream extent covered among different surveys. Additional GIS analysis in the next study season should permit calculation of linear densities. However, the same logistical constraints will persist during the next study season. Because the surveys flown in 2013 extended beyond the outer boundary of the study area by a distance equal to the reported linear home range of Harlequin Ducks, the variance is consistent with study objectives.

4.2.3. Brood Surveys

AEA implemented the methods described in the Study Plan, with no variances.

Brood surveys covered the subset of water bodies within a 1-mi buffer around the locations and alignments of proposed Project infrastructure, including access road and transmission corridors (Figures 4.1-1, 4.1-2, and 4.1-3). The survey team examined suitable lakes, ponds, streams, and flooded wetland complexes to provide information on waterbirds breeding in specific areas that may be affected by Project infrastructure or activities. Two observers conducted the brood surveys in a Robinson R-44 helicopter, flying at 125–200 ft agl and a speed of 20–45 kt. The first survey was conducted on July 20–22, and the second was conducted two weeks later, on August 1–5, to record the presence of adults accompanied by broods of juveniles (Table 4.1-1). . In RSP Section 10.15.4.2.3, a third brood survey was listed as a possibility, contingent on an assessment of the developmental stages of the juvenile waterbirds observed during the second brood survey. In 2013, the study team concluded that the first and second brood surveys were suitably timed to cover the variability in the development of waterbird juveniles, so a third brood survey was not needed.

The survey team circumnavigated water bodies to search for waterbird broods, recording observations of the number of adults and young on hand-held digital recorders and as GPS waypoints for later transcription and transfer to a digital database. Ages of waterfowl broods (primarily ducks) were estimated by classifying each brood into one of seven age classes, based on chick plumage patterns (Bellrose 1976). Data were summarized by species, location, survey area, and brood age class. Nest-initiation dates were estimated by subtracting the average incubation period from the estimated age of young.

4.2.3.1. Variances

No variances from the methods described in the Study Plan were necessary during the 2013 study season.

4.3. Information for Mercury Study

AEA implemented the methods described in the Study Plan, with the exception of variances explained below (Section 4.3.1).

Scientific literature was reviewed to compile and synthesize information on the food habits and diets of piscivorous waterbirds in freshwater aquatic systems, in support of the Mercury Assessment and Potential for Bioaccumulation Study (Study 5.7). Review of this information was recommended by USFWS in comments on the PAD for the Project (letter from USFWS to AEA dated May 31, 2012).

When nests of obligate piscivorous waterbirds (e.g., loons, grebes, terns) were observed during the breeding aerial surveys, the locations were recorded as GPS waypoints and marked on field survey maps. The locations of broods of piscivorous waterbirds also were recorded during brood and fall migration surveys. No nests of piscivorous waterbirds were examined on the ground. Only one nest was found but, because it was located on Cook Inlet Regional Working Group (CIRWG) lands, it could not be visited.

4.3.1. Variances

The study objective for acquiring tissue samples of piscivorous waterbirds for laboratory analysis of mercury levels was based on opportunistically finding nests during breeding aerial surveys and visiting those nests after the nesting season to collect feather samples, as described in RSP Section 10.15.4.3. Fewer nests of piscivorous waterbirds were found than expected during breeding aerial surveys in 2013. Only one Common Loon nest was found and no nests of other piscivorous waterbirds were found in 2013. Lack of access to CIRWG lands prevented a visit to look for feather samples at the Common Loon nest. However, that nest was located on an island in the Fog Lakes area and whether a helicopter could have landed there safely was questionable. Broods of all piscivorous waterbirds were found in the waterbird study area and lakes where they were observed can be targeted during future surveys for nesting birds.

As an ancillary method to attempt to obtain feathers of piscivorous waterbirds, the Study Plan proposed to supplement the collection of feathers from waterbird nests by visiting nest sites of Peregrine Falcons located in or near the study area and collecting feathers and prey remains of waterbirds eaten by the falcons. Peregrine Falcons are predators of a variety of birds, including waterbirds, and examination of prey remains is a commonly used technique to investigate their food habits, although the likelihood of obtaining feathers specifically from piscivorous species of waterbirds is unknown and probably small. Although the study team possessed the required federal salvage permit to collect feathers from all species of migratory birds except eagles, falcon nests were not visited in 2013 because a permit was not obtained for salvage of eagle feathers (see ISR Study 10.14, Surveys of Eagles and Other Raptors for more details), so the planned sampling visit was postponed until the second study season.

Further discussion with USFWS is planned in 2014 to discuss all possible methods of tissue collection, including feathers, feces, eggshell fragments, and eggshell swabbing, for effective laboratory analysis of mercury levels in piscivorous waterbirds. The effectiveness of determining mercury levels from these different kinds of tissue samples will be discussed and evaluated.

5. RESULTS

Data developed in support of ISR 10.15, Waterbird Migration, Breeding, and Habitat Use, are available for download at http://gis.suhydro.org/reports/isr. The data are in the following files:

- ISR_10_15_WBRD_Data_ABR.gdb/ISR_10_15_WBRD_Breeding_Transect_Lines
- ISR_10_15_WBRD_Data_ABR.gdb/ISR_10_15_WBRD_Breeding_Lake_Groups
- ISR_10_15_WBRD_Data_ABR.gdb/ISR_10_15_WBRD_Migration_Lake_Groups
- ISR_10_15_WBRD_Data_ABR.gdb/ISR_10_15_WBRD_Lakes_in_Breeding_Groups
- ISR_10_15_WBRD_Data_ABR.gdb/ISR_10_15_WBRD_Lakes_in_Migration_Groups
- ISR_10_15_WBRD_Data_ABR.gdb/ISR_10_15_WBRD_Lakes_Brood_Survey
- ISR_10_15_WBRD_Data_ABR.gdb/ISR_10_15_WBRD_HarlequinDuck_Streams
- ISR_10_15_WBRD_Data_ABR.gdb/ISR_10_15_WBRD_Migration_Streams
- ISR_10_15_WBRD_Data_ABR.gdb/ISR_10_15_WBRD_Spring_Visuals
- ISR_10_15_WBRD_Data_ABR.gdb/ISR_10_15_WBRD_Fall_Visuals
- ISR_10_15_WBRD_Breeding_Lake_2013.xlsx
- ISR_10_15_WBRD_Breeding_Transect_2013.xlsx
- ISR_10_15_WBRD_Brood_Survey_2013.xlsx
- ISR_10_15_WBRD_Harlequin_Breeding_2013.xlsx
- ISR_10_15_WBRD_Spring_Migration_2013.xlsx
- ISR_10_15_WBRD_Fall_Migration_2013.xlsx
- ISR_10_15_WBRD_NoctVisual2013.xlsx
- ISR_10_15_WBRD_Radar2013.xlsx
- ISR_10_15_WBRD_Visuals2013.xlsx.

5.1. Spring and Fall Migration

Thirty-eight species of waterbirds were observed during migration, breeding, and brood-rearing surveys in the waterbird study area (Table 5.1-1). Representatives from nine species or species-groups were recorded: geese (three species), swans (two species), ducks (21 species), loons (four species), grebes (two species), Sandhill Crane, gulls (three species), Arctic Tern, and Long-tailed Jaeger. Although shorebirds frequently are included in the general category of waterbirds, that broad species-group was included in a separate study (Study 10.16, Landbirds and Shorebirds), for which the results from 2013 are reported in ISR Study 10.16.

Twenty-seven species of waterbirds were confirmed as breeders in the study area, based on the presence of a nest or brood recorded during surveys. Another three species are possible breeders because they were observed in the study area during the breeding season and the area is within their breeding range. Eight other species observed only during spring and fall were considered migrants in the study area.

5.1.1. Aerial Surveys

5.1.1.1. Spring Migration

5.1.1.1.1. Temporal and Spatial Patterns

During spring, the timing of the arrival of waterbirds and their distribution in the study area was dependent on the availability of open water and suitable staging habitats. During the first three migration surveys (April 23, 29, and May 5), the only open water found on water bodies were at some beaver ponds adjacent to Indian River and at the outlets of a few large lakes, including Clarence, Deadman, Murder, and Stephan lakes. Small numbers of waterbirds (2–20 birds) were observed staging at each of these water bodies, with the beaver ponds adjacent to Indian River supporting the highest number of waterbirds on each of the three surveys (Table 5.1-2). Five species of waterbirds were recorded on these water bodies during one or more of these three surveys: Trumpeter Swan, Mallard, Bufflehead, goldeneyes, and Common Merganser (Table 5.1-3).

On April 23 and 29, streams were mostly frozen; small open-water areas were present on the Nenana and Susitna rivers where leads had formed and on a few tributaries where snow cover had caved into drainages. Small stretches of open water also were found on a few streams (i.e., Fog Creek and the stream connecting Stephan and Murder lakes) where it is likely that a spring was creating open water. On April 23, four waterbirds (a pair each of Trumpeter Swans and Mallards) were found at the stream connecting Stephan and Murder lakes and eight waterbirds, consisting of six Trumpeter Swans and two Mallards, were seen at that same location on April 29 (Table 5.1-2). The only other waterbirds observed on streams on April 29 was a flock of eight Mallards at a lead on the Nenana River. On May 5, many streams had small sections of open water and a total of 72 waterbirds were found occupying them. The Indian and Nenana rivers, and the stream connecting Stephan and Murder lakes supported the highest numbers of waterbirds on May 5. Northern Pintail, Northern Shoveler, and Mew Gull were species that were first observed in the study area on May 5 and all three species were staging along streams (Table 5.1-3). Seven waterbirds, consisting of two Mallards, two Buffleheads, one goldeneye, and two Mew Gulls, were observed staging on the Susitna River on May 5 at open-water leads between the confluences of Indian River and Fog Creek (Table 5.1-2). The numbers of waterbirds staging on water bodies and streams were similar on April 23 and 29, but by May 5, waterbirds were found mostly on streams (69 percent) rather than water bodies (31 percent). Most waterbirds in the study area on May 5 were found in the Chulitna and Gold Creek corridor survey areas, followed by the Denali Corridor and Watana Reservoir survey areas.

On May 11 and 18–19, large, deep lakes remained about 98 percent ice-covered with open water continuing to be found only at inlet and outlet areas. Lakes (Clarence, Deadman, Murder, and Stephan lakes) that were occupied by waterbirds on earlier surveys at these small open-water areas were occupied with a greater number of waterbirds on May 11 and 18–19 (Figure 5.1-1, Table 5.1-2). Waterbirds also were found at other large lakes (Pistol Lake and large lakes just north of Stephan Lake) where open water had formed since May 5 (Figure 5.1-1, Table 5.1-2). The highest number of waterbirds recorded at one of these large lakes was 84 birds at Murder Lake on May 11and 72 birds at Stephan Lake on May 18–19. Waterbirds also occupied some shallow water bodies that were partially to completely thawed on May 11 and May 18–19, including a couple of water bodies in the Fog Lakes group and Lake 1294 along the Denali Highway just northeast of Drashner Lake. From 200 to 250 waterbirds, including geese, swans, ducks, and gulls, occupied Lake 1294 on both May 11 and May 18–19.

Similar to the survey on May 5, most waterbirds (>60 percent) were found on streams on May 11 and May 18–19 rather than on water bodies (Table 5.1-2). The amount of open water on streams continued to increase considerably with each successive survey, and by May 18–19, stretches of open-water were common on the Susitna and Nenana rivers and their tributaries. On May 11, 469 of the 1,022 waterbirds (46 percent) counted in the study area were observed staging on the Susitna River. A similar number of those birds on the Susitna River were observed in the Gold Creek Corridor survey area (i.e., from the railroad bridge crossing at Project River Mile (PRM) 140.0 to the proposed dam site at PRM 187.1) and in the Watana Reservoir survey area (i.e., from the proposed dam site to above the Oshetna River confluence at PRM 237.7; Table 5.1-2). By May 18–19, 634 waterbirds, representing 52 percent of all waterbirds recorded in the study area on those dates, staged at open-water leads on the Susitna River. Most (60 percent) of the waterbirds on the Susitna River on May 18–19 were found above the proposed dam site in the Watana Reservoir survey area (Table 5.1-2). The portion of the Nenana River within the study area supported 109 waterbirds on May 11 and 117 waterbirds on May 18–19. Fifteen species of waterbirds were observed staging on the Susitna River on May 18–19 and 11 species were staging on the Nenana River. Open-water areas at the confluence of tributaries with the Nenana and Susitna rivers were popular staging sites. Six waterbird species were observed in the study area for the first time on May 11: Canada Goose, Bonaparte's Gull, and four species of ducks, including the first sighting of Harlequin Ducks on the Susitna River (Table 5.1-3). Another four species of ducks (scaup, Red-breasted Merganser, Redhead, and Canvasback) arrived in the study area by May 18–19.

By May 23–24, open water was present on many small water bodies <3,000 ft elevation and along the shorelines of some of the larger lakes. The amount of open water at inlet and outlet areas on large lakes (e.g., Clarence, Deadman, Pistol, Murder, and Stephan lakes) had increased since May 18 but overall these lakes and other large lakes were still 95 percent ice-covered. Waterbirds were crowded into these small open-water areas on large lakes and also were observed throughout the study area on some of the smaller water bodies with open water (Figure 5.1-1, Table 5.1-2). The highest concentrations of waterbirds staging on lakes were at Murder, Stephan, and Pistol lakes, and at water bodies along the Denali Highway and in the Fog Lakes group.

Sections of some streams within the study area were mostly ice-free and flowing fast on May 23–24 (Indian and Oshetna rivers, and Portage, Fog, and Watana creeks), including the section of the Susitna River between Jay Creek and the Oshetna River. Other streams were still mostly snow-covered, while meltwater runoff was flowing on top of snow and ice in Deadman, Devil, and Goose creeks. It is likely that the increase in the availability of open water on lakes and the increase in the volume of water flowing in streams led to the distribution of waterbirds shifting slightly from streams to water bodies on May 23–24 compared to the previous three surveys, however the overall number of waterbirds on streams (55 percent) was still slightly higher than on water bodies (45 percent). Of 2,299 waterbirds recorded in the study area on May 23–24, 47 percent were found on the Susitna River, and of all waterbirds recorded on streams on that survey, 85 percent were on the Susitna River (Table 5.1-2). Most of the waterbirds on the Susitna

River (65 percent) on May 23–24 were found below the proposed dam site in the Gold Creek Corridor survey area. Brushkana and Seattle creeks and the Nenana River in the Denali Corridor survey area supported between 38 and 66 waterbirds on May 23–24. Fewer than 16 waterbirds were observed on all other streams in the study area on that survey. Snow Goose, Herring Gull, and Horned Grebe were newly detected species in the study area on May 23–24 (Table 5.1-3).

Warm temperatures in the study area between May 23–24 and May 28–29 resulted in rapid snow melt, high-velocity flows in streams, and most water bodies <3,000 ft elevation having some open water. Because of these conditions, most waterbirds (78 percent) were found on water bodies on May 28–29 rather than on streams. Streams generally were no longer suitable for staging on May 28–29 because of their high velocity and muddy water. For example, the number of waterbirds recorded on the Susitna River in the Gold Creek Corridor survey area on May 28–29 was only 44 birds compared to 702 birds on the previous survey, and the number recorded on the Susitna River in the Watana Reservoir survey area also dropped from 374 birds on May 23–24 to 131 birds on May 28–29 (Table 5.1-2). The total number of waterbirds in the study area was similar on surveys conducted on May 23–24 (2,299 birds) and May 28–29 (2,090 birds), and thus it is likely that most waterbirds that had been staging on streams on May 23–24 shifted to staging on water bodies and tributaries of the Susitna River on May 28–29 rather than leaving the study area.

For most lakes and other water bodies in the study area, the highest number of waterbirds was observed on May 28–29 (Figure 5.1-1). More waterbirds were counted on large lakes, like Clarence, Murder, and Stephan lakes, on May 28–29 than on any previous spring survey, with numbers on each lake ranging from 108–144 birds (Table 5.1-2). The Fog Lakes group and a group of water bodies near Goose Creek and the Oshetna River also supported hundreds of waterbirds. Lake 1294 along the Denali Highway just northeast of Drashner Lake had fewer waterbirds on May 28–29 (175 birds) than any of the previous three surveys, however the number of waterbirds on nearby water bodies doubled from the number on May 23–24 because of the availability of open water. Many waterbirds, particularly American Wigeon, Mallard, Northern Shoveler, Northern Pintail, scaup, and Harlequin Duck, were commonly seen in single species-groups of 10–30 birds and occasionally in groups from 31–100 birds. Seven species not previously recorded in the study area during spring 2013 were seen on May 28–29, including Long-tailed Duck, two species of scoters, three species of loons, and Red-necked Grebe (Table 5.1-3). Five additional species (Greater White-fronted Goose, Gadwall, Black Scoter, Pacific Loon, and Arctic Tern) of waterbirds were not detected during migration surveys, and were seen on the first breeding survey on June 1–5.

During the two migration surveys in April, waterbirds were found only in the Denali, Chulitna, and Gold Creek corridor survey areas, with most birds (54 percent) occurring in the Chulitna Corridor (Table 5.1-2). For each survey in May, the Chulitna Corridor survey area had the lowest number of waterbirds recorded among all the survey areas except for the Dam/Camp Area, where no waterbirds were observed until May 28–29 (Figure 5.1-1). The highest number of waterbirds recorded among the Watana Reservoir and Denali and Gold Creek corridor survey areas during each survey in May differed from survey to survey. Most waterbirds were recorded in the Gold Creek Corridor survey area on May 5 and May 23–24, while on May 11 most waterbirds were found in the Denali Corridor survey area (Table 5.1-2). On May 18–19 and 28–29, most waterbirds were recorded in the Watana Reservoir survey area. For four of the five survey areas, the highest number of waterbirds recorded within the survey area during spring occurred on May 28–29: 817 birds in the Watana Reservoir, 727 birds in the Denali Corridor, 90 birds in the Chulitna Corridor, and 22 birds in the Dam/Camp Area. The Gold Creek Corridor survey area had more birds on May 23–24 (919 birds) than on May 28–29 (427), largely because of the drop in the number of waterbirds on the Susitna River.

5.1.1.1.2. Taxonomic Patterns

Trumpeter Swans were one of the first species to arrive in the study area during spring 2013 and a pair of birds often occupied small open-water outlet areas of large lakes (Tables 5.1-3 and 5.1-4). Pairs of swans were recorded at the same sites for at least four consecutive spring surveys. Swans were also observed staging along streams, including the Indian, Nenana, and Susitna rivers, Brushkana and Deadman creeks, and the stream connection between Stephan and Murder lakes. Numbers of swans observed in the study area continued to increase with each spring survey and most birds were observed as pairs or in groups of less than ten birds (Table 5.1-4). The highest number of swans recorded in the study area during spring was 72 birds on May 23–24, almost half of which were in the Denali Corridor survey area (Appendix B). During late April, swans were only found in the Denali and Gold Creek corridor survey areas, with most birds occurring in the Gold Creek Corridor (Table 5.1-4). On every spring migration survey in May, most of the swans in the study area were observed in the Denali Corridor survey area (range 13–35 swans), followed by the Watana Reservoir and the Gold Creek and Chulitna corridor survey areas. No swans were recorded in the Dam/Camp Area during spring.

Most swans recorded in the study area during spring were probably local breeders and were staging at sites near nesting territories. Four nests were found in the study area during migration or breeding surveys, three in the Denali Corridor survey area and one in the Chulitna Corridor survey area. The long, cold spring in 2013 may have caused some swans to forego nesting or may have contributed to early nest failures.

Three species of geese were recorded in small numbers in the study area during spring, with the first observations occurring on May 11 in the Watana Reservoir and Denali Corridor survey areas (Table 5.1-4, Appendix B). Canada Geese were observed in flocks of no higher than 10 birds on May 11 and most were seen staging along leads in the Nenana River and in the lower section of Seattle Creek in the Denali Corridor survey area (Appendix B). A few Canada Geese were recorded in the Gold Creek Corridor survey area on May 18–19 and 23–24 on the Susitna River and at Murder Lake, respectively. Two flocks of Snow Geese were observed in flight during migration surveys near the Oshetna River in the Watana Reservoir survey area: a group of 80 Snow Geese on May 23–24, and a group of 10 geese on May 28–29 (Table 5.1-3). Snow Geese were not observed staging on lakes during any spring migration survey but a few birds were seen on lakes during the June 1–5 breeding survey in the Watana Reservoir survey area. Greater White-fronted Geese were not observed during spring surveys, and only three birds were observed during breeding and fall migration surveys. No goose broods were seen during brood-rearing surveys and that coupled with the low numbers of geese seen during spring probably indicates that most geese observed in the study area are migrants or non-breeders. Of all observations of geese staging in the study area during spring migration, most were observed in the Denali Corridor survey area, followed by the Gold Creek Corridor and Watana Reservoir survey areas (Table 5.1-4). No geese were recorded in the Chulitna Corridor survey area or the Dam/Camp Area during spring.

Ducks were the most abundant waterbird species-group in the study area and were represented by 21 species (Tables 5.1-1 and 5.1-4; Appendix B). Some species arrived early in the study area and were present in small numbers during late April, including Mallard, goldeneyes, Common Merganser, and Bufflehead (Table 5.1-3). Six more species, including four dabbling ducks and 2 diving ducks, arrived in early May, and four more diving ducks arrived by mid-May. Long-tailed Ducks and two species of scoters were first seen in the study area in late May. Peak numbers were counted for eight species of ducks on May 23–24 (American Wigeon, Northern Shoveler, Northern Pintail, Green-winged Teal, Harlequin Duck, Bufflehead, goldeneyes, and Red-breasted Merganser) and for five species on May 28–29 (Ring-necked Duck, scaup, Surf Scoter, White-winged Scoter, and Long-tailed Duck) (Appendix B). Numbers of Mallards and Common Mergansers were highest on May 18–19, and small numbers of Canvasback and Redhead were seen on that survey only. Black Scoters were not seen in the study area until the breeding survey on June 1-5.

Most ducks in the study area were found in the Chulitna Corridor survey area in late April and early May because of the occurrence of open-water on beaver ponds. After May 5, numbers of ducks in the Chulitna Corridor survey area increased slowly to a maximum number of 83 ducks recorded within the survey area during spring. The number of ducks recorded in the study area was less than 100 birds on each of the first three migration surveys, with the highest numbers of 32 and 27 ducks occurring on May 5 in the Chulitna and Gold Creek corridor survey areas, respectively. A dramatic increase in the number of ducks in the study area occurred on May 11, when a total of 852 birds were counted (Table 5.1-4). During that survey, the number of ducks in the Watana Reservoir and the Denali and Gold Creek corridor survey areas ranged from 208 to 309 birds, with the highest number occurring in the Gold Creek Corridor. Ducks continued to increase in number in the study area on May 18–19 (1,139 ducks) and reached a peak number of 2,135 ducks on May 23–24. Most of the ducks recorded in the study area on May 18–19 were found in the Watana Reservoir survey area (37 percent) and on May 23–24, most ducks were observed in the Gold Creek Corridor survey area (41 percent). Most of the ducks in the two survey areas on those surveys occurred on the Susitna River (Table 5.1-2). The total number of ducks in the study area on May 28–29 (1,961 ducks) was slightly less than the previous survey, and most ducks were found in the Watana Reservoir survey area (40 percent). Hundreds of ducks (from 208 to 885 ducks) were found on each survey from May 11 to May 28–29 in each of three survey areas: the Watana Reservoir and the Denali and Gold Creek corridors survey areas. No ducks were recorded in the Dam/Camp survey area until May 28–29 when 29 were recorded on Tsusena Creek and some of the small water bodies (Tables 5.1-2 and 5.1-3).

Red-throated, Common, and Yellow-billed loons were observed in the study area on May 28–29 and Pacific Loons were first seen during the June 1–5 breeding survey (Table 5.1-3). A total of 12 loons were observed in the study area on May 28–29 (Table 5.1-4). Six of those 12 loons were recorded in the Denali Corridor survey area and included sightings of all three of the species recorded on that day (Appendix B). A total of five loons, including three Red-throated Loons and two Common Loons, were recorded in the Gold Creek Corridor survey area and one Red-throated Loon was found in the Watana Reservoir survey area. Most loons that were breeders in the study area probably did not arrive until early June because many of their breeding lakes were inaccessible in late May. Red-throated, Pacific, and Common loons are breeders in the study area, whereas the Yellow-billed Loon is a casual or rare migrant in the area.

Horned Grebes arrived in the study area by May 23–24 and Red-necked Grebes by May 28–29 (Table 5.1-3). A total of six grebes were observed in the study area on May 23–24 and five grebes on May 28–29 (Table 5.1-4). Grebes were recorded in all of the survey areas during spring except the Dam/Camp Area. The highest number of grebes occurred in the Watana Reservoir survey area on May 23–24 when five Horned Grebes were observed (Table 5.1-4, Appendix B). Two sightings of grebes were recorded in the Denali Corridor survey area and one each in the Chulitna and Gold Creek Corridor survey areas.

Three species of gulls were recorded in the study area during spring (Table 5.1-1). The first sighting of two Mew Gulls occurred on May 5, with the peak number occurring on May 11(109 birds; Table 5.1-3). Small numbers of Bonaparte's Gulls were seen on surveys on May 11, 23–24, and 28–29 and Herring Gulls were observed on the last two migration surveys (Appendix B). Arctic Terns were not seen in the study area until the June 1–5 breeding survey. All four species breed in small numbers in the study area. The highest number of gulls recorded during a spring migration survey occurred on May 11 when 112 birds were recorded (Table 5.1-4). All sightings of gulls on that date occurred in the Watana Reservoir and Denali and Gold Creek corridor survey areas and the numbers in each survey area ranged from 33 to 44 birds, with the highest number occurring in the Watana Reservoir survey area. The highest number of gulls recorded among those three survey areas on subsequent spring surveys differed from survey to survey: 6 gulls were recorded in both the Denali and Gold Creek corridors on May 18–19, 29 gulls in the Watana Reservoir on May 23–24, and 25 gulls in the Denali Corridor on May 28–29. Gulls were recorded in the Chulitna Corridor survey area only on May 28–29 when three Mew Gulls were observed. No gulls were recorded in the Dam/Camp Area during spring.

5.1.1.2. Fall Migration

5.1.1.2.1. Temporal and Spatial Patterns

Maximal numbers of waterbirds were recorded during the first fall migration survey, August 14–18 (2,963 birds; Table 5.1-4). Numbers varied thereafter between about 2,200 and 2,800 birds with no apparent trends until the third week of September, when totals dropped to about 1,450–1,600 birds. Numbers again remained steady until the second week of October when totals dropped to fewer than 600 birds. Broods from all species groups were observed during migration surveys in August, and small groups of birds and individuals were located on water bodies of various sizes throughout the study area. To some extent, subsequent changes in local numbers during the fall likely represented movements of local breeding birds within the study area.

Stephan and Murder lakes, in the Gold Creek Corridor survey area, were two of the most heavily used lakes during fall migration (Figure 5.1-2). Murder Lake is relatively small and shallow with emergent vegetation, and is especially favored by dabbling ducks and swans. Stephan Lake is large and deep, with shallow margins, particularly near the inlet and outlet streams. It supported both dabbling and diving ducks, loons, grebes and swans. Also consistently used were Clarence Lake and the southernmost Fog Lake (WB 059 in the APA study) in the Watana Reservoir survey area. Like Stephan Lake, these large, deep lakes supported both large numbers of birds and a wide range of species.

In the Denali Corridor survey area, large numbers of waterbirds were found throughout the fall in a series of shallow unnamed water bodies connected to Brushkana Creek, and to a lesser extent in the interconnected unnamed ponds and discrete small lakes east of Cantwell (Figure 5.1-2, Table 5.1-2). Other water bodies that supported high numbers of waterbirds at some point during the fall included the easternmost large Fog Lake (WB 060 in the APA study), Pistol Lake, Watana Lake, and Molar Lake in the Watana Reservoir survey area, and Big Lake and Deadman Lake in the Denali Corridor survey area.

Parallel to the trends observed for the most abundant species, peak waterbird numbers (i.e., all species combined) occurred between mid-August and mid-September in most survey areas (Table 5.1-4). Ice was first observed on lakes in the study area during the September 16–18 survey, and waterbird numbers declined thereafter in the Watana Reservoir, Denali Corridor and Chulitna Corridor survey areas. In contrast, waterbird numbers increased in the Gold Creek Corridor survey area in late September and peaked in early October, largely due to increased use of Stephan and Murder lakes which remained ice-free. The amount of ice cover in the study area was variable through early October, but had increased substantially by October 10, after which numbers declined steeply in all areas. Most birds after this date were recorded in the Gold Creek Corridor survey area.

Cumulative numbers of ducks (i.e., all duck species across all fall surveys) were highest in the Denali Corridor survey area. This area contained the highest number of ducks through mid-September, followed by the Watana Reservoir survey area (Table 5.1-4). After mid-September, the highest numbers of ducks occurred in the Gold Creek Corridor survey area, followed by the Watana Reservoir survey area.

Cumulative fall swan numbers were very similar between the Gold Creek and Denali Corridor survey areas. The Denali Corridor survey area contained the highest number of swans through mid-September, followed by the Gold Creek survey area (Table 5.1-4). Relative use of the two areas switched after mid-September, when swan numbers in the Denali Corridor dropped slightly, but numbers in the Gold Creek Corridor increased with the arrival of groups, particularly on Murder and Stephan lakes.

Cumulative fall loon numbers were highest in the Gold Creek Corridor survey area, primarily due to large numbers in August. Throughout the fall, however, numbers were highest during at least one survey in each of three other survey areas (Watana Reservoir, Chulitna Corridor, and Denali Corridor). Cumulative grebe numbers were highest in the Watana Reservoir survey area, followed by the Gold Creek survey area (Table 5.1-4).

5.1.1.2.2. Taxonomic Patterns

Trumpeter Swan counts were steady through mid-September and swans were found mostly in pairs (with or without cygnets) and in small groups (Table 5.1-3, Appendix B). Swan numbers increased between mid-September and early October as larger flocks (containing up to 76

Trumpeter and unidentified swans) began to arrive, primarily on Murder and Stephan lakes (Tables 5.1-2 and 5.1-4).

Scaup were by far the most numerous ducks observed during fall surveys (Table 5.1-3). Counts were variable (possibly related to survey conditions) but showed no overall trend until early September, after which they declined steadily until the end of the season. Similar patterns were observed for several dabbling duck species, including American Wigeon, Northern Pintail, Green-winged Teal and Northern Shoveler, all of which peaked between mid-August and mid-September (Table 5.1-3, Appendix B). In contrast, Mallard numbers varied through the third week of September before peaking in early October.

Patterns were weak for scoters and mergansers, but both groups reached maximal numbers in late August and declined a bit thereafter (Table 5.1-3, Appendix B). The highest count of Surf Scoters occurred in late August and a small pulse of Black Scoters was recorded in the second week of October.

Goldeneye and Bufflehead numbers were level throughout the season, except for a pulse of goldeneyes in early October (Table 5.1-3, Appendix B). The highest count of Long-tailed Ducks occurred during the first fall migration survey in August, after which they steadily declined until the end of the season. No Long-tailed Ducks were observed after the October 4–6 survey. Loons and grebes were present throughout the fall season, but their numbers declined after the second week of September.

5.1.1.3. Relative Importance Values of Lakes

Relative importance values were calculated for 34 lakes (or lake groups) used by waterbirds during fall 1980 and spring 1981 by Kessel et al. (1982). In 2013, information on the mean number of birds, density, and species richness (see Table 5.1-5) on 25 of those lakes was used to calculate relative importance values for both spring and fall migration, following the same method used in the 1980s (Table 5.1-6). Based on these factors and the duration of use by waterbirds, these 25 lakes appeared to include the majority of the most important water bodies used during spring and fall. Exceptions include the aforementioned unnamed water bodies in the Denali Corridor survey area (heavily used during fall especially) and river habitats (important during spring).

Similar to the earlier study, Murder Lake ranked as the most important water body in both fall and spring, followed by Stephan Lake (except for spring 1980 when Stephan Lake ranked third). Murder Lake has a comparatively small surface area but contained by far the highest density of waterbirds—especially dabbling ducks—in both fall and spring (Table 5.1-5). Although Murder Lake is shallow, stream flow from Stephan Lake keeps the lake partially open in early spring, which contributed to the very high importance value of Murder Lake in spring 2013, when few other water bodies were available to migrants. Murder Lake also remained partially open late in the fall after other shallow lakes froze and became unavailable to waterbirds.

Large, deep lakes such as Stephan, Clarence, Watana, Big, Deadman, and Fog lakes remained open throughout the fall as well, and were more heavily used by migrants during fall than spring

(Table 5.1-2). As described earlier, many waterbirds used river habitats during spring migration, when most lakes were ice covered.

Stephan Lake ranked second in importance in spring and fall (Table 5.1-6). It generally had a high number of birds and wide range of species. Diving ducks, swans, loons and grebes were observed throughout the lake and dabbling ducks were observed primarily in the shallower margins.

Clarence Lake ranked third in importance in spring and fourth in fall 2013 (Table 5.1-6). Scaup were the most numerous species in both seasons, but the lake also was used during both spring and fall by other diving ducks, dabbling ducks and swans (Table 5.1-2). The range of species was greater in the fall, and included grebes and Common Loon.

Pistol Lake ranked fourth in importance in spring 2013. A group of nine Trumpeter Swans was observed on May 11, but the lake was otherwise unoccupied until the fourth week of May when small numbers of several species of diving and dabbling ducks and a flock of 36 scaup were observed. The lake ranked only eleventh in importance in the fall, primarily because of low overall numbers and density, but it was used regularly by several species of diving and dabbling ducks until the last two fall surveys, when no birds were present despite an abundance of open water.

The southernmost Fog Lake (WB 059) ranked fifth in spring and third in fall 2013 (Table 5.1-6). Scaup were the most numerous species group in both seasons, but the lake was also used during both spring and fall by other diving ducks and dabbling ducks (Table 5.1-2). Grebes, swans and Common Loon used the lake during fall.

Also of high apparent importance were the series of unnamed ponds connected to Brushkana Creek in the Denali Corridor and, secondarily, the unnamed water bodies east of Cantwell (Figure 5.1-2, Table 5.1-2). The relatively small, shallow water bodies connected to Brushkana Creek were consistently used by very high numbers of birds (Table 5.1-2) and, like Murder Lake, were kept open by stream flow after other shallow ponds in the area had frozen. At a higher elevation than Murder Lake, these ponds were not available as early in the spring or as late in the fall, but they supported high densities of birds through the second week of October. Accurate surface area measurements are not yet available for these water bodies, and they were not included in importance value analyses conducted in the 1980s or in 2013.

5.1.2. Ground-based Surveys

5.1.2.1. Spring Migration

The sampling effort in spring 2013 comprised 87.5 h during 122 diurnal radar sessions across 43 days, 183.6 h during 267 nocturnal radar sessions across 42 nights, and 651.4 h during 1,558 diurnal visual survey sessions across 45 days. Audiovisual survey (night-vision) sessions conducted concurrently with the first 2–3 h of nocturnal radar sampling totaled 80.6 h across 43 nights. Radar and nocturnal visual sampling efforts were reduced on 10 days and 14 nights, respectively, because of precipitation, logistical problems, and contamination by insect targets. Precipitation prevented all sampling on two days and three nights. No diurnal data were collected during 19 visual survey sessions (1.2 percent of total) on four days because of logistical issues during crew transitions, a rain storm, and technical problems.

5.1.2.1.1. Radar Surveys

5.1.2.1.1.1. Passage Rate

During spring, both diurnal and nocturnal radar passage rates remained low until May 9, with higher rates occurring afterward until May 30 (Figure 5.1-3). Mean passage rates across the spring season varied among periods of the day and night (ANOVA, $F_{5,\ 157} = 4.86$, $P < 0.001$; Figure 5.1-4) and were highest during nocturnal hours (mean± SE = 114.4 ± 20.1 birds/km/h), and lowest during late afternoon (19.2 ± 7.3 birds/km/h). Throughout the season, passage rates were lower during diurnal sessions than the subsequent nocturnal sessions, regardless of the time of day of the diurnal sampling (paired t-tests; all $P < 0.03$), reflecting the greater volume of nocturnal passerine migration.

The overall mean diurnal passage rate during spring was 31.2 ± 7.8 targets/km/h ($n = 42$ days). Mean daily diurnal passage rates ranged from 0 targets/km/h (morning of May 2) to 287.3 ± 9.3 targets/km/h (morning of May 21; Figure 5.1-3). Mean passage rates of diurnal targets differed significantly among sampling periods (ANOVA, $F_{2,\ 93} = 4.18$, $P = 0.018$), being higher in the morning than in midday or afternoon (Figure 5.1-4).

The mean nocturnal passage rate during spring migration was 98.9 ± 17.0 targets/km/h ($n = 42$ nights). Mean nocturnal passage rates ranged from 0.3 ± 0.2 targets/km/h on the night of April 23 to 379.6 ± 135.7 targets/km/h on May 16 (Figure 5.1-3). The mean passage rate of the nocturnal targets tended to increase for the first 4 h after sunset, with rates more than 1 h after sunset significantly higher than during the crepuscular period in the first hour after sunset (ANOVA, $F_{2,\ 117} = 5.51$, $P = 0.005$; Figure 5.1-5). The rapidly shortening nocturnal period as the spring progressed precluded analysis of nocturnal hours more than 4 h after sunset.

5.1.2.1.1.2. Flight Direction and Distribution of Targets

In the spring, flight directions of the majority of targets during both diurnal (66.3 percent) and nocturnal (75.6 percent) survey periods were westerly (between 225° and 315°; Figure 5.1-6). Mean spring flight directions were 255° (median = 260°; CSD = 64°; $r = 0.54$) for diurnal targets and 268° (median = 270°; CSD = 54°; $r = 0.65$) for nocturnal targets.

Targets were categorized by whether north or south transects were crossed or would have been crossed by extrapolation of flight paths. Daily mean passage rates for diurnal targets crossing north (28.5 ±7.8 targets/km/h) and south (26.7±7.1 targets/km/h) of the radar station were similar (paired t-test, $t_{41} = 0.62$, $P = 0.54$). Similarly, for nocturnal targets there were no differences in passage rates of targets crossing north (93.5± 17.0 targets/km/h) and south (88.9± 15.6 targets/km/h; paired t-test, $t_{41} = 0.72$, $P = 0.48$) of the station.

The effectiveness of radar sampling at the 6-km range was limited by greater frequency of precipitation clutter and high densities of smaller targets (presumably passerines) within 1.5 km; however, it was possible to examine temporal and spatial variation of targets sampled between

1.5 km and 6.0 km from the radar. Numbers of targets in this range (representing flocks and individual larger birds) showed similar diurnal and nocturnal patterns, with two distinct pulses of increased activity: between May 5 and May 10 and from May 21 until May 29 (Figure 5.1-7). The distribution of targets >1.5 km from the radar sampling station also corroborated results of the spatial distribution of targets from sampling at the 1.5-km range, with approximately equal numbers of targets observed north and south of the radar during both diurnal and nocturnal sampling. During both diurnal and nocturnal sampling, however, the distribution of targets to the south extended slightly further from the station than that of targets north of the station (Table 5.1-7), suggesting that migratory flight paths of larger birds (e.g., waterfowl) may be more concentrated over the central and southern portions of the sampling area than farther (>2.5 km) north.

5.1.2.1.1.3. Flight Altitude

The overall mean flight altitude of radar targets during diurnal sampling was 349.7 ± 8.1 m agl (n =1,375 targets), with 22.5 percent of the targets flying at or below 100 m agl (Table 5.1-8). The overall mean flight altitude of radar targets during nocturnal sampling was 451.3 ± 3.6 m agl (n = 6,608 targets), with 9.0 percent of the targets flying at or below 100 m agl. Daily mean flight altitudes were highly variable through the season during both diurnal and nocturnal sampling periods. Mean diurnal altitudes ranged from 98 to 529 m during the study, and mean nocturnal altitudes ranged from 174 to 576 m (Figure 5.1-8). Mean flight altitudes of radar targets were significantly higher at night than during the day (paired t-test, t_{26} = –5.66, P < 0.001). Mean altitudes did not differ among periods within days (ANOVA, $F_{2, 1,372}$ = 0.05, P = 0.95) or nights (ANOVA, $F_{2, 6,605}$ = 1.60, P = 0.20; Figure 5.1-9).

5.1.2.1.2. Diurnal Visual Surveys

5.1.2.1.2.1. Abundance and Species Composition

Diurnal visual sampling in the spring observers recorded 8,188 birds in 2,366 flocks within the survey area (Appendix C). The most common species group recorded during visual surveys was passerines (excluding corvids), with 3,279 birds in 1,204 flocks (40 percent of all birds). Common Redpoll was the most abundant of these passerines observed, with 404 birds in 100 flocks (5 percent). Waterfowl were the second most common species group (2,658 birds in 229 flocks; 32 percent); of them, 1,086 birds in 72 flocks (13 percent) were swans and at least 527 birds in 29 flocks (6 percent) were scoters. Shorebirds (1,181 birds in 188 flocks; 14 percent) were the third most common species group, with Wilson's Snipe the most abundant species (87 birds in 64 flocks; 1 percent). Four hundred and sixty-one diurnal raptors (eagles and hawks) in 422 flocks represented 6 percent of all birds; of them, Golden Eagles (101 birds; 1 percent) were the most common, followed by Bald Eagles (94 birds; 1 percent).

5.1.2.1.2.2. Movement Rate

The overall mean movement rate of all birds during diurnal visual sampling was 11.30 ± 2.06 birds/h (n = 45 days). Mean movement rates on individual days ranged from 0.43 birds/h on April 27 to 81.76 birds/h on May 17. Passerines (excluding Common Ravens) had the highest overall mean movement rate (4.00 ± 0.95 birds/h; Table 5.1-9), with rates increasing starting May 9 (Figure 5.1-10) and peaking with the highest rates recorded on May 17 (39.92 birds/h) and May 23 (13.20 birds/h). Other waterfowl (excluding swans) had the second highest overall mean movement rate (2.31 birds/h; Table5.1-9) and peaked in abundance during the last week of May (Figure 5.1-11) with 20.00 birds/h on May 28 and 13.31 birds/h on May 29. Shorebirds and swans also exhibited some of the higher movement rates across the season, at 1.82 ± 0.93 birds/h and 1.80 ± 0.71 birds/h respectively (Table5.1-9). Whimbrels were the first shorebirds observed in the spring (May 10). Several larger flocks of other shorebird species appeared a week later, and subsequently flocks moved through the area regularly until the last week of May (Figure 5.1-11). Swan movements began to increase at the end of April (Figure 5.1-11) and spiked during a week-long period in early May, when large flocks of up to 200 Tundra Swans were heard and observed. Notably, the date with the highest number of swan detections, May 3, contributed only 64 individuals to the seasonal total, due to very limited visibility throughout the day. Of the 16 swan detections on that day, 15 were auditory-only detections, and flock sizes could not be determined. Swan observations, primarily Trumpeter Swans when identifiable, continued throughout the remainder of the spring season, although no flocks with more than 10 individuals were observed after May 9.

In contrast to passerines and waterbirds, eagles (0.33 ± 0.04 birds/h) and other raptors (0.37 ± 0.05 birds/h) had comparatively moderate to low movement rates (Table 5.1-9). Eagles were consistently present throughout the spring, whereas numbers of other raptors increased in early May and remained high throughout the remainder of the month (Figure 5.1-12). The highest rates for eagles occurred on May 21 (1.30 birds/h), and the highest rates for other raptors occurred on May 9 (1.37 birds/h). Sandhill Cranes first appeared on May 9 and had low movement rates (mean < 0.1 birds/h) throughout the subsequent weeks of the spring survey season (Figure 5.1-13).

Within days, more passerine (ANOVA, $F_{2,\,117} = 10.78$, $P < 0.001$) and fewer raptor movements (ANOVA, $F_{2,\,117} = 17.44$, $P < 0.001$) occurred during the morning than other time periods; however within-day temporal variation in movement rates were not found among other species groups (Figure 5.1-14).

5.1.2.1.2.3. Flight Altitude

The mean minimal flight altitude of birds observed during diurnal visual sampling was 76.7 ± 3.7 m (*n* = 1,064 flocks), with the highest mean minimum altitudes for loons (529.0 ± 290.6 m; *n* = 5 flocks), swans (248.8 ± 38.0 m, *n* = 21 flocks), and eagles (204.9 ± 23.3 m; *n* = 51 flocks; Figure 5.1-15). Other raptors had a lower mean minimum flight altitude (104.8 ± 14.1 m; *n* = 101 flocks), and the lowest mean minimum altitudes were observed in passerines (excluding ravens; 50.7 ± 2.6 m; *n* = 677 flocks), gulls and terns (56.6 ± 9.8 m; *n* = 43 flocks), and shorebirds (77.4 ± 10.3 m; *n* = 90 flocks).

5.1.2.1.2.4. Distribution and Patterns of Movement

Observers recorded flight paths of 1,944 flocks during spring diurnal visual sampling (Appendices D–J). Most flocks (64.13 percent of 1,132 flocks exhibiting straight-line flight) flew in an overall westerly direction (Figure 5.1-16). Species-groups showing the strongest westerly movement included swans (70.59 percent), other passerines (70.50 percent), other raptors (68.69 percent), shorebirds (65.22 percent), and eagles (62.69 percent). Other waterfowl (non-swans;

47.26 percent) exhibited a bimodal pattern of movement in spring (Figure 5.1-16), as most dabbling ducks were observed flying in a westerly direction, but many flocks of diving ducks (particularly scoters during the last week in May) were observed flying easterly (Appendix E).

Most flocks of birds observed at all distances had flight trajectories crossing either north or south of the observation station (*n* = 1,361; Table 5.1-9, Appendices D–J). Of these, 57.8 percent crossed south of the observation station, whereas 42.2 percent crossed to the north (Table 5.1-9). The species groups with the highest percentages of observations south of the site were cranes (91 percent) and eagles (82 percent). Most species groups, however, exhibited similar percentages of north versus south crossing observations (i.e., shorebirds [51.3 percent north; 48.7 percent south], larids [50.0 percent north; 50.0 percent south], and passerines [51.1 percent north; 48.9 percent south]).

To determine if greater numbers of bird movements south of the station were due to birds preferentially following the river channel, numbers of flight tracks crossing a 1.5-km transect line due south of the observation station (extending the full width of the river channel at the site) were compared with numbers crossing a 1.5-km transect line extending due north from the observation station. Limiting the comparison to birds flying over the canyon or over the highlands to the north, 55 percent of all birds were observed over the river channel south of the station (Table 5.1-9). Eagles (82 percent) and cranes (86 percent) had the strongest association with movements over the river channel relative to the highlands north of the canyon.

5.1.2.1.3. Nocturnal Audiovisual Surveys

The study team conducted crepuscular and nocturnal audiovisual observations during the first 2–3 h post-sunset during 43 nights in the spring and recorded 183 flocks (including single individuals), with 86 percent of detections occurring during the latter half of May (Table 5.1-10). Waterfowl, passerines, and shorebirds composed respectively 42 percent, 30 percent, and 23 percent of flocks detected. Mean audio-visual detection rates for the season were 2.76 flocks/h during the first hour post-sunset and 1.97 flocks/h during the second and third hour post-sunset. Audio-only detections accounted for 23 flocks recorded, including 11 detections of Wilson’s Snipe. Other birds detected acoustically included Swainson’s Thrush (*n* = 5), American Robin (*n* = 2), and single detections of Tundra Swan, White-crowned Sparrow, unidentified waterfowl, unidentified shorebird, and unidentified passerine. Among visual detections all except two flocks were observed using binoculars. One flock of Tundra Swans at an altitude of 80 m agl and one unidentified passerine at 5 m agl were observed with night-vision goggles. Use of night-vision goggles was discontinued after May 19 due to increasing sky brightness at night, and binoculars provided a greater detection range for all sampling hours. No bats were visually detected during these crepuscular/nocturnal surveys.

5.1.2.2. Fall Migration

The sampling effort in fall 2013 comprised 94.1 h during 147 diurnal radar sessions across 54 days; 367.4 h during 575 nocturnal radar surveys across 59 nights; and 651.6 h during 1,561 diurnal visual sessions across 61 days. Audiovisual survey (night-vision) sessions conducted concurrently with nocturnal radar sampling totaled 94.4 h across 50 nights. Precipitation, logistical problems, and contamination by insect targets limited radar and nocturnal audiovisual sampling during portions of 34 days and 45 nights and precipitation prevented sampling during all sessions on six days and two nights. No diurnal data were collected during 23 visual survey sessions (1.5 percent of total) on seven days, due to logistical issues.

5.1.2.2.1. Radar Surveys

5.1.2.2.1.1. Passage Rate

Fall radar passage rates were variable among different periods of the day and night (ANOVA, $F_{5, 199}$ = 10.90, P < 0.001; Figure 5.1-4) and were highest during nocturnal hours mean = 118.9 ± 22.5 birds/km/h), and lowest during late afternoon (1.9 ± 0.5 birds/km/h). Passage rates tended to be lower during diurnal radar sampling than during subsequent nocturnal sessions regardless of the time of day of the diurnal sampling (paired t-tests; all $P \leq 0.08$), although nocturnal rates were significantly higher only for days with diurnal sampling during the mid-day period (Paired t-test, t_{26} = 0.43, P = 0.02).

The overall mean fall diurnal passage rate was 10.9 ± 2.4 targets/km/h (n = 53 days). Mean diurnal passage rates fluctuated from the start of the survey season until October 4, subsequently remaining at very low levels through the end of the survey season (Figure 5.1-17). Mean diurnal passage rates on individual days were highly variable and ranged from 0 targets/km/h to 110.7 ± 51.8 targets/km/h (on August 18; Figure 5.1-17). As in the spring, mean passage rates of diurnal targets in the fall differed significantly among sampling periods (ANOVA, $F_{2, 50}$ = 3.51, P = 0.04), being higher in the morning than in the late afternoon (Tukey HSD test; Figure 5.1-4).

The mean nocturnal passage rate during fall migration was 95.1 ± 17.4 targets/km/h (n = 59 nights). Overall, nocturnal migration rates were highest in late August and early September, tapering off until late September, and subsequently remaining at very low levels through the end of the survey season (Figure 5.1-17). Mean nocturnal passage rates on individual days ranged from 0.4 targets/km/h on October 10 to 771.1 targets/km/h on August 23. Within a night, passage rates were much higher during middle hours of the night than either the first hour after sunset or the final hour before sunrise (ANOVA, $F_{2, 149}$ = 17.52, P < 0.001; Tukey HD test; Figure 5.1-4) The mean passage rates of nocturnal targets increased for the first four hours after sunset and declined subsequently (Figure 5.1-5).

5.1.2.2.1.2. Flight Direction and Distribution of Targets

In the fall, flight directions of diurnal radar targets were not strongly oriented in any direction and somewhat bimodal towards the east (36.5 percent between 45° and 135°) and the west (32.9 percent between 225° and 315°), while flight directions of nocturnal radar targets were generally easterly (63.4 percent between 45° and 135°; Figure 5.1-6). Mean fall flight directions were 42° (median = 48°; CSD = 136°; r = 0.06) for diurnal targets and 88° (median = 83°; CSD = 136°; r = 0.45) for nocturnal targets.

Daily mean passage rates for diurnal targets crossing north (9.1 ± 2.4 targets/km/h) and south (7.9 ± 1.8 targets/km/h) of the radar station were similar (paired t-test, t_{52} = 1.21, P = 2.31). For nocturnal targets, there was a non-significant trend for more targets to cross north of the station

(89.9 ± 17.4 targets/km/h) than to the south (85.4 ± 16.7 targets/km/h; paired t-test, t_{58} = 1.86, *P* = 0.07).

Unlike the pattern found during spring, there were no distinct peak periods of movements for targets >1.5 km from the 6-km-range radar during the fall survey season (Figure 5.1-7). A higher percentage of these distant targets were observed south of the radar than to the north during diurnal sampling, but there were no differences during nocturnal sampling (Table 5.1-7). For example, 8 percent of daytime targets >1.5 km north of the radar were at distances of >2.5 km; whereas 43 percent of those to the south were at distances of >2.5 km. During nocturnal sampling, similar percentages (i.e., ~20 percent of targets) to the north and south were at distances >2.5 km.

5.1.2.2.1.3. Flight Altitude

The overall mean flight altitude of radar targets during diurnal sampling was 240.3 ± 11.6 m agl (*n* = 313 targets), with 28.1 percent of the targets flying at or below 100 m agl. The overall mean altitude of radar targets during nocturnal sampling was 402.9 ± 3.3 m agl (*n* = 7,114 targets), with 12.1 percent of the targets flying at or below 100 m agl (Table 5.1-8). Mean diurnal altitudes ranged from 136 to 486 m during the study and mean nocturnal altitudes ranged from 237 to 681 m (Figure 5.1-18).

Mean flight altitudes of radar targets during the fall were significantly higher at night than during the day (paired t-test, t_{11} = –4.58, *P* = 0.001). For diurnal surveys, mean flight altitudes of radar targets were lower during mid-day hours than in the morning or late afternoon (ANOVA, $F_{2, 310}$ = 3.52, *P* = 0.03; Figure 5.1-9). During nocturnal hours, mean flight altitudes were highest during the hour pre-dawn and lowest during the first hour post-sunset (ANOVA, $F_{2, 7,111}$ = 6.51, *P* = 0.001; Figure 5.1-9).

5.1.2.2.2. Diurnal Visual Surveys

5.1.2.2.2.1. Abundance and Species Composition

During diurnal visual sampling in the fall, the study team recorded 6,445 birds in 1,234 flocks within the study area (Appendix C). The most common species group recorded during visual sampling was passerines (excluding ravens), with 3,793 birds in 790 flocks (59 percent of all birds). Within this species group Common Redpoll was again the most abundant species with 1,992 birds in 231 flocks (31 percent of all birds). Sandhill Cranes were the second most common species group (1,754 birds in 33 flocks, 27 percent of all birds). Waterfowl (372 birds in 37 flocks; 6 percent of all birds) were the third most common species group; of them, 301 birds in 30 flocks were swans (5 percent of all birds). One hundred and seventy-one diurnal raptors (Falconiformes) in 159 flocks represented 3 percent of total birds. Bald Eagles (37 birds;0.6 percent) were the most common raptor, followed by Peregrine Falcons (25 birds; 0.4 percent of total birds).

5.1.2.2.2.2. Movement Rate

The overall mean movement rate of all birds during diurnal sampling was 9.43 ± 2.56 birds/h (*n* = 59 days). The largest movement rates (for all species combined) occurred during the first two weeks of sampling (August 15–31, Figure 5.1-10). Mean movement rates on individual days ranged from 0.65 birds/h (September 2) to 150.34 birds/h (September 24). Passerines (excluding Common Ravens) had the highest overall mean movement rate (5.31 ± 0.01 birds/h) of all species groups. Sandhill Cranes (2.86 ± 2.52 birds/h) had the second highest overall mean movement rate with all observations occurring on three days in late September (September 23 [3.46 birds/h], September 24 [148.32 birds/h], September 25 [16.90 birds/h]; Figure 5.1-13). Eagles and other raptors had some of the lowest overall mean movement rates at 0.09 ± 0.02 birds/h and 0.18 ± 0.03 birds/h respectively. Eagle rates were highest from late September through the first week of October (Figure 5.1-12). Movement rates of other raptors declined during early September as falcon and Sharp-shinned Hawk numbers declined and then increased and peaked toward the end of the month as *Buteo* activity increased (Figure 5.1-12). Overall, waterfowl movement rates were low throughout the season. The seasonal mean movement rate of swans was 0.52 ± 0.20 birds/h (Table 5.1-9), with only a small pulse of swan activity occurring during late September (Figure 5.1-11). Only seven small flocks of other waterfowl species and no shorebirds were observed during the entire fall sampling period.

Within days, non-corvid passerine movement rates were lower in late afternoon than earlier in the day (ANOVA, $F_{2, 153}$ = 27.02, P < 0.001; (Figure 5.1-19). Swans tended to move through the area later in the day (ANOVA, $F_{2, 153}$ = 2.94, P = 0.06), while other waterfowl tended to occur earlier (ANOVA, $F_{2, 153}$ = 2.58, P = 0.08). Within-day temporal variation in movement rates were not found among other species groups (Figure 5.1-19). During the three days on which they moved through the area, Sandhill Cranes migrated almost exclusively during midday, when 30 of the 33 flocks (91 percent) were observed (G-test with Williams' correction; G_w = 27.49, df = 2, P < 0.001).

5.1.2.2.2.3. Flight Altitude

The mean minimal flight altitude of all birds during diurnal visual sampling was 44.0 ± 4.1 m (n = 540 flocks), with the highest mean altitudes for cranes (335.0 ± 142.2 m; n = 5 flocks), eagles (204.3 ± 56.4 m; n = 21 flocks), and swans (149.0 ± 80.2 m; n = 10 flocks; Figure 5.1-20). Other waterfowl had an intermediate mean flight altitude (100.0 m; n = 1 flock), whereas the lowest mean altitudes were seen in other passerines (26.8 ± 2.1 m; n = 401 flocks), ravens (46.68 ± 8.5 m; n = 48 flocks), and gulls and terns (50.0 ± 0.0 m; n = 2 flocks).

5.1.2.2.2.4. Distribution and Patterns of Movement

The study team recorded flight paths of 947 flocks during fall diurnal visual sampling (Appendices K–P). Overall flight directions of birds exhibiting straight-line flight (n = 412) were variable but the largest percentage of flights (47.82 percent) were in an easterly direction (Figure 5.1-21). Species-groups showing the strongest easterly movement included cranes (87.50 percent), eagles (78.57 percent), swans (70.37 percent), and other raptors (68.75 percent). Other waterbirds (50 percent) and passerines (41.83 percent) exhibited a weaker easterly movement in the fall.

Most flocks of birds had flight trajectories crossing either north or south of the observation station (n = 474; Appendices K–P). Of these flocks, 62.2 percent crossed south of the observation station, whereas 37.8 percent crossed to the north (Table 5.1-9). Cranes, however, exhibited an equal percentage (50 percent) of northerly versus southerly crossings. In contrast to all other species groups, ravens exhibited a higher percentage of northerly crossings (58.9 percent). Limiting the comparison to birds flying over the river channel or over the highlands within 1.5 km north of the station, more raptors, cranes, and passerines were observed over the channel than over the highlands (Table 5.1-9). Thus, many birds in the fall (with swans as a notable exception) appeared to preferentially fly over and potentially follow the course of the river.

5.1.2.2.3. Nocturnal Audiovisual Surveys

In the fall, the study team conducted crepuscular and nocturnal audiovisual sampling during the first 2–3 h post-sunset during 50 nights. Far fewer birds (44 flocks, including single individuals) were detected during fall nocturnal audio-visual sampling (Table 5.1-11) than during spring sampling, with 28 (64 percent) individual passerines detected on two nights (August 24 and August 25). Altogether, passerines composed 95 percent of all flocks detected. Mean audio-visual detection rates for the season were 0.08 flocks/h during the first hour after sunset and 0.72 flocks/h during the second and third hours after sunset. Only three detections (two single unidentified passerines and one Wilson's Snipe) occurred during the first hour post-sunset. Only one detection (an unidentified passerine flight call) was non-visual. No bats were visually detected during the fall crepuscular/nocturnal surveys. Night-vision goggles were used during all nights for sampling periods more than 1.5 h after sunset and accounted for 19 detections of individual passerines (all flying at altitudes of 10–70 m agl).

5.2. Breeding Season

5.2.1. Breeding Population Surveys

5.2.1.1. Aerial Survey Overview

During the lake-to-lake breeding population survey (hereafter breeding survey), total waterbird densities (by water body surface area) were highest in the Denali Corridor and Watana Reservoir survey areas (Tables 5.2-1 and 5.2-2). Densities in the Dam/Camp survey area also were high on the first of two surveys, but were variable and highly sensitive to small changes in abundance due to the area's small aggregate water body size. Scaup (including both Greater and Lesser scaup) were by far the most abundant species during both the first (June 1-5) and second (June 14-17) surveys, followed by goldeneyes (Common and Barrow's) and American Wigeon (Table 5.2-2). Total bird density decreased between the first and second surveys, driven by a similar decrease in density of scaup. For individual species, perceived and real changes in density between the two survey periods were related to timing of arrival, dispersal, staging and departure of breeding and/or transient birds, which varied among species.

Bird densities calculated from breeding population transect surveys (hereafter transect surveys) east of the Oshetna River cannot be compared directly to densities from the breeding surveys conducted in the rest of the study area, primarily because of differences in how the densities were calculated (the former being based on total survey area size including dry land, and the latter being based on surface area of water bodies only); and secondarily because of differences in survey methods that affect detection rates. As with the breeding surveys in the larger study area, scaup were the most abundant species during both surveys (June2 and 15) in the transect block (Table 5.2-3). However, in sharp contrast to patterns in the larger study area, density of waterbirds in the transect block increased between the first and second surveys. Indicated totals were substantially higher during the second transect survey for scaup, Surf Scoters, Bufflehead, and Red-breasted Mergansers. Patterns likely differed between the lake-to-lake and transect surveys because the latter were conducted over a small area, resulting in densities that were sensitive to minor changes in abundance and to the use of a limited set of habitat types at specific times.

5.2.1.2. Taxonomic Patterns

Scaup were mostly paired during the first breeding survey in early June, and large groups were found on lakes typically used by migrants (Table 5.2-2). Total numbers decreased from 1,080 birds during the first breeding survey to 761 birds during the second; the number of pairs decreased from 456 to 201, and the number of unpaired males increased from 160 to 327. Group sizes on large lakes decreased as birds presumably dispersed into breeding areas, and the total number of water bodies occupied by scaup increased from 101 to 126. The ratio of males to females increased from 57 percent to 69 percent, suggesting that some females were likely attending nests during the second breeding survey.

Similar patterns were observed for scaup in all survey subareas except the Chulitna Corridor survey area, where total numbers increased slightly. The largest decline in numbers and density occurred in the Watana Reservoir survey area, where 265 scaup were grouped on three large lakes during the first survey (Pistol and two Fog lakes) but only 98 scaup occupied the same three lakes during the second survey. Numbers of scaup increased from 16 indicated birds during the first survey in the transect block east of the Oshetna River to 67 indicated birds during the second transect survey (Table 5.2-3), suggesting that some scaup may have departed the larger lake-to-lake survey area after the first breeding survey in early June. It is also probable that reduced detectability of dispersed breeding pairs also contributed to lower numbers during the second breeding survey.

The first breeding survey (June 1–5) appeared to be timed appropriately to describe the breeding distribution of American Wigeon. A near-equal mix of pairs and lone males were recorded during that survey, whereas mostly males were recorded during the second survey. Total numbers increased from 162 birds during the first breeding survey to 196 birds during the second, but the number of water bodies occupied by wigeon decreased from 43 to 29, and more males were found in groups. One exception to the pattern of decreasing pairs was in the Denali Corridor survey area, where both the number of males and the number of pairs increased on the second survey. The total number of birds increased from 57 to 136 birds, but the number of occupied water bodies was nearly unchanged, and 94 (69 percent) of birds observed during the second survey were grouped on three water bodies.

Dabbling ducks as a whole followed a similar pattern to wigeon, generally shifting from pairs and lone males during the first breeding survey to groups composed mostly of males condensed to fewer water bodies during the second breeding survey. Total dabbling duck numbers increased from between the two surveys, but the number of water bodies occupied by dabblers decreased from 116 to 72. The percentage of males was 72 and 80 percent during the first and second breeding surveys respectively, suggesting that some females were attending nests during each survey. The increase in total numbers likely resulted from increased detectability of flocked birds, but a late arrival of breeding birds or of post-breeding males from outside the study area may also have occurred.

The pattern of increasing numbers for dabbling ducks was not evident in the Chulitna Corridor or Dam/Camp survey areas (Table 5.2-2). Declines were observed for wigeon, mallards and teal in the Dam/Camp Area, and for all dabbling ducks in the Chulitna Corridor survey area. In the latter area, 64 dabbling ducks were observed during the first breeding survey, compared to only 6 birds during the second. For dabbling ducks in general, unstable numbers between the two breeding surveys likely resulted from grouping and movement of post-breeding males after early June.

The breeding distribution of goldeneyes appeared to be captured more effectively by the first breeding survey than by the second. The total number of goldeneyes increased modestly between the surveys (Table 5.2-2), but the number of occupied water bodies decreased from 59 to 41. Few females were observed during the second breeding survey, and many males were found in groups. In the Gold Creek Corridor, 23 water bodies were occupied by a total of 44 goldeneyes during the first breeding survey, but only 6 water bodies were used by 25 goldeneyes during the second survey (19 were on Stephan Lake). In contrast, the number of water bodies occupied by goldeneyes in the adjacent Watana Reservoir survey area remained nearly constant, but the number of birds increased from 90 to 137, due primarily to the influx of males on two large lakes in the Fog Lake group (a total of 102 males and 10 females were grouped on two lakes during the second breeding survey). Numbers of goldeneyes and of water bodies occupied by goldeneyes were relatively stable in the Chulitna and Denali corridor survey areas, but density dropped in the Dam/Camp Area, where five birds were recorded on four different lakes during the first breeding survey, and no birds were observed during the second breeding survey.

The total number of scoters decreased between the two breeding surveys, but the number of males dropped only slightly (from 82 to 75 males). During the first breeding survey nearly all scoters were paired, but during the second breeding survey about half of males were unaccompanied by females. Most scoters during both surveys were observed in the Watana Reservoir survey area.

All White-winged Scoters were paired during the first breeding survey, and 29 of 32 pairs were grouped on three large lakes (Stephan and two Fog lakes). Total numbers dropped by nearly 60 percent on the second breeding survey (to 12 pairs and 2 lone males) and the remaining birds occupied only four water bodies, including the same two Fog lakes as before. These results suggest that at least some White-winged Scoters observed during the first breeding survey were migrating through the study area.

In contrast to White-winged Scoters, Surf Scoter numbers dropped only slightly between the two breeding surveys (Table 5.2-2) and the number of males increased. They were dispersed over a larger number of lakes, thus it appears they were more likely breeding in the area. A total of 75 Surf Scoters (34 pairs, 5 males and 2 females) were distributed among 25 water bodies during the first survey, and 72 Surf Scoters (18 pairs, 28 males and 8 females) occupied 19 water bodies during the second survey. Numbers declined between the first and second breeding surveys in the Dam/camp, Denali Corridor and Gold Creek Corridor survey areas; but increased in the Watana Reservoir survey area. Surf Scoters were seen on many of the same lakes during both breeding surveys in the Watana Reservoir survey area, and the total number of occupied lakes was unchanged; but small groups of males and a group of females were also observed during the second breeding survey in the Fog lake group and Clarence Lake. Surf Scoters also increased in the transect survey area, from 6 pairs during the first survey, to 10 pairs, 6 lone males, and 6 grouped birds during the second transect survey (Table 5.2-3).

Relatively few Black Scoters were observed, and locations varied between the two breeding surveys. The largest single group was five pairs plus seven males in Molar Lake in the Watana Reservoir survey area during the second survey, where none had been seen during the first survey.

Bufflehead numbers increased sharply from 63 birds during the first breeding survey to 113 birds during the second survey (Table 5.2-2). This increase may have resulted from a late influx of pairs, as the numbers of pairs, males and females all increased. The number of water bodies occupied by Bufflehead increased slightly from 26 to 29, and most water bodies contained 4 or fewer birds during both breeding surveys. During the second survey, however, five mixed-sex groups of 12–16 birds, comprising 39 males and 28 females, were also observed. The increase in Bufflehead numbers was concentrated in the east end of the study area. The three largest groups were in the Watana Reservoir survey area, and two of those were in water bodies near Goose Creek near the east end of the Watana area. Numbers also increased further east, in the transect block east of the Oshetna River, where no Bufflehead were observed during the first transect survey, and 9 birds (indicated total 18) were observed during the second survey (Table 5.2-3).

Long-tailed Duck numbers were similar between the two breeding surveys (Table 5.2-2) and a mix of pairs and lone males were observed during both surveys. The total number of males increased from 32 to 40, and the number of water bodies occupied by Long-tailed Ducks increased slightly from 25 during the first survey to 28 during the second. Little grouping was apparent during either survey, with most observations consisting of singles, pairs and small groups of <5 birds. Movements may have occurred among survey areas, as suggested by changes in density and numbers of pairs in several survey areas, but the drop in density in the Denali Corridor (where numbers were highest) resulted from the disappearance of females; pairs were mostly observed during the first breeding survey and lone males during the second.

Trumpeter swan numbers and densities were highest in the Denali Corridor, particularly during the second breeding survey when a flock of 14 swans plus several pairs and singles totaling an additional 20 birds were observed in a series of ponds and sloughs adjacent to the Nenana River (Table 5.2-2). Nineteen swans were observed in the same area during the first breeding survey. Flocks of 9 and 10 swans were observed in Stephan Lake in the Gold Creek corridor during the first and second surveys, respectively. Numbers were low in the Chulitna Corridor and Dam/Camp survey areas both surveys (one pair was observed on the same lake both surveys in the Dam/Camp Area, and one pair was observed in the Chulitna Corridor survey area during the second survey). Pairs and singles were sparsely scattered throughout the other three areas during both breeding surveys, and two small groups (four and five birds) were found in the Gold Creek Corridor survey area during the second survey.

Some grebes may have been attending nests during the first breeding survey on June 1–5. During that survey, a total of eight Horned Grebes (two pairs and four singles) were dispersed among six different water bodies, and nine Red-necked Grebes (two pairs and five singles) occupied seven water bodies. Numbers of both species dropped substantially on the second breeding survey, when only one Horned Grebe and no Red-necked Grebes were observed (Table 5.2-2).

Patterns were difficult to detect for some species occurring in low densities. Numbers were stable between breeding surveys for mergansers and loons, but apparent changes within survey areas could have reflected movements among areas, variable detection rates or both. Red-breasted Mergansers increased in the Denali Corridor survey area, from one pair and two females on three different lakes during the first breeding survey, to three pairs and three males on a single lake during the second survey. In the Gold Creek Corridor survey area, reduced numbers of Red-breasted Mergansers resulted partly from the disappearance of most females, which may have been attending nests during the second survey. Indicated numbers of Red-breasted Mergansers increased from zero during the first transect survey in the transect block east of the Oshetna River, to 16 during the second (four males and four pairs; Table 5.2-3). Nearly all loons were observed as singles or pairs during both breeding surveys, and numbers of all three species were relatively stable between surveys, but with changes in numbers within some survey areas (Table 5.2-2).

5.2.2. Harlequin Duck Surveys

5.2.2.1. Spring Migration

Harlequin Ducks were first seen in the study area on May 11 when a pair was observed on the Susitna River in the Gold Creek Corridor survey area, between Indian River and Portage Creek (Figure 5.2-1, Table 5.2-4). On May 18–19, a total of 22 Harlequin Ducks were counted, 20 of which were on the Susitna River and 2 of which were on the Oshetna River. About half of the 20 Harlequin Ducks seen on May 18–19 on the Susitna River were above the proposed dam site in the Watana Reservoir survey area and the other half were below it in the Gold Creek Corridor survey area.

Peak numbers of Harlequin Ducks occurred on May 23–24 when 554 individuals were counted, 521 of which were on the Susitna River. Slightly more than half of those 521 Harlequin Ducks on the Susitna River were in the Gold Creek Corridor survey area and the remainder were in the Watana Reservoir survey area (Figure 5.2-1, Table 5.2-4). Harlequin Ducks were found on eight other streams on May 23–24: Indian, Jack, and Nenana rivers and Brushkana, Fog, Kosina, Portage, and Seattle creeks. Of those eight streams, Brushkana Creek supported the highest number with 14 ducks.

By May 28–29, the total number of Harlequin Ducks recorded on streams dropped to 210 ducks and they were distributed on 17 different streams in the study area (Figure 5.2-1, Table 5.2-4). The portion of the Susitna River in the Watana Reservoir survey area supported the most Harlequin Ducks on May 28–29 (67 ducks), followed by Deadman Creek (27), Brushkana Creek (26), and the Susitna River in the Gold Creek Corridor survey area (20).

On all spring migration surveys, Harlequin Ducks were most often seen in pairs or groups of pairs. Groups of 10–32 ducks were common on the Susitna River, particularly on May 23–24, when more than half of the Harlequin Ducks sightings were in groups of that size (Figure 5.2-1). Harlequin Ducks were found staging along the entire length of the Susitna River in the study area and were commonly found at the confluence of a tributary (Figure 5.2-1). Harlequin Ducks occupied tributaries as stretches of open water became available on them. Some ducks probably were able to occupy breeding territories on tributaries after staging on the Susitna River while other ducks moved to tributaries as a secondary staging area while waiting for breeding territories in the upper reaches of streams to become available.

5.2.2.2. Pre-nesting

Thirty streams were surveyed for Harlequin Ducks during pre-nesting surveys, which consisted of 25 named streams and 5 unnamed streams (Figures 5.2-2, Tables 5.2-5). Three of the 30 streams were not surveyed during the June 1–5 survey because of either time constraints, strong winds in river drainages, or because it was questionable as to whether the stream was suitable for pre-nesting Harlequin Ducks. The Study Plan (RSP Section 10.15.4.2.2) stated that surveys for Harlequin Ducks would follow the entire length of tributaries where suitable nesting habitat was present. That proved not to be feasible because suitable nesting habitat likely extends to the upper reaches of most tributaries >10 mi from the study area and possibly includes most small secondary and tertiary tributaries within and outside the study area. During pre-nesting and brood-rearing aerial surveys in 2013, all primary tributaries of the Susitna and Nenana rivers were surveyed and additionally many secondary tributaries, but tertiary tributaries within or outside of the study area were not surveyed. What was considered suitable pre-nesting and brood-rearing habitat for Harlequin Ducks within the study area was continually evaluated during each survey and consequently, the extent of coverage of some streams differed among surveys.

A Harlequin Duck nest was found on June 11during the Landbird and Shorebird Study (Section 10.16) on a small tributary of Watana Creek that was not surveyed during the aerial survey because of its small size (Figure 5.2-2). The nest was on the ground at the base of a tree next to a stream that was only about 3 ft wide. The line-of-sight distance to Watana Creek was 1 mi and the downstream distance from the nest site to Watana Creek was 2.7 mi.

Harlequin Ducks were found on 20 of the 30 streams surveyed during pre-nesting and were distributed throughout the study area, occurring in all 5 survey areas (Figure 5.2-2). A similar number of Harlequin Ducks was recorded during the first pre-nesting survey on June 1–5 (173 ducks) and the second survey on June 14–16 (185 ducks), however, the distribution of ducks differed within the study area between the two surveys (Table 5.2-5, Figure 5.2-2). On June 1–5, most Harlequin Ducks were found in the Denali Corridor survey area (77 ducks) followed by the Watana Reservoir (66), whereas on June 14–16, the Watana Reservoir had more ducks (114 ducks) than the Denali Corridor (33). Further, Harlequin Ducks were found on six streams in the Watana Reservoir survey area on June 14–16 whereas no ducks were seen on those streams on June 1–5. The coverage of streams on June 1–5 was not as extensive as on June 14–16, and some of the sightings of Harlequin Ducks on the second survey were along stream sections that were not surveyed on the first survey. In other areas where Harlequin Ducks were seen on June 14–16 and not on June 1–5, the coverage was similar. The remaining 20 percent of the Harlequin Ducks observed in the study area on each survey occurred in the Gold Creek Corridor, the Chulitna Corridor, and Dam/Camp survey areas.

Of the four streams with the highest number of Harlequin Ducks on each pre-nesting survey (≥15 total ducks), three streams were the same between surveys: Deadman and Kosina creeks and the Susitna River (Table 5.2-5). Brushkana Creek had 26 ducks on June 1–5 and the Black River had 29 on June 14–17. Most of the observations on Kosina Creek and all of the observations on the Black River were outside of the 3-mi study area buffer (Figure 5.2-2). On other streams, like Deadman, Brushkana, and Tsusena creeks and the Susitna River, Harlequin Ducks were found distributed all along most of the entire length of the stream surveyed. Harlequin Ducks were seen on a total of 15 different streams on June 1–5 and 19 different streams on June 14–16 (Table 5.2-5).

Most of the Harlequin Ducks recorded during pre-nesting surveys were found in pairs. During the first pre-nesting survey, 87 percent of the Harlequin Ducks were in pairs, whereas 68 percent were in pairs on the second survey (Table 5.2-5). During June 1–5, a total of 75 pairs were observed, with the highest numbers occurring on Deadman and Brushkana creeks (12 pairs each), followed by the Susitna River (10 pairs), and Kosina Creek and the Jack River (7 pairs each) (Figure 5.2-2). Groups of pairs were seen on most of these streams, which may indicate that the location was serving as a staging site and ducks were not yet at breeding territories. During June 14–17, a total of 63 pairs were counted with the highest number of 10 pairs occurring on the Susitna River, followed by nine pairs on the Black River and five pairs each on Kosina, Watana, Deadman, and Tsusena creeks (Figure 5.2-2). Pairs were distributed a little more evenly along a stream on this survey compared to the first survey. Only four single females were seen on the first survey and males not in pairs were seen either as singles, in groups of males, or with pairs. Thirty-four single females and 27 males were seen on the second survey (Table 5.2-5). A few single females were seen near pairs and males not in pairs were, like the first survey, seen either as singles, in groups of males, or with pairs. On both surveys, Harlequin Ducks were seen in clear and turbid waters and on sections of placid and fast-flowing streams. Some Harlequin Ducks were found on beaver ponds in the upper stretches of tributaries.

5.2.2.3. Brood-rearing

During brood-rearing, Harlequin Ducks were found on 21 of the 28 streams surveyed (Figure 5.2-3). Some streams were not surveyed on one of the two brood-rearing survey or on both surveys because of either time constraints, strong winds in river drainages, or because it was determined that the stream was not suitable for brood-rearing Harlequin Ducks. One small tributary of the Susitna River (R18) was not surveyed during either survey because it had very little water in it during brood-rearing surveys. The Nenana River was not surveyed because it was very turbid and was considered to be poor brood-rearing habitat. The Susitna River was surveyed on the first brood-rearing survey but it too was very turbid and was not surveyed on the second brood-rearing survey because it was considered to be poor brood-rearing habitat.

Broods were found on 15 of the 21 streams surveyed, with the highest number of four broods observed on Devil Creek, followed by three broods each on Goose, Deadman, and Seattle creeks (Table 5.2-6). Twelve broods were observed on the first brood-rearing survey on August 1–5 on eight different streams and 27 broods were seen on the second survey on August 14–18 on 14 different streams. For both brood-rearing surveys combined, at least 30 individual broods were found in the entire area surveyed and just over half of the broods found on each survey were within the 3-mi buffer of the waterbird study area (Figure 5.2-3). Broods were recorded in all survey areas except the Dam/Camp Area.

The highest number of broods found in a survey area was 12 broods in the Watana Reservoir on August 14–18 (Table 5.2-6). Broods were found on seven different streams in the survey area on that survey. On August 1–5, seven broods were observed in the Watana Reservoir survey area on four of the same streams where broods were seen on August 14–18, and additionally on Jay Creek. Based on the age and locations of broods on each survey, the Watana Reservoir survey area in total had 14 broods for the season: three broods on Goose Creek, at least two broods each on Watana, Jay, Gilbert, and R21 creeks, and one each on the Black River, and Fog and R19 creeks (Figure 5.2-3). Additionally, females without young were found on Kosina and Tsisi creeks and the Oshetna River.

In the Denali Corridor survey area, three broods were found on both Deadman and Seattle creeks, and three and five females without young, respectively, were found on Jack River and Brushkana Creek (Figure 5.2-3, Table 5.2-6). In the Chulitna Corridor survey area, four broods were found on Devil Creek, two broods were found on Indian River, and one brood each on Portage, Clark, and Tsusena creeks. Females without young on were observed on Thoroughfare Creek. The only brood and Harlequin Duck observation in the Gold Creek survey area was on Fog Creek.

On August 1–5, 12 of 50 females were associated with 50 young and on August 14–18, 27 of 36 females were associated with 106 young. The average brood size on the first survey was 4.2 young/brood and 3.9 young/brood on the second survey. Most broods seen on the first survey were about 12 days old (range = approximately 8 to 26 days old) and on the second survey about 26 days old (range = approximately 8 to 39 days old). The start date of incubation was calculated by subtracting the chick age from the survey date to obtain the hatch date and then subtracting 28 days for the incubation period (Robertson and Goudie 1999). Thus, the earliest start date of incubation in 2013 was estimated to be June 10 and the latest was estimated to be July 9. The Harlequin Duck broods from the early season nests were found in Jay, Fog, and R21 creeks. These creeks had open water early in the season along some sections of the creeks and, on both Jay and R21 creeks, Harlequin Ducks were staging on beaver ponds during pre-nesting surveys. The average date of the start of incubation for all broods seen in the study area was June 26.

Broods with young chicks quickly took cover under overhanging branches when spotted from the helicopter and some moved from the water into cover on shore. Because of the secretive behavior of broods, particularly ones with young chicks, some broods probably were missed during surveys. Other reasons that broods sometimes may not have been detected included the dense vegetation covering some streams, sun glare on the water or reflective glare on the helicopter window which obscured clear views of streams, and not getting bank-to-bank views of the stream when tight sections of streams or windy conditions prevented the pilot from maintaining a flight path parallel to the stream course.

5.2.3. Brood Surveys

Two brood-rearing surveys were conducted during summer 2013 within a 1-mi area around and including the Dam/Camp Area, the Watana Reservoir, and the Denali, Chulitna, and Gold Creek corridor survey areas of the study area (Figures 4.1-1–4.1-3). A total of 499 water bodies were surveyed on each survey, which resulted in an area of 5.7 mi^2 of water bodies surveyed. The survey team recorded broods of 24 species on the two surveys, including one species of swan, 15 species of ducks, three species of loons, two species of grebes, two species of gull, and one species of tern (Table 5.2-7). A total of 111 broods were observed on July 20–22 and a total of 151 broods on August1–5. Between the two surveys at least 227 individual broods were found in the waterbird brood survey area. The four most common species with broods (numbering more than eight broods each) on each survey were scaup, goldeneyes, Green-winged Teal, and American Wigeon, in order of abundance. For 11 of the 24 species with broods, only one brood was observed on either or both surveys.

The Denali Corridor survey area contained most of the broods in the waterbird brood survey area on both brood-rearing surveys; 61 percent of the broods on July 20–22 and 59 percent of the broods on August 1–5 (Figure 5.2-4, Table 5.2-7). Broods of 18 species were observed between the two surveys combined in the Denali Corridor survey area and a total of 68 broods were observed on July 20–22 and 89 broods on August 1–5. Between the two surveys at least 138 individual broods were recorded, which was more than four times the number recorded in any other survey area. The four most common species with broods in the waterbird brood survey area—American Wigeon, Green-winged Teal, scaup, and goldeneyes—were also the most common species with broods in the Denali Corridor survey area. Further, more than 60 percent of the broods of American Wigeon, Green-winged Teal, and scaup were found in the Denali Corridor survey area (Table 5.2-7).The number of broods found in the Watana Reservoir, and Chulitna and Gold Creek corridor survey areas ranged from 9 to 19 broods on each survey. On both surveys combined, broods of eight species were seen in the Watana Reservoir and Gold Creek Corridor survey areas and nine species in the Chulitna Corridor survey area. Three broods of three species were found in the Dam/Camp Area on July 20–22 and six broods of five species on August 1–5 (Table 5.2-7).

Although the total number of broods was lower than in the Denali Corridor, the brood density was higher in the Watana Reservoir survey area than any other survey area (40.7 broods/mi^2; Table 5.2-7). The density of broods in the Denali Corridor survey area on the first and second was 30.5 and 39.9 broods/mi^2, respectively. The Watana Reservoir survey area has the lowest amount of water body surface area among the survey areas, except for the Dam/Camp Area, and the number of broods relative to the amount of water is high. The Dam/Camp Area had a higher density of broods on both surveys than the Gold Creek Corridor survey area, which had five times the amount of water body surface area.

Broods of eight species (Trumpeter Swan, Northern Shoveler, Long-tailed Duck, Bufflehead, Red-throated Loon, Bonaparte's Gull, Mew Gull, and Arctic Tern) were only found in the Denali Corridor survey area (Table 5.2-7). Seven other species were only found in one of the other four survey areas: Red-breasted Merganser in the Dam/Camp Area, White-winged Scoter and Horned Grebe in the Watana Reservoir survey area, Gadwall and Black Scoter in the Chulitna Corridor survey area, and Pacific Loon and Red-necked Grebe in the Gold Creek Corridor survey area.

Broods of three species were found in all five survey areas (Mallard, Green-winged Teal, and goldeneyes) and broods of scaup and Common Loon were found in all survey areas except the Dam/Camp Area.

Ten water bodies in the Denali Corridor survey area contained three or more different broods either on one survey or both surveys combined (Figure 5.2-4). The highest number of broods recorded on a water body on a single survey was nine broods on July 20–22. This water body was located at the divide between the Brushkana and Deadman creek drainages. Many other water bodies in this area supported multiple broods, including a couple of large shallow water bodies that are connected to Brushkana Creek (Figure 5.2-4). Large numbers of scaup broods were found in this area. Another area in the Denali Corridor survey area that supported multiple scaup broods and the broods of four other species were a couple of lakes adjacent to the Denali Highway (Figure 5.2-4). Additionally, lakes adjacent to lower Deadman Creek and in the drainages just west of Deadman Mountain were important brood-rearing areas too. Within the other four the survey areas, broods were found on lakes throughout each survey area with no more than three broods found on one lake during a survey (Figure 5.2-4).

During brood-rearing surveys, chicks from duck broods were classified into seven different age subclasses based on plumage development (Table 5.2-8). Class 1, which is made up of 1A, 1B, and 1C, is a stage when chicks are downy with no visible feathers. Class 2, which is made up of 2A, 2B, and 2C, is a stage when chicks are partially feathered. In Class 3, chicks are fully feathered. On the first brood survey on July 20–22, 80 percent of the broods were in the Class 1 category, which roughly equates to an age range of 1–20 days old. The age range related to each subclass varies by species. On the second brood survey on August 1–5, 64 percent of the broods were in Class 2. All the remaining broods except for one were in Class 1.

The midpoint of that age range is used to calculate hatch date by subtracting the chick age from the survey date and then an incubation start date by subtracting the duration of the incubation period. Dates for the start of incubation were calculated for a selection of species in which chick ages are associated with subclass categories and where a sample of greater than five broods was available (Gollop and Marshall 1941, Lesage et al. 1997). Northern Pintails were the earliest nesters with a median incubation start date of 31 May (n = 12 broods), followed by Mallard with a date of June6 (n = 9). Three species had a median incubation start date of June10, which included American Wigeon (n = 18), Surf Scoter (n = 6), and goldeneyes (n = 29). Green-winged Teal had a median incubation start date of June 20 (n = 36) and scaup was June 21 (n = 74). Dabbling ducks like Northern Pintail, Mallard, American Wigeon, and Green-winged Teal are usually considered early nesters and diving ducks like scaup, Surf Scoter and goldeneyes are considered late nesters. Because of the delay in the availability of open water and snow-free ground in the study area in 2013, many dabbling ducks may have started nesting later than average. The nesting phenology of diving ducks may have been similar to an average year in the study area.

5.3. Information for Mercury Study

A literature review conducted by the study team on the food habits of the waterbird species that occur in the study area indicated that fish were likely to compose 40 percent or more of the diets of these species: Common Loon, Red-throated Loon, Red-necked Grebe, Common Merganser, Red-breasted Merganser, Bonaparte's Gull, and Arctic Tern. Accordingly, these seven species were identified as the best candidate species for collection of feathers for laboratory sampling of mercury content.

Only a single nest and few broods of these piscivorous waterbirds were found during the breeding, brood, and fall migration waterbird aerial surveys in 2013 (those surveys focused on locating adult birds and broods, rather than nests). One Common Loon nest was found in the Watana Reservoir survey area, but could not be visited because it was located on CIRWG lands.

Broods of all seven species of piscivorous waterbirds were observed in 2013, but the nest locations were not found. Loons and grebes often return to the same nest lake each year, so lakes where broods were observed in 2013 can be targeted during aerial surveys in the next study season to look for nests. Merganser broods were found in all five survey areas, with most broods (nine) occurring in the Gold Creek Corridor, followed by the Denali Corridor (six), Watana Reservoir and Gold Creek Corridor (four each), and the Dam/Camp Area (one).

Seven broods of Common Loons were found in the study area, located in all survey areas except the Dam/Camp Area. Two Red-throated Loon broods were found in the Denali Corridor survey area. Three broods of Red-necked Grebes and an unidentified brood of grebes were found in the Watana Reservoir survey area. Two other unidentified grebe broods were found in the Denali Corridor survey area and a Red-necked Grebe brood was found in the Gold Creek Corridor survey area. All of the gull and tern broods found in 2013 were in the Denali Corridor survey area: three broods of Bonaparte's Gulls, two brood of unidentified gulls, and one brood of Arctic Terns.

6. DISCUSSION

6.1. Spring and Fall Migration

6.1.1. Aerial Surveys

The data collected in 2013 during spring and fall aerial surveys fulfilled the study objectives to document the occurrence, distribution, abundance, habitat use, and seasonal timing of waterbirds migrating through the Project area. Spring and fall migration aerial surveys for waterbirds were conducted at a frequency of every 5–6 days, which effectively identified important staging areas and documented the timing of migration and the distribution and abundance of waterbirds. Because snow and ice cover persisted much longer than average in south-central Alaska during spring 2013, spring migration in 2013 may have been more compressed than in an average spring. Furthermore, the arrival of peak numbers of early migrant waterbirds may have been later than average. From late April to mid-May, very little open water was available to waterbirds in the study area and waterbirds were concentrated at a few open-water areas on water bodies and streams. The first open water on large lakes was at outlet and inlet areas and those locations gradually supported more waterbirds with each successive spring survey. The amount of open water on rivers increased more rapidly than on lakes and between the first and third week in May, rivers supported more waterbirds than lakes. The Nenana and Susitna rivers were the most important rivers for staging waterbirds during May because of the development of leads in river ice. At that time, the water in these two rivers was clear and leads served as foraging sites for waterbirds while ice adjacent to leads provided resting sites. On the May 23–24 spring migration survey, 47 percent of the waterbirds in the study area were staging on the Susitna River. During late May, warm temperatures caused rapid snow melt and the breakup of rivers happened quickly. Rivers became less suitable for staging and by the last migration survey on May 28–29, just over three-quarters of the waterbirds were found on lakes.

In general, the pattern of use of the study area during spring in 2013 was similar to that recorded in 1981 during the APA project (Kessel et al. 1982). Kessel et al. (1982) noted early migrants used the Susitna River and the thawed edges of lakes, and that use of most of the water bodies did not increase until the end of May. The Susitna River was not surveyed in the 1980s and so the timing and the magnitude of use by waterbirds at that time is unknown. The selection of lakes surveyed in the 1980s during spring and fall migration was considerably less compared to 2013, but overall the species composition recorded between the two studies was similar (Kessel et al. 1982).

One interrelated study was described in the Study Plan that could potentially inform the Waterbird Migration, Breeding and Habitat Use Study. It was anticipated that information from the study of ice processes in the Susitna River (Study 10.7.6) would be helpful in scheduling the start date of spring migration surveys. However, because spring breakup was delayed in the study area in 2013, migration surveys commenced prior to availability of open water, so information from the ice processes study was not needed.

Fall migration surveys in 2013 documented the use of water bodies by waterbirds in the study area from mid-August to mid-October. Waterbirds were distributed throughout the study area during most of the fall until the freeze-up of water bodies restricted birds to large lakes that still had open water. Numbers of waterbirds were highest from mid-August until the third week of September. Numbers remained steady from late September until the second week of October when totals dropped to fewer than 600 birds. In general, the pattern of fall movement for most waterbirds species in 2013 was similar to the pattern recorded in the 1980s (Kessel et al. 1982), whereby the numbers of most dabbling ducks (except for Mallards) peaked in early fall and the movement of swans through the study area occurred between mid-September and early October.

Some large lakes in the study area were surveyed during spring and fall in the 1980s and in 2013. A relative importance value was determined for these lakes based on calculations that were developed for the APA project (Kessel et al. 1982). Four of the top five lakes of relative importance in the 1980s also ranked in the top five lakes of relative importance during spring and fall 2013:Murder, Stephan, and Clarence lakes, and a lake in the Fog Lakes group. Counts of waterbirds on those four lakes in 2013 during peak periods ranged from 100–200 during spring and 100–400 during fall. The highest species diversity recorded on a single survey in 2013 was at Stephan Lake where 17 species were found in late May and 12 species in mid-August.

The highest count of waterbirds recorded on a single survey during spring and fall in 2013 was between 2,000 and 3,000 birds. For spring the peak count occurred in late May and for fall, counts peaked from mid-August to mid-September. Ducks were the most abundant species group during spring and fall, followed by swans, loons, and grebes. Geese and gulls were mostly observed during spring. Single-species groups of 31–100 ducks were observed on every spring survey from early to late May and all 11 of the fall migration surveys. Large, single-species groups of Northern Pintail and Northern Shoveler were observed only in spring and large groups of Green-winged Teal were observed only in fall. Groups of Mallards and American Wigeon were seen during both seasons. For diving ducks, the only species observed in large groups during spring were scaup. During fall, large groups of scaup were common and groups of goldeneyes and merganser also were observed occasionally. Swans were observed in pairs or small groups during spring. During fall, a couple of groups of 53–76 swans were seen on Murder and Stephan lakes in late September. Snow Geese were the only goose species seen in a large group (80 birds) and that group was observed flying over the study area during late May. Snow Geese are migrants in the study area and were not present during the breeding season. Eight other species were recorded as migrants because they also were seen only during the migration season. All of the other 30 species were recorded in the study area during the breeding season and 27 of those species were confirmed breeders. Whether the large groups of ducks and swans in the study area during spring and fall migration are migrants or local breeders is not known. Regardless, many streams and water bodies within the study area were locally important staging areas for waterbirds before and after the breeding season.

6.1.2. Ground-based Surveys

These studies provide the first comprehensive survey of bird migration for the Upper Susitna River Basin. For the APA project (Kessel et al. 1982), avian surveys of the region concentrated on breeding season studies, although aerial surveys of water bodies were conducted in spring and fall to determine usage by migrating waterbirds. Results are also available for several other bird migration studies in central Alaska that used methodologies similar to those described here and provide some context for the results of this study (Appendices Q–S). Comparisons of the results of this radar study with those of other studies are presented below.

While these comparisons are useful in providing a general context for understanding patterns of bird migration in the region, it should be borne in mind that comparisons among these sites may be confounded by variation in study dates, study duration, categorization of species, analytical methods, and radar technology, as well as by extrinsic factors such as annual variation and site characteristics that may influence detectability. For these reasons, caution is warranted when interpreting these studies.

6.1.2.1. Species Composition and Abundance

Although the fall survey period was 16 days longer than the spring survey period, differences in average day length resulted in equal time being sampled during both seasons. The number of flocks observed in spring (2,366) was double the number observed in the fall (1,234). Total numbers of individuals observed, however, were more similar between the two seasons, indicating that mean flock sizes were larger during the fall. This result is largely due to the prevalence of Common Redpoll flocks in the fall, as they constituted less than 5 percent of flocks and individuals in the spring but almost 20 percent of all flocks and 30 percent of the total number of individuals in the fall. In both spring and fall, non-corvid passerines composed the majority of flocks observed, as well as 40 percent of individuals in the spring and 59 percent of individuals in the fall. In the spring, waterfowl also were numerous, composing 32 percent of the total number of birds observed; and shorebirds (14 percent) were the only other group representing more than 10 percent. In the fall, only Sandhill Cranes (27 percent) and passerines represented more than 6 percent of the total observed.

The study team recorded 183 groups of birds during post-sunset periods in the spring and 44 groups during the same time of day in the fall. In the spring, passerines, ducks, and shorebirds (primarily Wilson's Snipe) composed the majority of flocks observed at night, whereas passerines comprised nearly all nocturnal observations in the fall. During much of the spring season, crepuscular light conditions allowed for continued use of binoculars and unaided visual scanning for observations of birds out to several kilometers (to the north) for 2–3 h after sunset. In the fall, darkness precluded use of binoculars after the first hour post-sunset, and detectability of birds was thereafter more limited by the restricted field of view and detectability distance (e.g., limited to within ~100 m for passerine-sized birds) of night-vision goggles. Although detectability differences contributed to the differences in numbers of birds observed in the two seasons, relative abundances of the species groups reflected those during diurnal sampling as well. In two studies north of the Alaska Range, fewer birds (predominantly passerines) were observed visually after sunset in the spring than during fall migration studies (Shook et al. 2009, 2011).

6.1.2.2. Species Groups

The study team recorded 93 species of birds during the spring and fall migration periods of 2013. A number of these were year-round residents and/or local breeders, and observations of these likely include multiple observations on single individuals and groups. Many of these bird species differ in flight behaviors, flock sizes, altitude and timing of flights, and seasons of use. The following discussion presents information on four species groups that pass through the area. The prioritization and selection of these groups was based on abundance, and/or their conservation and protection status. Species groups discussed include waterfowl (with emphasis on Trumpeter and Tundra swans), Sandhill Cranes, raptors (with emphasis on Bald and Golden eagles), and passerines.

6.1.2.2.1. Swans and Other Waterbirds

Kessel et al. (1982) suggested that the Upper Susitna River Basin was not a significant flyway for migrating waterfowl, and results of the migration surveys conducted in 2013, in comparison with other migration studies in central Alaska (Appendices Q and R), generally support this assertion. Waterfowl accounted for 32 percent of individual birds observed in spring, but the total number of individuals (2,658) was lower than reported in nearly all other studies. Waterfowl numbers in fall (372, 6 percent of all birds) were substantially lower. Results of aerial surveys in 1981, 1982, and 2013 (Table 5.1-6) indicated that fewer waterfowl used water bodies of the upper Susitna River basin for stopover in the spring than in the fall; however, the results of ground-based surveys conducted in 2013 suggest that more birds fly through the region in the spring than in the fall. During spring 2013, swans (47 percent) and scoters (23 percent) accounted for the majority of identifiable waterfowl observed, but only accounted for 1 percent and 8 percent, respectively, of waterfowl seen during aerial surveys of the area in spring 1981 (Kessel et al. 1982) and 4 percent and 2 percent, respectively, of waterfowl seen during aerial surveys of the area in spring 2013 (see Aerial Survey Results, this study). These results suggest that some species primarily migrate through the basin without stopping-over at local water bodies.

Swans accounted for 41 percent of waterfowl observed in the spring and 81 percent of waterfowl observed in the fall. Trumpeter Swans breed locally, and both Trumpeter and Tundra swans migrate through the region to and from breeding areas in western Alaska (Ely et al. 1997, Kessel et al. 1982, Bellrose 1976). Although swans accounted for 13 percent of all species recorded during the spring migration period, the total number observed across the season (1,086) was lower than reported from comparable studies in the region (Appendix Q), most of which were located north of the Alaska Range, within the Tanana River basin, a well-documented migration corridor (see Cooper et al. 1991). Few migration studies have been done south of the Alaska Range, however, and none have been conducted in the Talkeetna Range where the Project would be located.

It is unlikely that the 2013 sampling season failed to encompass all of the spring migration of swans, because extended winter weather and record late ice break up regionally also delayed much of the spring 2013 bird migration, resulting in few swans moving through the region until early May, two weeks after initiation of surveys. Spring swan numbers, however, were reduced by low visibility conditions throughout the day on May 3, during which 16 different flocks of swans, including both species, were recorded passing; but only one group of 29 birds was observed and accurately counted. Because flocks of up to 200 individuals were observed on subsequent days, and no more than 12 flocks were seen or heard during any other day of the season, it seems certain that a substantial proportion of the total number of swans flew through the survey area untallied during that single day. In contrast to the May peak reported here, other studies observed peak dates of swans occurring more than a week earlier, during ~April 23–27 (Appendix Q).

In the fall, far fewer swans (301 birds) were observed moving through the study area than in the spring; and the fall 2013 count also was low in comparison to other fall migration studies (Appendix R). Given that water bodies in the region were yet unfrozen at the end of the survey period, it is possible that additional movements of swans may have occurred after surveys ended in mid-October. Among five central Alaskan studies with survey seasons extending later in October, however, dates of peak swan migration ranged from September 28 to October 13 (Cooper et al. 1991), all of which are well before the final day of surveys for this study.

Swan mortality resulting from collisions with power lines and other artificial structures has been documented across much of North America and Europe (Avery et al. 1980, Erickson et al. 2005), although such mortality events appear rare in Alaska (Cooper et al. 1991, Ritchie and King 2000, Shook et al. 2009). Directional, spatial, and altitudinal flight patterns are therefore important factors in assessing potential collision risk for birds present in an area. As with most migrating species during the survey, swan movements were strongly directional in both seasons along an east/west axis. In both seasons, more swans were observed south of the visual observation station than to the north. In spring, this appeared to be a result of birds concentrating along the river channel, but in the fall more birds tracked parallel to but south of the channel (Appendices D and K; Table 5.1-9).

In the spring, swans generally flew at higher altitudes than most species, with a mean flock flight height of ~250 m agl and a quarter of flocks flying less than 100 m agl. Flight altitudes in the spring were similar to those recorded at the Eva Creek wind development near Ferry (Shook et al. 2011), but higher than reported elsewhere along the Tanana River Valley or at Fire Island, in Cook Inlet (Appendix S). In the fall, the mean flight altitude for swans was 150 m agl, with almost half the flocks flying less than 100 m agl, and similar to that reported for most other migration studies in the region (except lower than observed at Eva Creek; Appendix S). It is possible that variability in the mean flight altitudes of swans observed during the survey, both within and between seasons, may reflect species differences as well. Trumpeter Swans, which breed locally, generally were observed at lower flight altitudes and constituted a greater proportion of swans identified to species in the fall than in the spring.

Ducks accounted for 43 percent of waterfowl and 44 percent of all birds observed in the spring but only 3 percent of waterfowl and <1 percent of all birds observed in the fall. Geese composed 12 percent of the total number of waterfowl and 4 percent of all birds in the spring, and only 6 percent of waterfowl and <1 percent of all birds in the fall. Five percent of waterfowl in the spring and 13 percent in the fall were observed at too great a distance to determine if they were ducks or geese. The total number of ducks observed in the spring (1,136) was intermediate relative to numbers observed during previous migration studies in the region (Appendix Q); however, numbers of geese seen during this study were much lower than observed during most other spring studies. In the fall, numbers of both ducks and geese were much lower than reported during nearly all previous fall migration studies in the region (Appendix R). For both seasons, numbers of waterfowl were within the lower range of numbers observed during three years of surveys at Gulkana, which is also located south of the Alaska Range, 110 mi east of the Project site. The relatively low numbers of geese observed during this study can be attributed largely to Greater White-fronted Goose migration being more prevalent north of the Alaska Range than to the south (Cooper et al. 1991).

Flight directions of geese in spring were predominantly westerly; however, those of ducks were bimodal along the east-west axis, with most flocks flying in an easterly direction. Approximately equal numbers of dabbling duck flocks were observed flying to the east and west, but flight directions of diving ducks, scoters in particular, were strongly easterly, suggesting that sea ducks migrate from coastal areas to the south or west before heading to inland breeding areas. Supporting this hypothesis further, most loons also were observed flying easterly in the spring. Flight directions of larids, however, were bimodal along the east-west axis in the spring. Most of the larids observed were Herring Gulls, however, which often exhibited patterns of movements up river (easterly) in the morning and westerly (later in the day), potentially reflecting daily transit between nocturnal roosting sites and diurnal foraging areas.

Shorebirds migrated through the area during a two-week period in mid-May, in higher numbers than have been reported during most other migration surveys in central Alaska (except Tok in 1987 and 1989; Cooper et al. 1991; see Appendix Q). Although the species composition could not be determined for the majority of shorebirds observed, at least 10 species were represented among the flocks recorded. No shorebirds were observed during diurnal surveys in the fall; the only fall observation being a single Wilson's Snipe observed during an early evening audiovisual survey session in early September. Few shorebirds have been observed during fall migration studies elsewhere in the region as well (Appendix R); although these studies, as well as the current efforts, likely missed a large portion of the fall shorebird migration period, which generally begins in late June.

6.1.2.2.2. Sandhill Cranes

In the spring, Sandhill Cranes appear to migrate through Interior Alaska in a broad front and are less concentrated than they are in the fall. In the fall, birds breeding in western Alaska must fly toward the northeast, around the northward curve of the Alaska Range, then swing to the southeast to exit the Tanana Valley. Cooper et al. (1991) conducted several years (1987–1989) of extensive bird migration studies during spring and fall migration at Gakona (near Gulkana) and stated that "almost no cranes fly over the Gulkana study area during migration." Low numbers also were observed at Fire Island during spring (83 individuals) and fall (111 individuals) migration (Day et al. 2005). This study recorded low numbers of Sandhill Cranes migrating through the study area during spring (23 individuals) and fall (1,754 individuals).

In contrast to the study area, Sandhill Cranes appear to move in large numbers north of the Alaska Range. The Tanana Valley is a well-known spring and fall migration corridor for the mid-continental population of Sandhill Cranes (Kessel 1979, 1984; Cooper et al. 1991). The number of birds moving through the region is on the order of 150,000 birds in the spring and 200,000 birds in the fall (Kessel 1984). A variety of sites north of the Alaska Range have recorded high numbers of cranes during spring and fall (Appendices Q and R), including Tok [(1987: 113,167; 97,988) (1988: 31,311; 43,442) (1989: 97,970; 67,776; Cooper et al. 1991)]; Eva Creek (12,757; 48,276; Shook et al. 2011); Delta Junction (31,163 spring only; Parrett et al. 2009); the Golden Valley Electric Association Northern Intertie corridor (GVEA Intertie; 30,509; 84,979; Day et al. 2011), whereas a site along the Delta River in the Alaska Range had much lower numbers during spring and fall migration (339; 200; ABR 2010).

The timing of peak spring migration for cranes has been relatively consistent for sites in Interior Alaska, during May 4–11 in spring (Appendix Q) and September 10–23 in fall (Appendix R). Peak crane movements in this study fell within the spring range (May 9) and just outside the fall range (September 24).

Mean flight altitudes of migratory cranes have varied from 76 m agl at a coastal location (Fire Island) to 113–201 m agl (Tok) to 364 m agl at Eva Creek (Appendix S). This study only had one Sandhill Crane observation within 1 km of the observation point, which was recorded at a minimum flight altitude of 100 m agl; thus, it is not possible to make any broad generalizations about crane altitudes in this study. Cranes at greater distances had significantly higher estimated mean minimum flight altitudes (>500 m agl in both spring and fall) but altitude estimates at such distances were probably less accurate than those made nearby.

6.1.2.2.3. Raptors

Although they accounted for only 6 percent of all birds recorded in spring and 3 percent in the fall, raptors were second to passerines in the frequency of occurrence throughout the study and were seen during 96 percent of survey days in the spring and 74 percent of survey days in the fall. Of birds identified to species, Golden (25 percent) and Bald eagles (24 percent) were the most frequently observed raptors in the spring. Together with unidentified eagles they represented 48 percent of all raptors and 3 percent of all birds seen in the spring. Relatively fewer Golden Eagles (9 percent of identifiable raptors) were seen in the fall, when Bald Eagles (24 percent of raptors), Peregrine Falcons (16 percent), and Sharp-shinned Hawks (14 percent) were relatively more numerous.

Movement rates of raptors in the Project generally were within the range of rates observed elsewhere in Alaska during spring and lower than rates observed elsewhere during the fall (Appendices Q and R). As with other species groups, spring raptor migration occurred late in 2013. Peak movement rates occurred in May rather than April, as reported for previous studies in the region (Appendix Q). The increase and peak in raptors in late September suggests that fall raptor migration largely fell within the range of Project-wide survey dates. Mean minimum flight altitudes observed during this study also differed from mean flight altitudes reported elsewhere, generally being higher in the study area than observed at other locations within the region (Appendix S). Higher movement rates of many raptors after May 15, however, may be inflated by the presence of local breeders rather than represent late migrants, and mean flight altitudes also may differ among migrating and local individuals. Raptor migration counts conducted at other points within the study area overlapped temporally with the surveys reported here during the spring period from April 20 through May 15 and during the fall from September 15 through October 15. Further discussion of raptor migration in the study area is presented in ISR Study 10.14, Surveys of Eagles and Other Raptors.

6.1.2.2.4. Passerines

Migration routes of passerines in Interior Alaska are poorly known, but they appear to migrate over a broad front for an extended period from early April through late May and during August through early October (Cooper et al. 1991). The spring and fall survey periods in 2013 encompassed the peak dates of passerine migration reported elsewhere in central Alaska (Appendices Q and R), and the seasonal patterns of daily mean movement rates during this study suggest that the sampling period encompassed nearly all of the passerine migration period in the spring. Diurnal visual movement rates of passerines in the fall were highest during the first week of sampling, and 10 species observed during spring sampling were not recorded during the fall (compared to three species in the fall that were not observed earlier in the year), suggesting that some early season fall migration of passerines may have been missed.

Relative abundance of passerines during migratory seasons has not been studied well in the Project area and counts of 3,369 and 3,913 during the 2013 spring and fall migration seasons, respectively, begin to provide some baseline information. A variety of sites north of the Alaska Range have recorded variable numbers of passerines during spring and fall including Tok [1987: 9,275, 9,318]; [1988: 7,030, 5,959]; [1989: 9,290, 7,052]; Cooper et al. 1991); Eva Creek wind development near Ferry (493, 1,252; Shook et al. 2011); Delta Junction (911; spring only; Parrett et al. 2009); and Delta River, a site within the Alaska Range (270, 460; ABR 2010). One site south of the Alaska Range (Gulkana) recorded lower numbers of passerines during spring and fall migration ([1987: 357, 866]; [1988: 912, 600]; [1989: 675, 628]; Cooper et al. 1991); however, these results (as well as those at Tok) only included passerines observed within 100 m of the survey station.

Peak passerine movements in this study were later in the spring (May 17) than reported for other migration studies (ranging from April 28 to May 11) in central Alaska (Appendix Q), which likely corresponds to the late onset of spring-like conditions across the state in 2013. Within the study area, the area surveyed was largely snow-covered at almost all elevations until late May in 2013. The peak dates of fall passerine movements were highly variable among different studies and years (Appendix R), likely due to variable relative abundances of species with different migration chronologies. Half of the studies in the region, including the survey reported here, however, had a peak passerine migration date between September 10 and September 15.

The mean minimum flight altitude of passerines observed in the spring (51 m agl) was significantly higher than mean altitudes reported from other spring migration studies in central Alaska (range 16–28 m agl), while the mean for the fall migration survey at the Project (27 m agl) was mid-way within the range (19–38 m agl) reported elsewhere (Appendix S). The higher spring flight altitudes may be associated with the topography near the visual sampling station, which included the river gorge. Minimum flight altitudes of birds that flew along the river channel (particularly swallows in the spring), often were recorded as higher than 50 m agl, although their flight heights relative to the observers were generally much lower or even negative.

Mean flight altitudes of migratory passerines are typically the lowest among species groups observed during terrestrial visual studies; however, these results tend to be biased by the limited detectability range for smaller birds. Concurrent radar observations demonstrate that most migrants, and smaller birds in particular, will not be detected by visual observers. Even within a short horizontal distance from the observer, many, and often most individual passerines will fly at altitudes high enough to be undetected. Although other types of studies confirm that passerines tend to migrate over land at lower altitudes than other species groups (Kerlinger 1995), the difficulty in observing smaller birds at greater distances and altitudes also results in mean altitude estimates that are biased low. The flight altitude of passerines also can be biased by the inclusion of local or foraging birds that tend to fly at lower altitudes due to the local nature of their flights and may be difficult to distinguish from migratory flights.

6.1.2.3. Radar Passage Rates

Passage rates are an index of the number of targets (birds) flying past a location and are a widely-used metric in studies of migration activity (Day et al. 2005, Day et al. 2011, Shook et al. 2011). Thus, passage rates allow for comparisons of bird use among different sites and regions. In this study, target characteristics observed at the 1.5-km range as well as the relatively low numbers of radar targets observed greater than 1.5 km from the radar (representing larger-bodied birds and flocks) indicate that nocturnal radar passage rates primarily reflect passerine migration rates.

Radar observations indicate that low numbers of birds migrate through the Project during diurnal periods of spring and fall migration. The diurnal radar surveys recorded passage rates of 31 and 11 targets/km/h during spring and fall, respectively. A similar pattern was found at Eva Creek (42 and 10 targets/km/h during spring and fall, respectively; Shook et al. 2011). No other diurnal mean passage rates are available from Alaska for comparison.

The nocturnal radar surveys recorded passage rates of 114 and 119 targets/km/h during spring and fall, respectively, at the Project. For comparison, spring and fall nocturnal passage rates at other locations in Alaska include Eva Creek (148 and 198 targets/km/h), Delta River (approximately 27 targets/km/h during 10days of peak fall migration; ABR 2010), and Fire Island (14 and 7 targets/km/h; Day et al. 2005). Nocturnal mean passage rates were not calculated from studies in Tok and Gulkana (Cooper et al. 1991), but passage rate by date are available in this report. No additional studies are available for comparison in Alaska; however, fall radar migration rates at a continental scale are reported by Johnston et al. (2013). The lack of additional studies for comparison in this region, highlights the general lack of information on nocturnal migration passage rates in Alaska and the western US and warrants the cautious interpretation of comparisons with the few studies that are available.

6.1.2.4. Flight Directions

Flight directions in both the spring and the fall were consistent with expectations during both radar surveys and diurnal visual surveys. In the spring, the mean flight direction on radar was 255° during the day and 268° at night; during visual surveys, 83 percent of all flocks seen during the daytime flew in a westerly direction, which is consistent with flight paths of birds migrating to Western and Interior Alaska from their winter ranges. In the fall, the mean flight direction on radar was 042° during the day and 088° at night; during visual surveys, with 80 percent of all flocks seen during the daytime flying in an easterly direction. For comparison, the main axis of the Upper Susitna River Basin in the vicinity of the survey area is essentially east–west (90°/270°), suggesting that these birds were following the predominant orientation of the river channel in both seasons.

6.1.2.5. Radar Flight Altitudes

Flight altitudes are critical for understanding the vertical distribution of migrants in the airspace and have implications for collision risk assessment and other predictors of disturbance for migrating birds. Large numbers of birds found dead at tall, human-made structures (generally lighted and guyed communications towers; Avery et al. 1980) and the predominance of nocturnal migrant passerines among such fatalities (Manville 2000; Longcore et al. 2005) indicate that large numbers of these birds fly lower than 500 m agl on at least some nights. Radar studies have confirmed that most nocturnal migration occurs below approximately 1.0–1.5 km agl (Larkin 2006, Mabee and Cooper 2004, Mabee et al. 2006, Clemson University Radar Ornithology Lab [CUROL] 2007). Results from the vertical distribution of radar targets in this study and those from other published studies indicate that the majority of nocturnal migrants fly below 600 m agl (Bellrose 1971; Gauthreaux 1972, 1978, 1991; Bruderer and Steidinger 1972; Cooper and Ritchie 1995, Kerlinger 1995).

Similar to nocturnal migration studies elsewhere in Alaska (Cooper et al. 1991; Cooper and Ritchie 1995; Day et al. 2005; Day et al. 2011; Shook et al. 2001), large among-night variation in mean flight altitudes occurred during the 2013 migrationsampling for this study. Daily variation in mean flight altitudes may have reflected changes in species composition, vertical structure of the atmosphere, and/or weather conditions. Variation among days in the flight altitudes of migrants at other locations has been associated primarily with changes in the vertical structure of the atmosphere. For example, birds crossing the Gulf of Mexico appear to fly at altitudes where favorable winds minimize the energetic cost of migration (Gauthreaux 1991). Kerlinger and

Moore (1989), Bruderer et al. (1995), and Liechti et al. (2000) have concluded that atmospheric structure is the primary selective force determining the height at which migrating birds fly.

Diurnal mean spring and fall flight altitudes of all radar targets in this study (350 ± 8.1, 240 ±11.6 m agl, respectively) were higher than those reported at Eva Creek (250 ± 14.2, 197 ± 17.0 m agl; Shook et al. 2011). Mean altitudes of passerines (57 m agl) and cranes (576 m agl) and other groups with intermediate flight altitudes were reported from spring and fall seasons in Tok, Alaska (Cooper and Ritchie 1995). Direct comparisons with Cooper and Ritchie (1995), however, are hindered by the differences in radars (i.e., 5 kW units with a parabolic antenna used by them versus 12kW units with a slotted array antenna used in all other studies).

Nocturnal mean spring flight altitudes of all birds in this study (451 ± 3.6, m agl, respectively) were higher than those reported at Eva Creek (403 ± 6.0 m agl; Shook et al. 2011) and potentially lower than those from Delta Junction (478 ± 17.8; Parrett and Day 2009), although only five nights were sampled during their study. Mean altitudes (146–184 m agl) also were reported during two years of spring migration in Tok, Alaska (Cooper et al. 1991), but direct comparisons with this study are hindered by the differences in radar equipment (see above).

Nocturnal mean fall flight altitudes of all birds in this study (403 ± 3.3, m agl, respectively) were lower than those reported at Eva Creek (432 ± 4.8 m agl; Shook et al. 2011). Mean altitudes (341–426 m agl) also were reported during two years of spring migration in Tok, Alaska (Cooper et al. 1991); but direct comparisons with this study are hindered by the differences in radar equipment. Comparisons at a continental scale suggest that migratory flight altitudes in Alaska are within the range of those reported in areas to the south (Johnston et al. 2013). A lack of additional studies for comparison in this region highlights the general lack of information on nocturnal migration rates in Alaska and the western U.S. and warrants the cautious interpretation of comparisons with the few studies that are available.

6.1.2.6. Conclusions

The 2013 radar and visual surveys of bird movements in the vicinity of the Watana Dam site are the most comprehensive migration surveys ever conducted for the Upper Susitna River Basin. Radar survey results indicated that moderate numbers of nocturnal migrants flew over the study area in predicted seasonally-appropriate directions during both spring and fall. Visual survey results suggest that spring migration rates in the basin for waterbirds and cranes are lower than those recorded elsewhere in central Alaska, particularly those in the Tanana River Valley, north of the Alaska Range. Fall numbers for all non-passerine groups except cranes were significantly lower than were spring numbers, and also were lower (including cranes) than have been reported for fall migration elsewhere in the region. Spring shorebirds were the only group with high numbers of individuals observed relative to most other studies.

Through the data collection efforts in 2013, the study team is on track to meet the objectives stated in the Study Plan (RSP Section 10.15.1) for this multi-year study to "[d]ocument the occurrence, distribution, abundance, habitat use, and seasonal timing of waterbirds migrating through the Project area in spring and fall." Swans were undercounted to some extent during the spring survey because of low visibility during the day with the highest number of (audio) detections for the season. The record-setting extension of winter weather into May 2013 delayed the anticipated onset of migration in the region, but it is unclear to what extent it also may have affected migratory pathways and passage rates over the Project. What is clear is that arrival dates of spring migrants to the study area in 2013 were likely to have been much later than in most other years. It is likely that the survey periods encompassed the vast majority of migration for most species groups, although water bodies remained open through the end of the survey period on October 15; so it is possible that some swan migration may have occurred after sampling ended. Radar and visual surveys confirmed that flight directions of most species groups were strongly oriented in the directions expected for each season (westerly in spring and easterly in fall), except for easterly movements of scoter flocks in late May. Radar results indicated moderate numbers of nocturnal migrants that matched patterns in the seasonal timing of diurnal radar passage rates and visual movement rates of passerines.

6.2. Breeding Season

The data collected in 2013 during aerial surveys for breeding and brood-rearing waterbirds, including Harlequin Ducks, met the study objectives to document the occurrence, distribution, abundance, productivity, and habitat use of waterbirds breeding in the Project area.

6.2.1. Breeding Population Surveys

The first waterbird breeding population survey (June 1-5) appeared to be timed appropriately to describe the breeding distribution of dabbling ducks in the study area. Large aggregations of migrants were not observed, and pairs and lone males were dispersed widely across the study area. The first breeding survey also appeared to capture likely nesting areas for goldeneyes and grebes. Some mergansers and scoters may not have been present in their nesting locations during the first week of June, but the first survey was likely the most appropriate for those species as well due to the reduction of occupied water bodies for mergansers, and the early stages of grouping and decline in the number of occupied water bodies for scoters during the second survey. The second breeding waterbird survey (June 14-17) seemed to best identify breeding areas for scaup, Long-tailed Ducks, and Bufflehead. Swans and loons appeared to occupy known or likely breeding areas during both surveys. The highest numbers for a given species often occurred not during the survey when birds were dispersed into nesting areas, but rather when they were grouped and most conspicuous (i.e. prior to dispersal into nesting areas or after initiation of nests and departure of males from nesting areas). However, because the counts of grouped birds may have contained migrants from outside the study area, they did not necessarily provide the most accurate estimates of the local breeding population.

USFWS conducts an annual waterfowl breeding population survey in early June in an area adjacent to the transect block from this study east of the Oshetna River (hereafter transect block), using similar methods. The most recent published data from their survey is from 2011 (Nelchina Stratum in Mallek and Groves 2011). During that survey, American Wigeon occurred at the highest density of all waterfowl, followed by Mallards and Green-winged Teal. In the transect block, Mallards, scaup and Ring-necked Ducks occurred at similar densities during the first survey, and scaup were by far the most abundant species during the second survey. Compared to the USFWS survey (Nelchina Stratum), lower densities of most dabbling ducks were observed in the transect block, including Mallards, American Wigeon, Green-winged Teal and Northern Pintail. Higher densities of scaup, Northern Shovelers and Long-tailed Ducks were observed in the transect block; and similar densities (on at least one of two surveys) of Ring-necked Ducks, scoters, mergansers and swans. Bufflehead density in the transect block was lower than reported for the Nelchina Stratum in the first survey, and higher during the second survey. Because the transect block covers a smaller area and likely occurs in a more uniform habitat than the broader USFWS survey, it is not surprising to see differences in relative abundance and density of species between the two surveys. Data compared here were collected in different years; a more appropriate comparison will be possible when 2013 data from the Nelchina Stratum of the USFWS surveys become available.

6.2.2. Harlequin Duck Surveys

Harlequin Ducks form pair bonds on the wintering grounds and the pairs return together to traditional breeding areas (Robertson et al. 1998). During the courtship period, males and females are visible on breeding streams and defend an area where they forage and conduct courtship activities (Robertson and Goudie 1999). The Project area is supports a large number of Harlequin Ducks during the spring, pre-nesting and brood-rearing seasons. The Susitna River provides good staging habitat in spring when numerous leads in the river ice allow Harlequin Ducks a place to feed in clear-flowing waters (prior to the muddy waters of river breakup) and a place to rest on exposed gravel bars or shore fast river ice. Over 500 ducks were recorded on the Susitna River on May 23–24 and they were distributed all along the river within the study area. As the amount of open water increased on nearby streams, Harlequin Ducks moved to occupy breeding territories on them. By the May 28–29 spring survey, the number of Harlequin Ducks on the Susitna River had dropped to 87 ducks. At other inland breeding areas in North America, Harlequin Ducks also stage on large rivers before occupying breeding streams (Smith 1998 in Robertson and Goudie 1999).

The occurrence of spring migration surveys at an interval of every 5–6 days documented the importance of the Susitna River to Harlequin Ducks as a staging location prior to nesting. The first pre-nesting survey occurred on June 1–5, just three days after the last spring migration survey. This date of the first pre-nesting survey was changed from that stated in the Study Plan because of late river breakup in 2013. By June 1–5, most Harlequin Ducks had moved from the Susitna River to tributaries and therefore, the first pre-nesting survey was well-timed to document the use of tributaries for pre-nesting activities. Some of the larger tributaries of the Susitna and Nenana rivers, like Deadman and Brushkana creeks, may have served as secondary staging locations for Harlequin Ducks at the time of June 1–5 survey because pairs were grouped closely together on some streams on that survey. By the time of the June 14–17 survey, Harlequin Ducks occupied more streams than on the first pre-nesting survey and locations of pairs were distributed more evenly on streams. The locations of Harlequin Ducks on this survey may have been a better representation of breeding territories on some streams. Because of a difference across the study area in the timing of suitable stretches of open water on streams, there is variation in when Harlequin Ducks can occupy breeding territories on tributaries. The two pre-nesting surveys conducted in 2013 in the Project area effectively covered the window of time that pairs are visible on breeding streams.

Streams in the Watana Reservoir and the Denali Corridor survey areas supported the highest number of pre-nesting Harlequin Ducks in the study area. Greater than ten ducks were found on the Susitna, Black, Oshetna, and Jack rivers, and Kosina, Goose, Watana, R21, Deadman, Brushkana, Tsusena, and Fog creeks. Although most Harlequin Ducks were in pairs on June 14-17, the high number of sightings of females and males outside of pairs on that survey compared to the first pre-nesting survey may mean that the process of nest site selection had begun for some ducks. Only female Harlequin Ducks select the nest site, although males may accompany female to prospective locations (Robertson and Goudie 1999). Males have been documented to wait at the confluence of larger watersheds while females select a nest site along a smaller tributary. The extent of a stream defended by a pair during the pre-nesting period is variable. Some breeding Harlequin Ducks defend a stretch of stream no greater than 2 mi while other pairs use twice that much or more (Kuchel 1977, Cassirer and Groves 1992 in Robertson and Goudie1999). Also, Harlequin Ducks may forage and court on one part of a stream and nest on another. In Alberta, pre-nesting females were recorded foraging 5 mi downstream from nesting sites (MacCallum and Bugera 1998 in Robertson and Goudie 1999) and a nesting female was documented to fly 9 mi from the nest site to a feeding site during incubation breaks (Smith 1999 in Robertson and Goudie 1999). The discovery of a Harlequin Duck nest during the Landbird and Shorebird Study (Study 10.16) on a very small tributary of Watana Creek indicates that Harlequin Ducks similarly may nest at sites far from main tributaries where most of their courting and foraging activities take place.

The dates of the first brood-rearing survey (August 1–5) was determined based on the date of the discovery of a Harlequin Duck nest in the Project area and the timing of the presence of Harlequin Ducks on tributaries during pre-nesting. The timing was later than that stated in the Study Plan, which was based on the assumption of an earlier seasonal phenology. Most broods were an average age of 12 days old on the August 1–5 brood-rearing survey, which was an age where they could be detected on rivers with females. If the survey had been conducted any earlier, the detection of broods probably would have been very low because young broods are very secretive. Broods on the second brood-rearing survey on August 14–18 were an average of 26 days old. The range in age on that survey was 8–34 days old, which includes broods that hatched since the first brood-rearing survey. More than twice as many broods were seen on the second survey (27 broods) as the first survey (12), and between the two surveys at least 30 individual broods were found in the study area. On both surveys, most broods were found in the Watana Reservoir survey area. The stream with the highest number of broods was Devil Creek with 4 broods, followed by Goose, Deadman, and Seattle creeks, which had three each. Some broods probably were missed on each survey because challenging survey conditions (i.e., dense vegetation and glare) obscured them or made them harder to detect. The use of two brood surveys helped to detect ducks that were missed on one or the other survey, however, and effectively covered the window of time in which broods were visible on breeding streams.

6.2.3. Brood Surveys

The two brood surveys conducted in the waterbird brood study area successfully documented the species composition of waterbirds breeding in the study area. Broods were found for at least 24 of the 38 species recorded in the study area. The dates of the first and second brood survey were changed from those stated in the Study Plan because of the delay in the availability of open water and snow-free ground in the study area in 2013. The study team selected the survey dates of the first brood survey based on the dates when ducks were observed on breeding water bodies and the presence of female ducks during the breeding population surveys. The timing of the first survey on July 20–22 successfully documented the start of the nesting season for ducks and the

August 1–5 survey documented the end of the nesting season. The older broods found on the first brood survey were ducks that started nesting early, most of which were dabbling ducks (Northern Pintail, Mallard, and American Wigeon). Scaup were the latest-nesting ducks and were the most abundant species in the waterbird brood study area. There was a lot of overlap in the age of broods between dabbling and diving ducks and whether that is a result of the delayed spring is uncertain. The presence of open water at breeding water bodies varied throughout the study area during late spring and some areas were suitable for nesting earlier than other areas, which may also be a reason for the variation in brood ages within a species and between species.

The results of brood surveys in 2013 are not directly comparable with survey results from the APA project in the 1980s because the two survey areas differed substantially in size; the exact water bodies surveyed for broods in the 1980s is not known. Brood densities in the 2013 waterbird brood study area were 2.5 to 4 times higher than those reported by Kessel et al. (1982). However, only 28 water bodies were surveyed in 1981, compared with 499 in 2013. Long-tailed Duck and Black Scoters were reported as the most productive waterfowl in 1981 on those 28 water bodies (Kessel et al. 1982). During surveys in 2013, scaup were the most productive waterbird species, followed by goldeneyes, Green-winged Teal, and American Wigeon.

6.3. Information for Mercury Study

A literature review on the diet of waterbirds identified seven species of waterbirds (Common Loon, Red-throated Loon, Red-necked Grebe, Common Merganser, Red-breasted Merganser, Bonaparte's Gull, and Arctic Tern) in the study area as piscivorous waterbirds, for which fish composed 40 percent or more of their diets. During aerial surveys for waterbirds, numerous lakes in the study area were occupied by piscivorous waterbirds, but an active nest was found only for one pair of Common Loons. The nest was on an island in a large lake in the Fog Lakes area and could not be inspected for feather samples because it occurred on CIRWG lands.

Fewer nests of piscivorous waterbirds were found than expected during aerial surveys in 2013. The study objective for obtaining tissue samples of piscivorous waterbirds for analysis of mercury levels was based on opportunistically finding nests. Common Loons on nests are the most easily detected nesting bird of the seven piscivorous species, but some nests in the study area probably were missed because waterbird aerial surveys conducted in 2013 focused on locating and counting birds on the water and did not focus on surveying the lake shorelines where loons nest. Also, based on the chick ages of Common Loon broods found during brood surveys, most Common Loons probably did not occupy nests until after the second breeding survey in mid-June.

Broods of all seven piscivorous species of waterbirds were found during brood and fall migration surveys in 2013. For Common Loon, Red-throated Loon, Red-necked Grebe, Bonaparte's Gull, and Arctic Tern, nesting probably occurred on the same lake where the brood was observed. These lakes where broods of Common Loon, Red-throated Loon, Red-necked Grebe, Bonaparte's Gull, and Arctic Tern were observed, and any additional lakes where only adults were observed should be surveyed in the next study season for nesting birds. A survey that specifically targets these nesting birds and is timed to detect birds on nests would be more effective in meeting the study objectives than relying on finding nests opportunistically.

7. COMPLETING THE STUDY

[As explained in the cover letter to this draft ISR, AEA's plan for completing this study will be included in the final ISR filed with FERC on June 3, 2014.]

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9. TABLES

Table 4.1-1. Details of Aerial Surveys for Migrating and Breeding Waterbirds, 2013.

Target Species	Purpose	Survey Date	Method
Waterbirds	Spring Migration	April 23	Lake-to-Lake
Waterbirds	Spring Migration	April 29	Lake-to-Lake
Waterbirds	Spring Migration	May 5	Lake-to-Lake
Waterbirds	Spring Migration	May 11	Lake-to-Lake
Waterbirds	Spring Migration	May 18–19	Lake-to-Lake
Waterbirds	Spring Migration	May 23–24	Lake-to-Lake
Waterbirds	Spring Migration	May 28–29	Lake-to-Lake
Waterbirds	Breeding	June 1–5	Lake-to-Lake
Waterbirds	Breeding	June 2	Transect
Harlequin Duck	Pre-nesting	June 1–5	Stream
Waterbirds	Breeding	June 14–17	Lake-to-Lake
Waterbirds	Breeding	June 15	Transect
Harlequin Duck	Pre-nesting	June 14–17	Stream
Waterbirds	Brood-rearing	July 20–22	Lake-to-Lake
Waterbirds	Brood-rearing	August 1–5	Lake-to-Lake
Harlequin Duck	Brood-rearing	August 1–5	Stream
Harlequin Duck	Brood-rearing	August 14–18	Stream
Waterbirds	Fall Migration	August 14–18	Lake-to-Lake
Waterbirds	Fall Migration	August 23–25	Lake-to-Lake
Waterbirds	Fall Migration	August 29–30	Lake-to-Lake
Waterbirds	Fall Migration	September 4-6	Lake-to-Lake
Waterbirds	Fall Migration	September 10–12	Lake-to-Lake
Waterbirds	Fall Migration	September 16–18	Lake-to-Lake
Waterbirds	Fall Migration	September 22–23	Lake-to-Lake
Waterbirds	Fall Migration	September 27–29	Lake-to-Lake
Waterbirds	Fall Migration	October 4-6	Lake-to-Lake
Waterbirds	Fall Migration	October 10–12	Lake-to-Lake
Waterbirds	Fall Migration	October 17–18	Lake-to-Lake

Table 5.1-1. Status of Waterbird Species Observed during Waterbird Migration and Breeding Surveys, 2013.

SPECIES-GROUP SPECIES-SUBGROUP Common Name	Scientific Name	Status
WATERFOWL		
GEESE		
Greater White-fronted Goose[1]	*Anser albifrons*	Migrant
Snow Goose[1]	*Chen caerulescens*	Migrant
Canada Goose[1]	*Branta canadensis*	Migrant
SWANS		
Trumpeter Swan[1,]	*Cygnus buccinator*	Confirmed Breeder
Tundra Swan[2]	*Cygnus columbianus*	Migrant
DABBLING DUCKS		
Gadwall[1]	*Anas strepera*	Confirmed Breeder
American Wigeon[1]	*Anas americana*	Confirmed Breeder
Mallard[1]	*Anas platyrhynchos*	Confirmed Breeder
Northern Shoveler[1]	*Anas clypeata*	Confirmed Breeder
Northern Pintail[1]	*Anas acuta*	Confirmed Breeder
Green-winged Teal[1]	*Anas crecca*	Confirmed Breeder
DIVING DUCKS		
Canvasback[1]	*Aythya valisineria*	Migrant
Redhead[1]	*Aythya americana*	Migrant
Ring-necked Duck[1]	*Aythya collaris*	Confirmed Breeder
Greater Scaup[1,]	*Aythya marila*	Confirmed Breeder
Lesser Scaup[1,]	*Aythya affinis*	Confirmed Breeder
Harlequin Duck[1]	*Histrionicus histrionicus*	Confirmed Breeder
Surf Scoter[1]	*Melanitta perspicillata*	Confirmed Breeder
White-winged Scoter[1]	*Melanitta fusca*	Confirmed Breeder
Black Scoter[1]	*Melanitta nigra*	Confirmed Breeder
Long-tailed Duck[1]	*Clangula hyemalis*	Confirmed Breeder
Bufflehead	*Bucephala albeola*	Confirmed Breeder
Common Goldeneye[1,]	*Bucephala clangula*	Possible Breeder
Barrow's Goldeneye	*Bucephalai slandica*	Confirmed Breeder
Common Merganser	*Mergus merganser*	Confirmed Breeder

SPECIES-GROUP SPECIES-SUBGROUP Common Name	Scientific Name	Status
Red-breasted Merganser	*Mergus serrator*	Confirmed Breeder
LOONS		
Red-throated Loon[1]	*Gavia stellata*	Confirmed Breeder
Pacific Loon	*Gavia pacifica*	Confirmed Breeder
Common Loon	*Gavia immer*	Confirmed Breeder
Yellow-billed Loon	*Gavia adamsii*	Migrant
GREBES		
Horned Grebe[1]	*Podiceps auritus*	Confirmed Breeder
Red-necked Grebe	*Podiceps grisegena*	Confirmed Breeder
CRANES		
Sandhill Crane	*Grus canadensis*	Migrant
GULLS		
Bonaparte's Gull	*Chroicocephalus philadelphia*	Confirmed Breeder
Mew Gull	*Larus canus*	Confirmed Breeder
Herring Gull	*Larus argentatus*	Possible Breeder
TERNS		
Arctic Tern	*Sterna paradisaea*	Confirmed Breeder
JAEGERS		
Long-tailed Jaeger[2]	*Stercorarius longicaudus*	Possible Breeder

1 Waterbirds identified as species of conservation and management concern in the Wildlife Data-Gap Analysis for the Proposed Susitna–Watana Hydroelectric Project (ABR 2011).

2 Presence and identification confirmed on ground-based migration surveys.

Table 5.1-2. Numbers of Waterbirds Observed on Streams and Water Bodies during Spring and Fall Migration Surveys, 2013.

Survey Area/ Feature Location	April		May					August			September					October		
	22[1]	29[2]	5	11	18–19	23–24	28–29	14–18	23–25	29–30	4–6	10–12	16–18	22–23	27–29	4–6	10–12	17–18
Dam/Camp Area																		
Stream																		
Tsusena Creek	–	0	0	0	0	0	7	–	–	–	–	–	–	–	–	–	–	–
Water Body																		
Fog Lakes[3]	0	0	0	0	0	0	0	15	8	8	5	3	7	6	7	2	0	0
Unnamed Water Bodies	0	0	0	0	0	0	22	1	8	6	6	6	6	16	5	11	0	3
Dam/Camp Area Total	0	0	0	0	0	0	29	16	16	14	11	9	13	22	12	13	0	3
Watana Reservoir																		
Stream																		
Susitna River	0	–	0	249	390	374	131	–	–	–	–	–	–	–	–	–	–	–
Watana Creek	0	–	0	2	0	0	16	–	–	–	–	–	–	–	–	–	–	–
Kosina Creek	0	–	4	5	0	3	7	–	–	–	–	–	–	–	–	–	–	–
Oshetna River	–	–	0	0	4	0	5	–	–	–	–	–	–	–	–	–	–	–
Gilbert Creek	–	–	0	0	0	0	2	–	–	–	–	–	–	–	–	–	–	–
Stream Subtotal	0	–	4	256	394	377	161	–	–	–	–	–	–	–	–	–	–	–
Water Body																		
Fog Lakes[3]	0	0	0	0	32	95	231	344	168	372	303	259	279	115	172	173	24	66
Clarence Lake	0	–	2	5	12	48	113	129	66	152	133	197	148	167	118	91	6	22
Pistol Lake[4]	0	–	0	9	–	73	52	47	23	39	38	38	54	5	2	15	0	0
Sally Lake	0	–	0	0	0	44	34	2	1	0	0	0	0	0	1	0	2	0
Watana Lake	0	–	0	0	0	2	5	18	24	18	40	14	28	73	75	61	0	0
Molar Lake	0	0	0	0	0	0	0	62	69	40	50	54	53	38	24	11	0	0
Unnamed Water Bodies	0	0	0	0	0	110	221	338	194	196	202	252	348	80	89	98	10	12
Water Body Subtotal	0	0	2	14	44	356	666	940	545	817	766	814	910	478	481	449	42	100
Watana Reservoir Total	0	0	6	270	438	733	817	940	545	817	766	814	910	478	481	449	42	100
Denali Corridor																		
Stream																		
Nenana River	–	8	18	106	110	66	109	–	–	–	–	–	–	–	–	–	–	–
Brushkana Creek	–	0	0	14	25	48	43	–	–	–	–	–	–	–	–	–	–	–
Seattle Creek	–	–	2	0	2	38	3	–	–	–	–	–	–	–	–	–	–	–
Deadman Creek	–	0	0	0	0	0	62	–	–	–	–	–	–	–	–	–	–	–
Jack River	–	0	0	0	0	2	3	–	–	–	–	–	–	–	–	–	–	–
Stream Subtotal	–	8	20	120	137	154	220	–	–	–	–	–	–	–	–	–	–	–
Water Body																		
Lake 1294 (NE of Drashner Lake)	–	0	0	223	235	270	175	0	47	110	27	54	14	0	0	0	0	0
Deadman Lake	–	1	2	18	4	6	0	40	58	73	53	87	77	48	67	2	0	2
Big Lake	0	0	0	0	0	0	0	27	33	17	10	14	30	28	13	165	43	7
Unnamed Water Bodies	–	0	0	0	0	150	332	1,388	1,103	1074	905	1023	691	191	210	209	4	22
Water Body Subtotal	–	1	2	241	239	426	507	1,455	1,241	1274	995	1178	812	267	290	376	47	31
Denali Corridor Total	–	9	22	361	376	580	727	1,455	1,241	1274	995	1178	812	267	290	376	47	31

Survey Area/ Feature Location	April		May					August			September					October		
	22[1]	29[2]	5	11	18–19	23–24	28–29	14–18	23–25	29–30	4–6	10–12	16–18	22–23	27–29	4–6	10–12	17–18
Chulitna Corridor																		
Stream																		
Indian River	0	0	21	20	0	15	4	–	–	–	–	–	–	–	–	–	–	–
Portage Creek	0	0	2	2	0	10	11	–	–	–	–	–	–	–	–	–	–	–
Devil Creek	0	–	0	0	0	4	5	–	–	–	–	–	–	–	–	–	–	–
Stream Subtotal	0	0	23	22	0	29	20	–	–	–	–	–	–	–	–	–	–	–
Water Body																		
Indian River Beaver Ponds	3	20	17	13	38	34	37	8	0	0	4	4	1	2	0	0	0	3
High Lake	0	0	0	0	0	0	0	0	9	3	6	3	4	0	0	0	0	0
Miami Lake	0	0	0	0	0	0	0	1	7	0	5	12	4	1	0	2	30	24
Swimming Bear Lake	0	0	0	0	0	0	0	12	11	5	11	24	3	0	0	2	0	0
Unnamed Water Bodies	0	2	0	0	0	4	33	141	100	127	104	121	78	68	5	25	9	6
Water Body Subtotal	3	20	17	13	38	38	70	162	127	135	130	164	90	71	5	29	39	33
Chulitna Corridor Total	3	20	40	35	38	67	90	162	127	135	130	164	90	71	5	29	39	33
Gold Creek Corridor																		
Stream																		
Susitna River	0	0	7	220	244	702	44	–	–	–	–	–	–	–	–	–	–	–
Stephan-Murder Connection	4	8	18	0	4	0	0	–	–	–	–	–	–	–	–	–	–	–
Fog Creek	0	0	0	0	0	3	13	–	–	–	–	–	–	–	–	–	–	–
Indian River	0	0	0	0	0	2	1	–	–	–	–	–	–	–	–	–	–	–
Stream Subtotal	4	8	25	220	248	707	58	–	–	–	–	–	–	–	–	–	–	–
Water Body																		
Murder Lake	0	0	4	84	43	122	144	0	38	116	12	78	103	240	284	116	37	35
Stephan Lake	0	0	6	49	72	72	108	153	62	114	109	112	183	229	378	382	339	303
Lakes North of Stephan Lake	0	0	1	1	12	11	62	46	52	77	91	78	89	94	105	141	50	26
Fog Lakes[3]	0	0	0	2	0	4	23	32	26	37	46	38	16	8	11	23	2	15
Unnamed Water Bodies	0	0	0	0	0	3	32	159	125	159	85	78	64	40	37	62	5	3
Water Body Subtotal	0	0	11	136	127	212	369	390	303	503	343	384	455	611	815	724	433	382
Gold Creek Corridor Total	4	8	36	356	375	919	427	390	303	503	343	384	455	611	815	724	433	382
All Survey Areas																		
Total Number on Streams	4	16	72	618	779	1,267	466	–	–	–	–	–	–	–	–	–	–	–
Total Number on Water Bodies	3	21	32	404	448	1,032	1,624	2,963	2,232	2,743	2,245	2,549	2,280	1,449	1,603	1,591	561	549
Total All Survey Areas	7	37	104	1,022	1,227	2,299	2,090	2,963	2,232	2,743	2,245	2,549	2,280	1,449	1,603	1,591	561	549

1 The northern part of the Denali Corridor was not surveyed because of inclement weather.

2 The eastern part of the Watana Reservoir was not surveyed because of inclement weather.

3 Fog Lakes are part of three survey areas: Dam/Camp Area, Watana Reservoir, and Gold Creek Corridor.

4 Pistol Lake was not surveyed on May18–19.

Table 5.1-3. Numbers and Occurrence of Waterbirds during Migration and Breeding Surveys, 2013.

	Spring Migration[1]							Breeding[1]		Fall Migration[1]										
	April		May					June		August			September					October		
Species	23	29	5	11	18–19	23–24	28–29	1–5	14–17	14–18	23–25	29–30	4–6	10–12	16–18	22–23	27–29	4–6	10–12	17–18
Trumpeter Swan	2	12	30	38	51	52	52	53	87	86	67	93	80	68	78	50	57	45	24	14
Unidentified swan[2]				6	12	20					10		10	14	21	76	69	65		
Mallard	2	12	9	155	200	183	108	154	124	222	138	169	145	137	117	105	209	331	86	131
Unidentified goldeneye	2	6	9	64	88	158	95	186	201	183	117	165	132	159	148	165	181	328	97	72
Common Merganser	1	2	5	14	26	20	23	0	2	8	19		7							
Bufflehead		5	14	14	42	114	33	63	113	25	36	27	28	41	58	43	43	51	53	26
Northern Pintail			26	163	152	263	151	109	121	192	93	219	100	152	138	25	49	56		26
Northern Shoveler			9	70	69	111	66	85	95	64	16	35	38	28	33	1		3	20	
Mew Gull			2	109	13	28	46			3			1							
American Wigeon				180	177	217	165	162	196	336	359	351	306	394	298	159	234	150	15	29
Green-winged Teal				114	48	122	114	86	132	324	184	139	124	337	270	4	32	32	4	11
Unidentified teal				43	15	7														
Unidentified dabbler				8	77	30	8			31										
Canada Goose				14	12	21	3	4												
Ring-necked Duck				14	42	48	62	142	42	118	95	98	45	42	77	49	15	44	20	2
Unidentified duck				11	33	48	18			65	62	13			7	29	1			1
Bonaparte's Gull				3		4	7	2		2										
Harlequin Duck				2	20	553	186													
Unidentified scaup					124	190	662	1,080	761	1,006	787	1,080	1,021	953	892	622	580	418	97	188
Red-breasted Merganser					5	54	30	15	18	33	52	61	39	40	27	10	28	14	1	2
Unidentified merganser					15	17	3	1	0	3		22			7	36	3	4	53	
Redhead					4															
Canvasback					2			4												
Snow Goose[3]						80	10	15												
Herring Gull						9	3			2										

	Spring Migration[1]							Breeding[1]		Fall Migration[1]										
	April		May					June		August			September					October		
Species	23	29	5	11	18–19	23–24	28–29	1–5	14–17	14–18	23–25	29–30	4–6	10–12	16–18	22–23	27–29	4–6	10–12	17–18
Unidentified gull						24	1			2						1				
Horned Grebe						6	4	8	1	2		1	4	4	4	1	4	4		3
Long-tailed Duck							101	58	53	85	73	67	57	44	27	10	11	9		
Surf Scoter							73	75	72	77	35	87	49	72	29	38	39	4	29	12
White-winged Scoter							63	64	26	18	8	15	18	17	20	13	12	13	9	24
Unidentified scotr								1	2		7	10					1			
Red-throated Loon							8	14	10	8	8	6	1	2	2					
Common Loon							3	22	21	24	24	25	13	18	11	1	3	3		2
Red-necked Grebe							1	9		5	18	1	1	6	1				4	3
Unidentified grebe										5	2	12								
Unidentified diver											4		2	1	2		1			2
Yellow-billed Loon							1													
Greater White-fronted Goose								4		1										
Gadwall								2												
Black Scoter								14	22	12	10	26	12	11	8	9	15	16	49	
Pacific Loon								11	13	19	8	21	12	9	5	2		1		1
Arctic Tern									21	2										
Sandhill Crane																	16			
Number of Birds	7	37	104	1,022	1,227	2,379	2,100	2,443	2,133	2,963	2,232	2,743	2,245	2,549	2,280	1,449	1,603	1,591	561	547
Number of Species	4	5	8	14	17	19	26	26	21	26	20	20	22	20	20	18	17	18	14	16

1 Blank cells indicate no birds observed; intentionally left blank for easy recognition of the occurrence of species in the study area.

2 Some unidentified swans may have been Tundra Swans because groups were observed during spring and fall on the ground-based migration study.

3 Snow Geese observed on May 23–24 and 28–29 were in flight over the Oshetna River area.

Table 5.1-4. Numbers of Waterbirds by Species-group Observed on Streams and Water Bodies during Spring and Fall Migration Surveys, 2013.

Survey Area	Spring							Fall										
	April		May					August			September					October		
Species-Group	23[1]	29[2]	5	11	18–19	23–24	28–29	14–18	23–25	29–30	4–6	10–12	16–18	22–23	27–29	4–6	10–12	17–18
Dam/Camp Area																		
Geese	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Swans	0	0	0	0	0	0	0	2	2	0	0	0	2	0	0	0	0	0
Ducks	0	0	0	0	0	0	29	13	12	8	9	9	11	22	12	13	0	3
Loons	0	0	0	0	0	0	0	1	2	6	2	0	0	0	0	0	0	0
Grebes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cranes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gulls/Terns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	29	16	16	14	11	9	13	22	12	13	0	3
Watana Reservoir																		
Geese	0	0	0	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Swans	0	0	2	14	15	23	15	19	10	8	12	8	16	12	21	8	5	3
Ducks[3]	0	0	4	208	422	676	783	895	524	788	746	797	888	466	454	436	36	95
Loons	0	0	0	0	0	0	1	15	6	14	4	4	4	0	3	2	0	0
Grebes	0	0	0	0	0	5	1	7	5	7	4	5	2	0	3	3	1	2
Cranes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gulls/Terns	0	0	0	44	1	29	17	3	0	0	0	0	0	0	0	0	0	0
Subtotal	0	0	6	270	438	733	817	940	545	817	766	814	910	478	481	449	42	100
Denali Corridor																		
Geese	0	0	0	10	7	19	3	0	0	0	0	0	0	0	0	0	0	0
Swans	0	1	13	18	30	35	27	40	47	57	46	45	47	28	24	30	4	7
Ducks[4]	0	8	9	300	333	512	664	1,407	1,172	1,211	949	1,126	762	239	249	346	43	22
Loons	0	0	0	0	0	0	6	5	11	6	0	5	2	0	0	0	0	0
Grebes	0	0	0	0	0	0	2	1	11	0	0	2	0	0	1	0	0	2
Cranes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0
Gulls/Terns	0	0	0	33	6	14	25	2	0	0	0	0	0	0	0	0	0	0
Subtotal	0	9	22	361	376	580	727	1,455	1,241	1,274	995	1,178	811	267	290	376	47	31

Survey Area	Spring							Fall										
	April		May					August			September					October		
Species-Group	23[1]	29[2]	5	11	18–19	23–24	28–29	14–18	23–25	29–30	4–6	10–12	16–18	22–23	27–29	4–6	10–12	17–18
Chulitna Corridor																		
Geese	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Swans	0	5	8	0	2	4	3	5	4	4	7	2	2	2	2	6	0	0
Ducks	3	15	32	35	36	62	83	148	112	124	115	149	82	67	3	22	39	31
Loons	0	0	0	0	0	0	0	9	11	7	8	11	6	2	0	1	0	2
Grebes	0	0	0	0	0	1	1	0	0	0	0	2	0	0	0	0	0	0
Cranes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gulls/Terns	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Subtotal	3	20	40	35	38	67	90	162	127	135	130	164	90	71	5	29	39	33
Gold Creek Corridor																		
Geese	0	0	0	0	5	2	0	0	0	0	0	0	0	0	0	0	0	0
Swans	2	6	7	12	16	10	7	20	14	24	25	27	32	84	79	66	15	4
Ducks	2	2	27	309	348	885	402	339	275	453	304	347	414	524	736	656	415	375
Loons	0	0	0	0	0	0	5	21	10	19	12	9	6	1	0	1	0	1
Grebes	0	0	0	0	0	0	1	4	4	7	1	1	3	1	0	1	3	2
Cranes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gulls/Terns	0	0	2	35	6	22	12	6	0	0	1	0	0	1	0	0	0	0
Subtotal	4	8	36	356	375	919	427	390	303	503	343	384	455	611	815	724	433	382
All Survey Areas																		
Geese	0	0	0	14	12	21	3	1	0	0	0	0	0	0	0	0	0	0
Swans	2	12	30	44	63	72	52	86	77	93	90	82	99	126	126	110	24	14
Ducks	5	25	72	852	1,139	2,135	1,961	2,802	2,091	2,584	2,121	2,427	2,156	1,318	1,453	1,473	533	524
Loons	0	0	0	0	0	0	12	51	40	52	26	29	18	3	3	4	0	3
Grebes	0	0	0	0	0	6	5	12	20	14	5	10	5	1	4	4	4	6
Cranes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0
Gulls/Terns	0	0	2	112	13	65	57	11	0	0	1	0	0	1	0	0	0	0
Total Number	7	37	104	1,022	1,227	2,379	2,100	2,963	2,232	2,743	2,245	2,549	2,280	1,449	1,603	1,591	561	549

1 The northern part of the Denali Corridor was not surveyed because of inclement weather.

2 The eastern part of the Watana Reservoir was not surveyed because of inclement weather.

3 Includes 11 observations of unidentified divers which could have been diving ducks, loons, or grebes.

4 Includes 1 observation of an unidentified diver which could have been a diving duck, loon, or grebe.

Table 5-1-5. Seasonal Population Statistics for Water Bodies Surveyed during Spring and Fall Migration Surveys, 1980–1981 and 2013.

Water Bodies[2]	Size (mi²)	Spring 1981[1] Mean no. birds	Spring 1981[1] Mean density (no./mi²)	Spring 1981[1] Mean no. species	Fall 1980[1] Mean no. birds	Fall 1980[1] Mean density (no./mi²)	Fall 1980[1] Mean no. species	Spring 2013 Mean no. birds	Spring 2013 Mean density (no./mi²)	Spring 2013 Mean no. Species	Fall 2013 Mean no. birds	Fall 2013 Mean density (no./mi²)	Fall 2013 Mean no. species
WB 107 (Murder Lake)	0.06	51.3	876.0	5.0	39.0	665.9	4.3	60.1	931.8	5.3	96.3	1,644.3	4.5
WB 106 (Stephan Lake)	1.38	99.7	72.2	7.3	156.0	112.9	9.5	35.4	29.7	4.6	214.2	155.1	8.8
WB 145 (Clarence Lake)	0.58	54.7	93.6	7.0	103.8	177.6	7.0	28.3	48.4	2.9	111.7	191.1	5.7
WB 059 (in Fog Lake group)	0.58	21.3	36.4	4.7	72.8	124.5	6.5	18.7	32.0	1.4	123.4	211.0	6.3
WB 067[3] (Pistol Lake)	0.34[3]	85.0	250.5	6.0	19.0	40.5	4.0	16.9	49.7	2.4	26.9	57.4	3.0
WB 105[4] (near Stephan Lake)	0.21							4.4	20.9	1.9	40.8	192.2	4.8
WB 130[4] (Deadman Lake)	0.62							2.1	3.4	0.9	46.1	74.2	2.6
WB 060[4] (in Fog Lake group)	0.43							7.1	16.7	1.3	55.8	130.3	5.6
WB 148 (Watana Lake)	0.48	21.3	44.6	3.0	95.8	200.5	3.8	0.7	1.5	0.3	31.0	64.9	4.3

1 Data from APA Susitna Hydroelectric Project study (Kessel et al. 1982).

2 Water body designations follow Kessel et al. 1982.

3 Includes water bodies 064–067 for fall 1980 and fall 2013 analyses (water body size = 0.47 mi²). Statistics are based on this lake grouping for fall surveys only.

4 Population statistics not available for 1980–1981 surveys.

Table 5.1-6. Importance Ranks and Values of Water Bodies Surveyed for Waterbirds during Spring and Fall Migration Surveys, 1980–1981 and 2013.

		Importance Rank[1] (Value[2])							
Water Bodies[3]	Survey Area	Spring 1981[4]		Fall 1980[4]		Spring 2013		Fall 2013	
WB 107 (Murder Lake)	Gold Creek Corridor	1	(21.5)	1	(19.7)	1	(136.3)	1	(63.9)
WB 106 (Stephan Lake)	Gold Creek Corridor	3	(9.0)	2	(18.7)	2	(43.7)	2	(41.3)
WB 145 (Clarence Lake)	Watana Reservoir	4	(7.7)	3	(15.0)	3	(34.9)	4	(26.3)
WB 059 (in Fog Lake group)	Watana Reservoir	8	(3.8)	4	(12.7)	5	(19.8)	3	(29.0)
WB 067 (Pistol Lake)	Denali Corridor	2	(11.9)	9[5]	(6.0)	4	(24.7)	11[5]	(10.0)
WB 105 (near Stephan Lake)	Gold Creek Corridor	10	(3.5)	6	(10.3)	6	(12.6)	6	(17.0)
WB 130 (Deadman Lake)	Denali Corridor	6	(4.3)	7	(7.0)	8	(6.6)	10	(11.1)
WB 060 (in Fog Lake group)	Watana Reservoir	9	(3.8)	13	(1.8)	7	(11.2)	5	(18.1)
WB 148 (Watana Lake)	Watana Reservoir	11	(3.0)	5	(12.0)	11	(1.8)	9	(11.5)

1 Rank of importance value within the season. Includes water bodies that were among the six highest importance value ratings in at least one season. For 1980 and 1981, rankings are restricted to the lakes also surveyed in 2013.

2 Single metric combining abundance, density, and species diversity to describe relative use ("importance") of water bodies by birds (see text for equation). Importance values are relative to a specific dataset and cannot be compared among seasons or analyses.

3 Water body designations follow Kessel et al. 1982.

4 Importance values were approximated from figures in Kessel et al. 1982.

5 Includes water bodies 064–067, which were grouped for the fall analyses ("Pistol Lake Group").

Table 5.1-7. Distributions of Radar Targets Observed between 1.5 km and 6.0 km on 6-km-range Surveillance Radar.

Season	Minimum distance (m)	Diurnal		Nocturnal	
		Transect crossed		Transect crossed	
		North	South	North	South
Spring		*n* = 71	*n* = 77	*n* = 236	*n* = 212
	1,501–2,000	45.1%	41.6%	45.8%	39.6%
	2,001–2,500	21.1%	13.0%	25.8%	20.3%
	2,501–3,000	18.3%	11.7%	7.6%	9.4%
	3,001–3,500	8.5%	13.0%	5.5%	10.4%
	3,501–4,000	2.8%	13.0%	6.4%	8.5%
	4,001–4,500	2.8%	3.9%	3.0%	6.6%
	4,501–5,000	1.4%	2.6%	3.0%	2.4%
	5,001–5,500	0.0%	1.3%	2.5%	2.8%
	5,501–6,000	0.0%	0.0%	0.4%	0.0%
Fall		*n* = 13	*n* = 30	*n* = 96	*n* = 156
	1,501–2,000	61.5%	43.3%	72.9%	67.3%
	2,001–2,500	30.8%	13.3%	11.5%	13.5%
	2,501–3,000	0.0%	23.3%	8.3%	3.2%
	3,001–3,500	7.7%	13.3%	3.1%	4.5%
	3,501–4,000	0.0%	0.0%	2.1%	8.3%
	4,001–4,500	0.0%	3.3%	0.0%	0.6%
	4,501–5,000	0.0%	3.3%	0.0%	0.0%
	5,001–5,500	0.0%	0.0%	1.0%	1.9%
	5,501–6,000	0.0%	0.0%	1.0%	0.6%

Table 5.1-8. Flight Altitudes of Targets Observed on 1.5-km Vertical Radar.

Survey period	Flight altitude (m agl)	Spring			Fall		
		n	Category %	Cumulative %	*n*	Category %	Cumulative %
Diurnal	1–100	310	22.5	22.5	88	28.1	28.1
	101–200	249	18.1	40.7	76	24.3	52.4
	201–300	208	15.1	55.8	67	21.4	73.8
	301–400	160	11.6	67.4	33	10.5	84.3
	401–500	99	7.2	74.6	15	4.8	89.1
	501–600	81	5.9	80.5	15	4.8	93.9
	601–700	80	5.8	86.3	4	1.3	95.2
	701–800	36	2.6	88.9	3	1.0	96.2
	801–900	39	2.8	91.8	6	1.9	98.1
	901–1,000	48	3.5	95.3	4	1.3	99.4
	1,001–1,100	35	2.5	97.8	1	0.3	99.7
	1,101–1,200	13	0.9	98.8	1	0.3	100.0
	1,201–1,300	7	0.5	99.3	0	0.0	100.0
	1,301–1,400	9	0.7	99.9	0	0.0	100.0
	1,401–1,500	1	0.1	100.0	0	0.0	100.0
	Total	1,375			313		
Nocturnal	1–100	592	9.0	9.0	863	12.1	12.1
	101–200	893	13.5	22.5	1,119	15.7	27.9
	201–300	914	13.8	36.3	1,077	15.1	43.0
	301–400	893	13.5	49.8	912	12.8	55.8
	401–500	777	11.8	61.6	886	12.5	68.3
	501–600	693	10.5	72.1	691	9.7	78.0
	601–700	583	8.8	80.9	542	7.6	85.6
	701–800	398	6.0	86.9	370	5.2	90.8
	801–900	304	4.6	91.5	253	3.6	94.4
	901–1,000	224	3.4	94.9	147	2.1	96.4
	1,001–1,100	118	1.8	96.7	88	1.2	97.7
	1,101–1,200	100	1.5	98.2	79	1.1	98.8
	1,201–1,300	76	1.2	99.3	48	0.7	99.5
	1,301–1,400	31	0.5	99.8	30	0.4	99.9
	1,401–1,500	12	0.2	100.0	9	0.1	100.0
	Total	6,608			7,114		

Table 5.1-9. Seasonal Movement Rates and Movement Patterns of Species Groups Observed North and South of the Visual Observation Station during Diurnal Visual Survey Periods.

Season/Avian Group	Mean ± SE daily movement rates (birds/h)	Flocks observed crossing north or south transects					
		All distances[1]			Within 1.5 km of station[2]		
		n	Percent crossing north transect	Percent crossing south transect	*n*	Crossing north transect (N of canyon)	Crossing south transect (over Susitna River canyon)
Spring							
Swans	1.80 ± 0.71	51	33.3	66.7	41	34.1	65.9
Other waterfowl	2.31 ± 0.61	139	36.0	64.0	77	28.6	71.4
Loons	0.03 ± 0.01	20	40.0	60.0	10	40.0	60.0
Bald Eagle	0.14 ± 0.02	47	14.9	85.1	24	12.5	87.5
Golden Eagle	0.15 ± 0.02	73	20.5	79.5	41	22.0	78.0
Unidentified eagles	0.03 ± 0.01	9	11.1	88.9	3	0.0	100.0
Other raptors	0.37 ± 0.05	148	30.4	69.6	103	36.9	63.1
Cranes	0.03 ± 0.02	11	9.1	90.9	7	14.3	85.7
Shorebirds	1.82 ± 0.93	119	51.3	48.7	88	52.3	47.7
Larids	0.46 ± 0.14	82	50.0	50.0	50	48.0	52.0
Ravens	0.13 ± 0.02	39	33.3	66.7	27	37.0	63.0
Other passerines	4.00 ± 0.95	617	51.1	48.9	458	53.5	46.5
Unknown/other birds	0.02 ± 0.01	6	16.7	83.3	3	66.7	33.3
Spring Total	11.30 ± 2.06	1,361	42.2	57.8	932	44.8	55.2
Fall							
Swans	0.52 ± 0.20	25	44.0	56.0	16	56.3	43.8
Other waterfowl	0.12 ± 0.09	6	50.0	50.0	2	50.0	50.0
Loons	0.01 ± 0.01	2	50.0	50.0	1	100.0	0.0
Bald Eagle	0.06 ± 0.02	24	45.8	54.2	13	30.8	69.2

Season/Avian Group	Mean ± SE daily movement rates (birds/h)	Flocks observed crossing north or south transects					
		All distances[1]			Within 1.5 km of station[2]		
		n	Percent crossing north transect	Percent crossing south transect	*n*	Crossing north transect (N of canyon)	Crossing south transect (over Susitna River canyon)
Golden Eagle	0.02 ± 0.01	13	15.4	84.6	7	28.6	71.4
Fall (continued)							
Other raptors	0.18 ± 0.03	65	27.7	72.3	45	33.3	66.7
Cranes	2.86 ± 2.52	26	50.0	50.0	5	20.0	80.0
Shorebirds	0.00	0	--	--	0	--	--
Larids	0.01 ± 0.01	2	50.0	50.0	0	--	--
Ravens	0.33 ± 0.08	56	58.9	41.1	44	59.1	40.9
Other passerines	5.31 ± 0.73	255	33.7	66.3	224	37.1	62.9
Unknown/other birds	0.01 ± 0.01	1	0.0	100.0	0	--	--
Fall Total	9.43 ± 2.56	476	37.6	62.4	358	39.7	60.3

1 Includes all non-local movements with extrapolated flight paths that cross the north or south cardinal transects.

2 Includes all non-local movements with flight paths that cross the north or south cardinal transects within 1.5 km of visual observation station.

Table 5.1-10. Post-sunset Audio-visual Observations of Birds (Number of Flocks) Detected Using Binoculars and Night-vision Goggles during Spring 2013.

Species-group[1] Common Name	Week Starting							
	Apr 20	Apr 27	May 4	May 11	May 18	May 25	June 1	Total[2]
Waterfowl	1	2	7	0	17	46	3	76 (31/45)
Unidentified geese			1			1		2 (2/0)
Tundra Swan		2	1					3 (1/2)
Mallard			1					1 (1/0)
Northern Shoveler					1			1 (0/1)
White-winged Scoter						1		1 (0/1)
Unidentified scoters						3		3 (1/2)
Red-breasted Merganser						1		1 (1/0)
Unidentified ducks	1		3		9	39	3	55 (24/31)
Unidentified waterfowl			1		7	1		9 (1/8)
Loons	0	0	0	0	0	1	0	1 (1/0)
Unidentified loons						1		1 (1/0)
Raptors	0	0	1	1	2	4	0	8 (6/2)
Peregrine Falcon				1		1		2 (1/1)
Short-eared Owl			1		2	3		6 (5/1)
Shorebirds	0	0	0	0	16	25	1	42 (18/24)
Pectoral Sandpiper					2			2 (0/2)
Long-billed Dowitcher					1			1 (1/0)
Wilson's Snipe					9	23	1	33 (13/20)
Unidentified shorebirds					4	2		6 (4/2)
Larids	0	0	0	0	0	2	0	2 (1/1)
Herring Gull						1		1 (1/0)
Unidentified gulls						1		1 (0/1)
Passerines	0	0	2	5	25	20	2	54 (39/15)
Swainson's Thrush						5		5 (1/4)
American Robin			1	2	4			7 (6/1)
Varied Thrush					1			1 (0/1)
Unidentified thrushes					5		1	6 (5/1)
White-crowned Sparrow					1			1 (1/0)
Unidentified passerines			1	3	14	15	1	34 (26/8)
Total spring flocks	1	2	10	6	60	98	6	183 (96/87)

1 Numbers in bold are subtotals of individual species within species-groups.

2 Numbers in parentheses are numbers of flocks seen during first hour post-sunset compared to number of flocks seen during later hours of the night.

Table 5.1-11. Post-sunset Audio-visual Observations of Birds (Number of Flocks) Detected Using Binoculars and Night-vision Goggles during Fall 2013.

Species-group[1] Common Name	Week Starting									
	Aug 16	Aug 23	Aug 30	Sep 6	Sep 13	Sep 20	Sep 27	Oct 4	Oct 11	Total[2]
Waterfowl	0	0	0	0	0	0	0	1	0	1 (0/1)
Unidentified swans								1		1 (0/1)
Shorebirds	0	0	1	0	0	0	0	0	0	1 (1/0)
Wilson's Snipe			1							1 (1/0)
Passerines	3	28	1	7	3	0	0	0	0	42 (2/40)
Unidentified passerines	3	28	1	7	3					42 (2/40)
Total fall flocks	3	28	2	7	3	0	0	1	0	44 (3/41)

1 Numbers in bold are subtotals of individual species within species-groups.

2 Numbers in parentheses are numbers of flocks seen during the first hour post-sunset compared to number of flocks seen during later hours of the night.

Table 5.2-1. Mean Density of Waterfowl Observed during Breeding Surveys in Breeding Lake Groups, 2013.

Survey Area	No. of Birds		Density (birds/mi²)		Water Body Area Surveyed (mi²)	
Breeding Lake Group	June 1–5	June 14–17	June 1–5	June 14–17	June 1–5	June 14–17
Dam/Camp Area						
Fog Lakes[1]	9	4	278.7	97.4	0.03	0.04
Lower Tsusena[2]	58	29	181.7	92.8	0.32	0.31
Dam/Camp Area Total	67	33	190.6	93.3	0.35	0.35
Watana Reservoir						
Clarence Lake Area	71	128	109.3	197.0	0.65	0.65
East Lower Watana	32	10	293.5	91.7	0.11	0.11
East Upper Watana	23	17	426.0	327.9	0.05	0.05
Fog Lakes[1]	402	370	232.0	214.3	1.73	1.73
Goose	55	32	370.4	225.0	0.15	0.14
Molar Lake	18	104	52.0	300.5	0.35	0.35
North Kosina	58	51	562.8	493.4	0.10	0.10
Oshetna	76	67	206.4	182.0	0.37	0.37
Pistol Lake[3]	193	54	395.1	112.8	0.49	0.48
South Kosina	12	17	275.4	254.0	0.04	0.07
Watana Lake	16	22	33.5	46.0	0.48	0.48
Watana Mt	11	14	291.0	383.5	0.04	0.04
West Lower Watana	59	21	667.3	237.5	0.09	0.09
West Upper Watana	15	8	389.9	210.1	0.04	0.04
Watana Reservoir Total	1,041	915	222.2	195.4	4.69	4.68
Denali Corridor						
Big Lake	7	24	4.3	14.6	1.64	1.64
Brushkana	139	165	308.9	436.3	0.45	0.38
Deadman East	40	–	276.8	–	0.14	–
Deadman Lake	42	37	64.2	56.9	0.65	0.65
Deadman North	0	9	0.0	243.3	0.04	0.04
Deadman Pass	102	68	828.2	1,038.0	0.12	0.07
Deadman South	24	42	127.9	171.7	0.19	0.24
Deadman West	60	44	732.2	589.3	0.08	0.07
Lower Big Lake	8	20	59.9	149.8	0.13	0.13
Nenana East	127	210	643.1	1,063.4	0.20	0.20
Nenana West	223	175	689.4	526.7	0.32	0.33
Pistol Lake[3]	2	3	19.3	28.9	0.10	0.10
Upper Tsusena[4]	51	–	2,341.6	–	0.02	–
Denali Corridor Total	825	797	201.1	206.5	4.10	3.86

Survey Area Breeding Lake Group	No. of Birds		Density (birds/mi²)		Water Body Area Surveyed (mi²)	
	June 1–5	June 14–17	June 1–5	June 14–17	June 1–5	June 14–17
Chulitna Corridor						
Devil North	23	27	31.0	40.4	0.74	0.67
Indian[5]	63	35	107.2	58.9	0.59	0.59
Lower Tsusena[2]	18	5	1,527.7	424.3	0.01	0.01
Miami Lake	3	1	13.9	4.6	0.22	0.22
Portage[6]	19	24	24.5	28.9	0.78	0.83
Upper Tsusena[4]	2	2	4.5	4.5	0.44	0.44
Chulitna Corridor Total	128	94	46.1	34.0	2.77	2.76
Gold Creek Corridor						
Devil North	4	4	449.9	449.9	0.01	0.01
Devil South	5	8	36.5	57.3	0.14	0.14
Fog Lakes[1]	25	3	31.8	29.4	0.79	0.78
Indian[5]	11	2	159.8	30.8	0.07	0.06
Lake Group 10	7	–	203.2	–	0.03	–
Lake Group 14	9	–	125.1	–	0.07	–
Lake Group 146	5	3	66.7	33.9	0.07	0.09
Murder Lake	73	4	1,246.5	68.3	0.06	0.06
Portage[6]	44	25	51.4	31.3	0.86	0.80
Stephan Lake	157	146	113.5	105.6	1.38	1.38
Stephan North	42	79	58.6	110.2	0.72	0.72
Gold Creek Corridor Total	382	294	91.0	72.7	4.20	4.04
Total All Survey Areas	2,443	2,133	151.7	135.8	16.11	15.70

1 Fog Lakes breeding lake group was divided between three survey areas: Dam/Camp Area, Watana Reservoir, and Gold Creek Corridor.

2 Lower Tsusena breeding lake group was divided between two survey areas: Dam/Camp Area and Chulitna Corridor.

3 Pistol Lake breeding lake group was divided between two survey areas: Watana Reservoir and Denali Corridor.

4 Upper Tsusena breeding lake group was divided between two survey areas: Denali and Chulitna corridors

5 Indian breeding lake group was divided between two survey areas: Chulitna and Gold Creek corridors.

6 Portage breeding lake group was divided between two survey areas: Chulitna and Gold Creek corridors.

Table 5.2-2. Number and Density[1] (birds/mi²) of Waterfowl Observed during Breeding Surveys of Water Bodies, 2013.

	Dam/Camp Area[2]		Watana Reservoir[2]		Denali Corridor[2]		Chulitna Corridor[2]		Gold Creek Corridor[2]		Total Density[2]	
Species	June 1–5	June 14–17	June 1–5	June 14–17	June 1–5	June 14–17	June 1–5	June 14–17	June 1–5	June 14–17	June 1–5	June 14–17
Greater White-fronted Goose	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.2)	0 (0)	0 (0)	0 (0)	3 (0.7)	0 (0)	4 (0.2)	0 (0)
Snow Goose	0 (0)	0 (0)	15 (3.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	15 (0.9)	0 (0)
Canada Goose	1 (2.8)	0 (0)	2 (0.4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.2)	0 (0)	4 (0.2)	0 (0)
Trumpeter Swan	2 (5.7)	2 (5.7)	11 (2.3)	12 (2.6)	29 (7.1)	49 (12.7)	0 (0)	2 (0.7)	11 (2.6)	22 (5.4)	53 (3.3)	87 (5.5)
Gadwall	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.1)	0 (0)
American Wigeon	5 (14.2)	1 (2.8)	62 (13.2)	32 (6.8)	57 (13.9)	136 (35.2)	13 (4.7)	1 (0.4)	25 (6.0)	26 (6.4)	162 (10.1)	196 (12.6)
Mallard	8 (22.8)	0 (0)	43 (9.2)	41 (8.8)	55 (13.4)	58 (15.0)	33 (11.9)	5 (1.8)	15 (3.6)	20 (4.9)	154 (9.6)	124 (7.9)
Northern Shoveler	0 (0)	(5.6)	51 (10.9)	29 (6.2)	24 (5.8)	55 (14.2)	4 (1.4)	0 (0)	6 (1.4)	9 (2.2)	85 (5.3)	95 (6.0)
Northern Pintail	0 (0)	0 (0)	26 (5.5)	57 (12.2)	70 (17.1)	57 (14.8)	6 (2.2)	0 (0)	7 (1.7)	7 (1.7)	109 (6.8)	121 (7.7)
Green-winged Teal	2 (5.7)	0 (0)	22 (4.7)	72 (15.4)	39 (9.5)	41(10.6)	6 (2.2)	0 (0)	17 (4.1)	19 (4.7)	86 (5.3)	132 (8.4)
Canvasback	0 (0)	0 (0)	1 (0.2)	0 (0)	3 (0.7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4 (0.2)	0 (0)
Ring-necked Duck	9 (25.6)	4 (11.3)	67 (14.3)	22 (4.7)	40 (9.8)	14 (3.6)	4 (1.4)	0 (0)	22 (5.2)	2 (0.5)	142 (8.8)	42 (2.7)
Unidentified scaup	17 (48.4)	13 (36.8)	478 (102.0)	304 (64.9)	375 (91.4)	279 (72.3)	37 (13.3)	45 (16.3)	173 (41.2)	120 (29.7)	1,080 (67.0)	761 (48.5)
Surf Scoter	6 (17.1)	0 (0)	49 (10.5)	61 (13.0)	8 (1.9)	4 (1.0)	0 (0)	0 (0)	12 (2.9)	7 (1.7)	75 (4.7)	72 (4.6)
White-winged Scoter	0 (0)	0 (0)	56 (11.9)	26 (5.6)	0 (0)	0 (0)	2 (0.7)	0 (0)	6 (1.4)	0 (0)	64 (4.0)	26 (1.7)
Black Scoter	0 (0)	0 (0)	5 (1.1)	17 (3.6)	6 (1.5)	0 (0)	0 (0)	0 (0)	3 (0.7)	5 (1.2)	14 (0.9)	22 (1.4)
Unidentified scoter	0 (0)	0 (0)	1 (0.2)	1 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.2)	1 (0.1)	2 (0.1)
Long-tailed Duck	0 (0)	5 (14.1)	19 (4.0)	23 (4.9)	31 (7.6)	18 (4.7)	1 (0.4)	6 (2.2)	7 (1.7)	1 (0.2)	58 (3.6)	53 (3.4)
Bufflehead	7 (19.9)	3 (8.5)	18 (3.8)	62 (13.2)	27 (6.6)	24 (6.2)	2 (0.7)	16 (5.8)	9 (2.1)	8 (2.0)	63 (3.9)	113 (7.2)
Common Goldeneye	0 (0)	0 (0)	1 (0.2)	0 (0)	0 (0)	0 (0)	3 (1.1)	0 (0)	0 (0)	0 (0)	4 (0.2)	0 (0)
Barrow's Goldeneye	4 (11.4)	0 (0)	53 (11.3)	0 (0)	7 (1.7)	0 (0)	10 (3.6)	0 (0)	30 (7.2)	0 (0)	104 (6.5)	0 (0)
Unidentified goldeneye	1 (2.8)	0 (0)	36 (7.7)	137 (29.2)	27 (6.6)	27 (7.0)	0 (0)	12 (4.3)	14 (3.3)	25 (6.2)	78 (4.8)	201 (12.8)
Common Merganser	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.3)	0 (0)	0 (0)	0 (0)	1 (0.2)	0 (0)	2 (0.1)
Red-breasted Merganser	0 (0)	0 (0)	0 (0)	5 (1.1)	4 (1.0)	9 (2.3)	2 (0.7)	0 (0)	9 (2.1)	4 (1.0)	15 (0.9)	18 (1.1)
Unidentified merganser	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.1)	0 (0)
Red-throated Loon	0 (0)	0 (0)	2 (0.4)	2 (0.4)	7 (1.7)	2 (0.5)	2 (0.7)	2 (0.7)	3 (0.7)	4 (1.0)	14 (0.9)	10 (0.6)
Pacific Loon	5 (14.2)	3 (8.5)	4 (0.8)	2 (0.4)	1 (0.2)	0 (0)	0 (0)	2 (0.7)	1 (0.2)	6 (1.5)	11 (0.7)	13 (0.8)
Common Loon	0 (0)	0 (0)	9 (1.9)	9 (1.9)	5 (1.2)	2 (0.5)	3 (1.1)	3 (1.1)	5 (1.2)	7 (1.7)	22 (1.4)	21 (1.3)
Horned Grebe	0 (0)	0 (0)	6 (1.3)	1 (0.2)	2 (0.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	8 (0.5)	1 (0.1)
Red-necked Grebe	0 (0)	0 (0)	3 (0.6)	0 (0)	3 (0.7)	0 (0)	0 (0)	0 (0)	3 (0.7)	0 (0)	9 (0.7)	0 (0)
Bonaparte's Gull	0 (0)	0 (0)	1 (0.2)	0 (0)	1 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.1)	0 (0)
Area (mi²) of Lakes Surveyed	0.3	0.3	4.7	4.7	4.1	3.9	2.8	2.8	4.2	4.0	16.1	15.7
Total Number (Total Density)	67 (190.6)	33 (93.3)	1,041(222.1)	915 (195.4)	825 (201.1)	797 (206.5)	128 (46.1)	94 (34.0)	382 (91.0)	294 (72.7)	2,443(151.7)	2,133(135.8)

1 Density calculated as the number of birds/lake area surveyed in each corridor.

2 Density is presented in parentheses.

Table 5.2-3. Numbers and Densities of Waterbirds Observed during Breeding-population Transect Surveys, 2013.

Date Species	Males[1]	Pairs	Grouped Birds[2]	Indicated Total No. Birds[3]	Visibility Correction Factor[4]	Corrected Total No. Birds[5]	Density[6] (birds/ mi²)	Composition (% of total)
June 2								
Snow Goose[7]	0	0	26	26	1	26	1.4	12
Canada Goose	0	1	0	2	1	2	0.1	1
Trumpeter Swan[7]	1	5	0	11	1	11	0.6	5
American Wigeon	0	1	0	2	3.65	7	0.4	3
Mallard	2	2	0	8	3.57	29	1.5	13
Northern Shoveler	0	1	0	2	3.35	7	0.3	3
Northern Pintail	1	0	0	2	2.51	5	0.3	2
Green-winged Teal	1	0	0	2	8.88	18	0.9	8
Ring-necked Duck[7]	3	2	0	7	4.02	28	1.5	13
Unidentified scaup[7]	4	6	0	16	1.82	29	1.5	14
Surf Scoter	0	6	0	12	1.08	13	0.7	6
Long-tailed Duck	0	1	0	2	1.99	4	0.2	2
Barrow's Goldeneye	0	2	0	4	3.61	14	0.8	7
Red-throated Loon[7]	1	2	0	5	3.3	17	0.9	8
Common Loon[7]	0	3	0	6	1	6	0.3	3
Total	13	32	26	107		216	11.4	100
June 15								
Trumpeter Swan[7]	5	5	0	15	1	15	0.8	4
American Wigeon	2	3	0	10	3.65	37	1.9	10
Mallard	0	1	0	2	3.57	7	0.4	2
Northern Shoveler	2	0	0	4	3.35	13	0.7	4
Ring-necked Duck[7]	5	0	0	5	4.02	20	1.0	5
Unidentified scaup[7]	14	22	9	67	1.82	122	6.3	33
Surf Scoter	6	10	6	38	1.08	41	2.1	11
Long-tailed Duck	1	2	0	6	1.99	12	0.6	3
Bufflehead	5	4	0	18	1.86	33	1.7	9
Unidentified goldeneye	0	1	0	2	3.61	7	0.4	2
Red-breasted Merganser	4	4	0	16	1.27	20	1.1	5
Red-throated Loon[7]	5	1	0	7	3.3	23	1.2	6
Common Loon[7]	1	0	0	1	1	1	0.1	0
Horned Grebe[7]	0	2	0	4	5.4	22	1.1	6
Total	50	55	15	195		373	19.4	100

1 Includes single birds of unknown sex for geese, swans, loons, and grebes.

2 Grouped birds are those that occurred in flocks with >4 males and for which no assumptions were made as to the number of pairs.

3 Indicated Total No. Birds = (number of males in groups [<5 males] x 2) + (number of pairs x 2) + number of birds in groups.

4 Visibility Correction Factor developed by USFWS (as reported in Mallek and Groves 2011 for most species; Conant et al. 1991 for loons and grebes).

5 Corrected Total No. Birds = Indicated Total No. Birds x Visibility Correction Factor.

6 Density based on corrected total number of birds in a 19.25-square-mile (mi²) sample area.

7 Males and single birds not doubled in calculating indicated total number of birds.

Table 5.2-4. Numbers of Harlequin Ducks Observed during Spring Migration Surveys, 2013.

Survey Area Stream	May 11	May 18–19	May 23–24	May 28–29
Dam/Camp Area				
Tsusena Creek	0	0	0	3
Dam/Camp Area Total	0	0	0	3
Watana Reservoir				
Susitna River	0	11	235	67
Kosina Creek	0	0	3	7
Oshetna River	0	0	0	4
Watana Reservoir Total	0	11	238	78
Denali Corridor				
Deadman Creek	0	0	0	27
Brushkana Creek	0	0	4	26
Nenana River	0	0	14	6
Seattle Creek	0	0	2	0
Denali Corridor Total	0	0	20	59
Chulitna Corridor				
Portage Creek	0	0	4	6
Indian Creek	0	0	2	4
Devil Creek	0	0	0	2
Chulitna Corridor Total	0	0	6	12
Gold Creek Corridor				
Susitna River	2	9	286	20
Fog Creek	0	0	3	13
Indian River	0	0	0	1
Gold Creek Corridor Total	2	9	289	34
Outside 3-mile Buffer				
Jack River	0	0	1	10
Oshetna River	0	2	0	7
Indian River	0	0	0	4
Gilbert Creek	0	0	0	3
Outside 3-mile Buffer Total	0	2	1	24
Total All Survey Areas	2	22	554	210

Table 5.2-5. Numbers of Harlequin Ducks Observed during Pre-nesting Surveys, 2013.

Survey Area Stream[2]	June 1–5[1] Single Male	Single Female	Pairs	Total Birds[3]	June 14–17[1] Single Male	Single Female	Pairs	Total Birds[3]
Dam/Camp Area								
Deadman Creek	2	0	0	2	0	2	0	2
Susitna River	0	0	0	0	0	0	1	2
Tsusena Creek	0	0	0	0	0	0	0	0
Dam/Camp Area Total	2	0	0	2	0	2	1	4
Watana Reservoir								
Black River	0	0	0	0	5	6	9	29
Fog Creek	0	0	0	0	1	0	0	1
Gilbert Creek	1	0	2	5	1	1	1	4
Goose Creek	2	0	5	12	0	1	1	3
Jay Creek	0	0	0	0	0	0	4	8
Kosina Creek	1	0	7	15	2	5	5	17
Oshetna River	1	0	5	11	0	1	1	3
R12	0	0	0	0	1	0	1	3
R18	0	0	0	0	0	0	0	0
R19	0	0	0	0	0	0	0	0
R21	0	0	0	0	0	2	4	10
Susitna River	3	0	5	13	1	1	5	12
Tsisi Creek	2	0	4	10	1	2	3	9
Watana Creek	0	0	0	0	4	1	5	15
Watana Reservoir Total	10	0	28	66	16	20	39	114
Denali Corridor								
Brushkana Creek	1	1	12	26	0	2	2	6
Deadman Creek	6	2	12	32	4	3	5	17
Jack River	0	0	7	14	0	2	3	8
Nenana River	0	0	0	0	0	0	0	0
Seattle Creek	0	0	1	2	0	0	1	2
Wells Creek	0	0	0	0	0	0	0	0
Denali Corridor Total	7	3	32	74	4	7	11	33
Chulitna Corridor								
Clark Creek	0	0	0	0	0	0	0	0
Devil Creek	0	0	1	2	0	1	0	1
Indian River	0	0	2	4	0	0	1	2
Portage Creek	0	1	1	3	0	0	0	0
R9	0	0	0	0	0	0	0	0
Thoroughfare Creek	–	–	–	–	0	0	0	0
Tsusena Creek	0	0	1	2	2	1	5	13
Chulitna Corridor Total	0	1	5	11	2	2	6	16
Gold Creek Corridor								
Cheechako Creek	0	0	0	0	0	0	0	0
Chinook Creek	–	–	–	–	0	0	0	0
Fog Creek	0	0	5	10	0	0	0	0
Gold Creek	–	–	–	–	0	0	0	0
Indian River	0	0	0	0	0	1	0	1
Susitna River	0	0	5	10	5	0	6	17
Gold Creek Corridor Total	0	0	10	20	5	1	6	18
Total All Survey Areas	19	4	75	173	27	32	63	185

1 Dashed lines indicate stream was not surveyed.

2 Indian and Susitna rivers and Deadman, Fog, and Tsusena creeks occur in multiple survey areas.

3 Total = (number of single males) + (number of single females) + (number of pairs x 2).

Table 5.2-6. Numbers of Harlequin Ducks Observed during Brood-rearing Surveys, 2013.

Survey Area Stream[2]	August 1–5[1] Females	Young	Total Birds	No. Broods	August 14–18[1] Females	Young	Total Birds	No. Broods
Dam/Camp Area								
Deadman Creek	0	0	0	0	0	0	0	0
Susitna River	0	0	0	0	–	–	–	–
Tsusena Creek	0	0	0	0	0	0	0	0
Dam/Camp Area Total	0	0	0	0	0	0	0	0
Watana Reservoir								
Black River	2	4	6	1	1	2	3	1
Fog Creek	0	0	0	0	1	6	7	1
Gilbert Creek	2	4	6	1	3	9	12	2
Goose Creek	2	0	2	0	3	13	16	3
Jay Creek	2	5	7	2	0	0	0	0
Kosina Creek	7	0	7	0	1	0	1	0
Oshetna River	0	0	0	0	3	0	3	0
R12	0	0	0	0	0	0	0	0
R18	–	–	–	–	–	–	–	–
R19	–	–	–	–	1	6	7	1
R21	4	5	9	1	3	9	12	2
Susitna River	0	0	0	0	–	–	–	–
Tsisi Creek	3	0	3	0	0	0	0	0
Watana Creek	5	10	15	2	3	10	13	2
Watana Reservoir Total	27	28	55	7	19	55	74	12
Denali Corridor								
Brushkana Creek	5	0	5	0	0	0	0	0
Deadman Creek	5	4	9	1	3	9	12	3
Jack River	3	0	3	0	0	0	0	0
Nenana River	–	–	–	–	–	–	–	–
Seattle Creek	2	7	9	2	3	8	11	3
Wells Creek	–	–	–	–	0	0	0	0
Denali Corridor Total	15	11	26	3	6	17	23	6
Chulitna Corridor								
Clark Creek	0	0	0	0	1	4	5	1
Devil Creek	0	0	0	0	4	12	16	4
Indian River	2	11	13	2	3	3	6	1
Portage Creek	1	0	1	0	1	4	5	1
R9	0	0	0	0	0	0	0	0
Thoroughfare Creek	2	0	2	0	0	0	0	0
Tsusena Creek	1	0	1	0	1	5	6	1
Chulitna Corridor Total	6	11	17	2	10	28	38	8
Gold Creek Corridor								
Cheechako Creek	0	0	0	0	0	0	0	0
Chinook Creek	0	0	0	0	0	0	0	0
Fog Creek	2	0	2	0	1	6	7	1
Gold Creek	0	0	0	0	0	0	0	0
Indian River	0	0	0	0	0	0	0	0
Susitna River	0	0	0	0	–	–	–	–
Gold Creek Corridor Total	2	0	2	0	1	6	7	1
Total All Survey Areas	50	50	100	12	36	106	142	27

1 Dashed lines indicate stream was not surveyed.

2 Indian and Susitna rivers and Deadman, Fog, and Tsusena creeks occur in multiple survey areas.

Table 5.2-7. Numbers of Waterbird Broods Observed on Water Bodies during Brood-rearing Surveys, 2013.

	Dam/Camp Area		Watana Reservoir		Denali Corridor		Chulitna Corridor		Gold Creek Corridor		Total Broods	
Species	Jul 20–22	Aug 1–5	Jul 20–22	Aug 1–5	Jul 20–22	Aug 1–5	Jul 20–22	Aug 1–5	Jul 20–22	Aug 1–5	Jul 20–22	Aug 1–5
Trumpeter Swan	0	0	0	0	1	2	0	0	0	0	1	2
Gadwall	0	0	0	0	0	0	0	1	0	0	0	1
American Wigeon	0	0	0	0	9	9	0	1	0	0	9	10
Mallard	0	1	2	0	2	0	1	2	1	0	6	3
Northern Shoveler	0	0	0	0	1	1	0	0	0	0	1	1
Northern Pintail	0	0	0	1	3	7	1	0	0	0	4	8
Green-winged Teal	1	0	2	2	12	14	2	0	2	2	19	18
Unidentified dabbler	0	0	0	0	2	1	1	0	0	0	3	1
Ring-necked Duck	0	1	0	0	1	0	0	0	0	0	1	1
Unidentified scaup	0	0	9	9	23	37	0	3	1	7	33	56
Surf Scoter	1	1	0	0	1	1	0	0	3	3	5	5
White-winged Scoter	0	0	1	1	0	0	0	0	0	0	1	1
Black Scoter	0	0	0	0	0	0	1	0	0	0	1	0
Long-tailed Duck	0	0	0	0	4	3	0	0	0	0	4	3
Bufflehead	0	0	0	0	1	1	0	0	0	0	1	1
Unidentified goldeneye	1	2	2	4	2	5	3	11	2	4	10	26
Red-breasted Merganser	0	1	0	0	0	0	0	0	0	0	0	1
Unidentified merganser	0	0	0	0	0	1	0	0	0	0	0	1
Unidentified duck	0	0	0	1	0	0	0	0	0	0	0	1
Red-throated Loon	0	0	0	0	1	0	0	0	0	0	1	0
Pacific Loon	0	0	0	0	0	0	0	0	1	1	1	1
Common Loon	0	0	1	0	0	1	0	1	2	0	3	2
Horned Grebe	0	0	2	1	0	0	0	0	0	0	2	1
Red-necked Grebe	0	0	0	0	0	0	0	0	0	1	0	1
Bonaparte's Gull	0	0	0	0	1	2	0	0	0	0	1	2
Mew Gull	0	0	0	0	1	3	0	0	0	0	1	3
Unidentified gull	0	0	0	0	2	1	0	0	0	0	2	1
Arctic Tern	0	0	0	0	1	0	0	0	0	0	1	0
Total Broods	3	6	19	19	68	89	9	19	12	18	111	151
Number of Species	3	5	7	6	16	14	5	6	7	6	21	21
Density (broods/mi^2)	8.1	16.1	40.7	40.7	30.5	39.9	11.1	23.4	7.0	9.7	19.5	26.3

Table 5.2-8. Age Subclass[1] of Duck Broods Observed during Brood-rearing Surveys, 2013.

	July 20–22							August 1–5							
Species	1A	1B	1C	2A	2B	2C	Brood Total	1A	1B	1C	2A	2B	2C	3	Brood Total
Gadwall	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
American Wigeon	0	0	4	4	1	0	9	0	0	0	7	2	1	0	10
Mallard	0	2	2	0	2	0	6	0	0	0	1	1	1	0	3
Northern Shoveler	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1
Northern Pintail	0	0	0	0	2	2	4	0	0	0	0	1	6	1	8
Green-winged Teal	5	6	5	2	1	0	19	0	0	3	6	4	5	0	18
Unidentified dabbler	1	1	1	0	0	0	3	0	0	1	0	0	0	0	1
Ring-necked Duck	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1
Unidentified scaup	10	22	1	0	0	0	33	1	9	25	18	3	0	0	56
Surf Scoter	0	4	1	0	0	0	5	0	0	0	5	0	0	0	5
White-winged Scoter	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1
Black Scoter	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Long-tailed Duck	0	1	0	3	0	0	4	0	0	1	0	2	0	0	3
Bufflehead	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1
Unidentified goldeneye	3	6	0	1	0	0	10	0	3	1	14	4	4	0	26
Red-breasted Merganser	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Unidentified merganser	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Unidentified duck	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Total	21	43	14	11	7	2	98	1	13	35	52	19	17	1	138

1 Age span for each subclass differs among species; however, for all species, Class 1 chicks are downy and there are no visible feathers. Class 2 chicks are partially feathered, and Class 3 chicks are fully feathered.

10. FIGURES

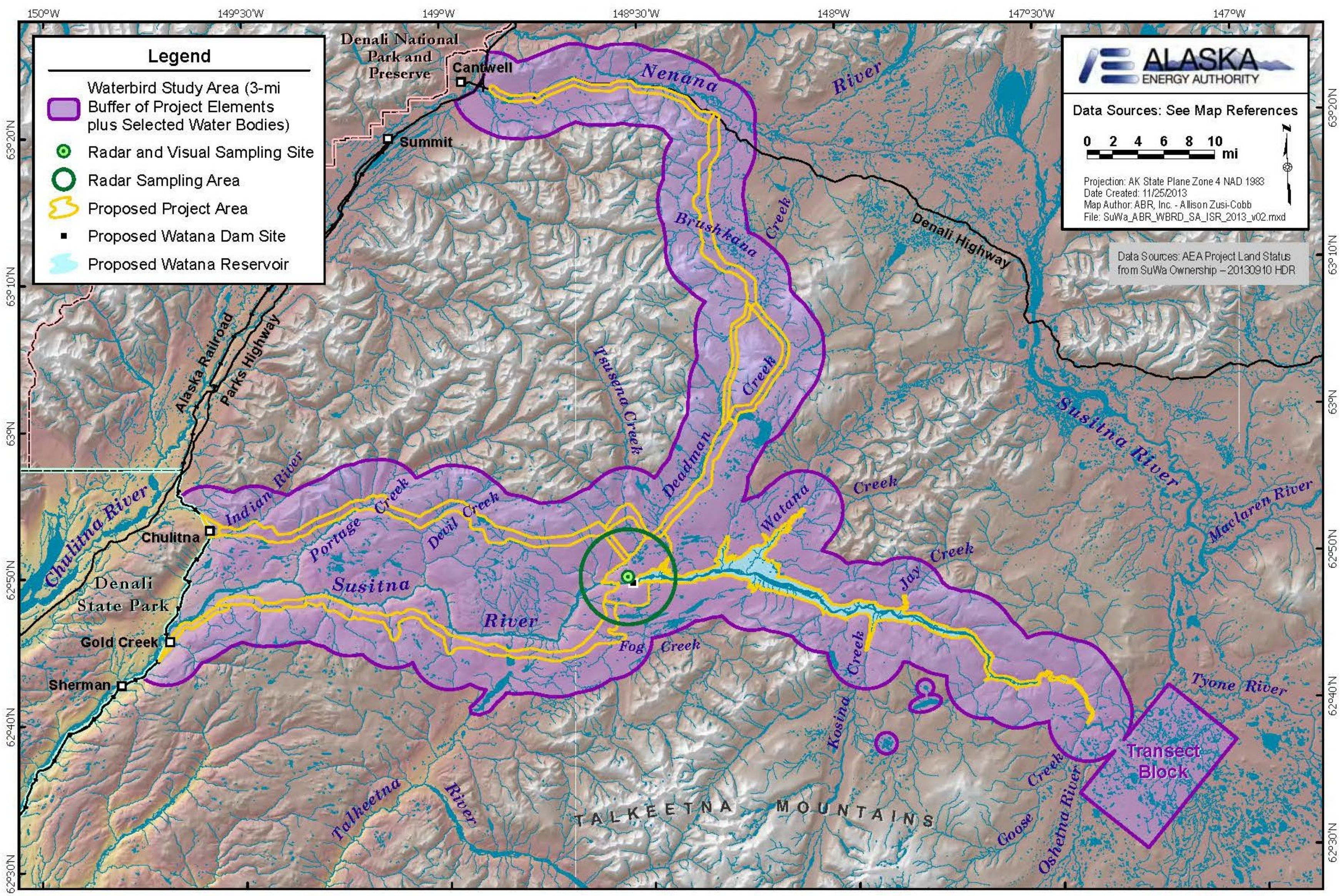

Figure 3-1. Waterbird Study Area for the Susitna–Watana Hydroelectric Project.

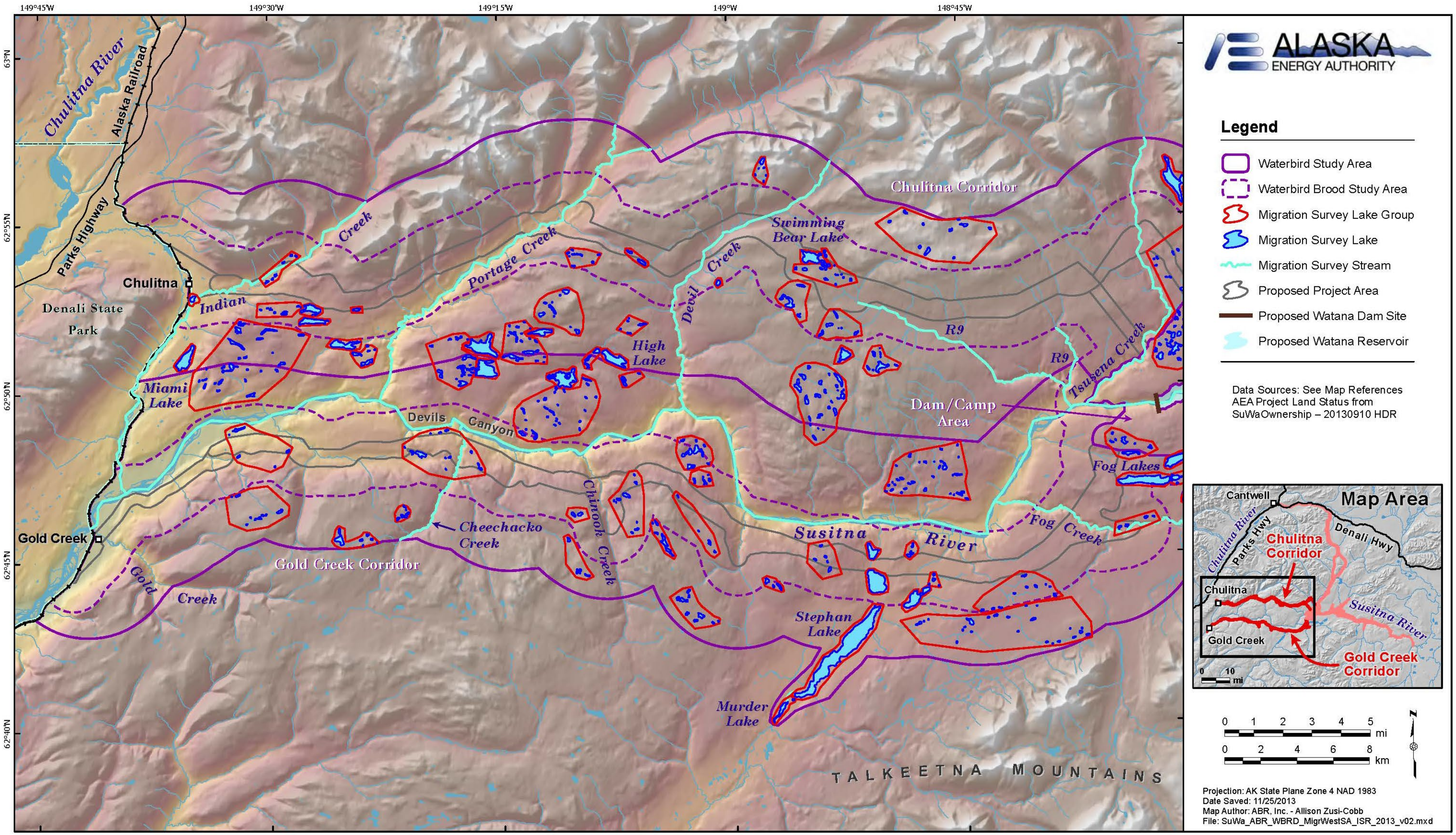

Figure 4.1-1. Water Bodies Surveyed for Waterbirds during Spring and Fall Migration in the Chulitna and Gold Creek Corridors, 2013.

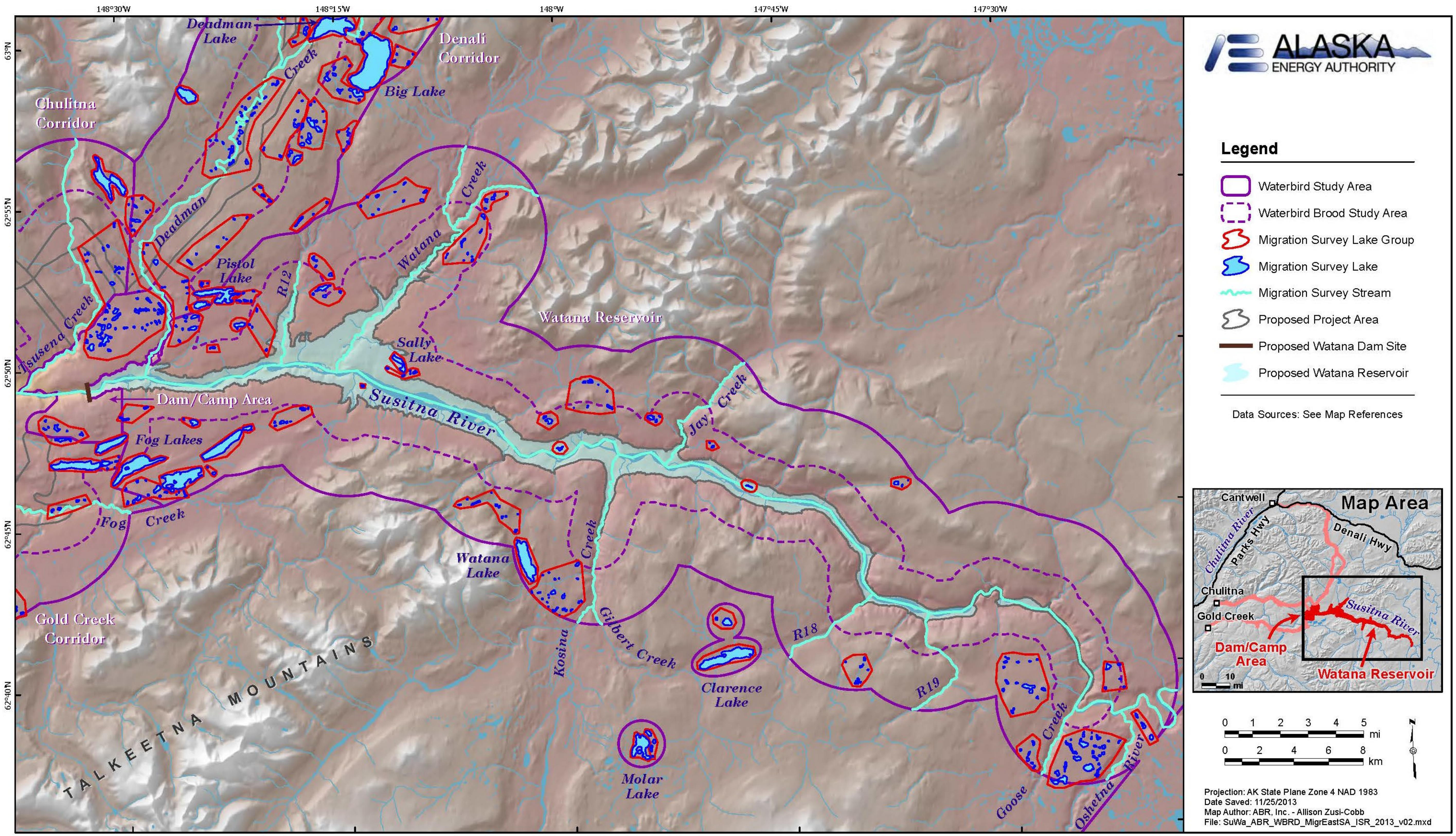

Figure 4.1-2. Water Bodies Surveyed for Waterbirds during Spring and Fall Migration in the Reservoir Inundation Zone and Vicinity, 2013.

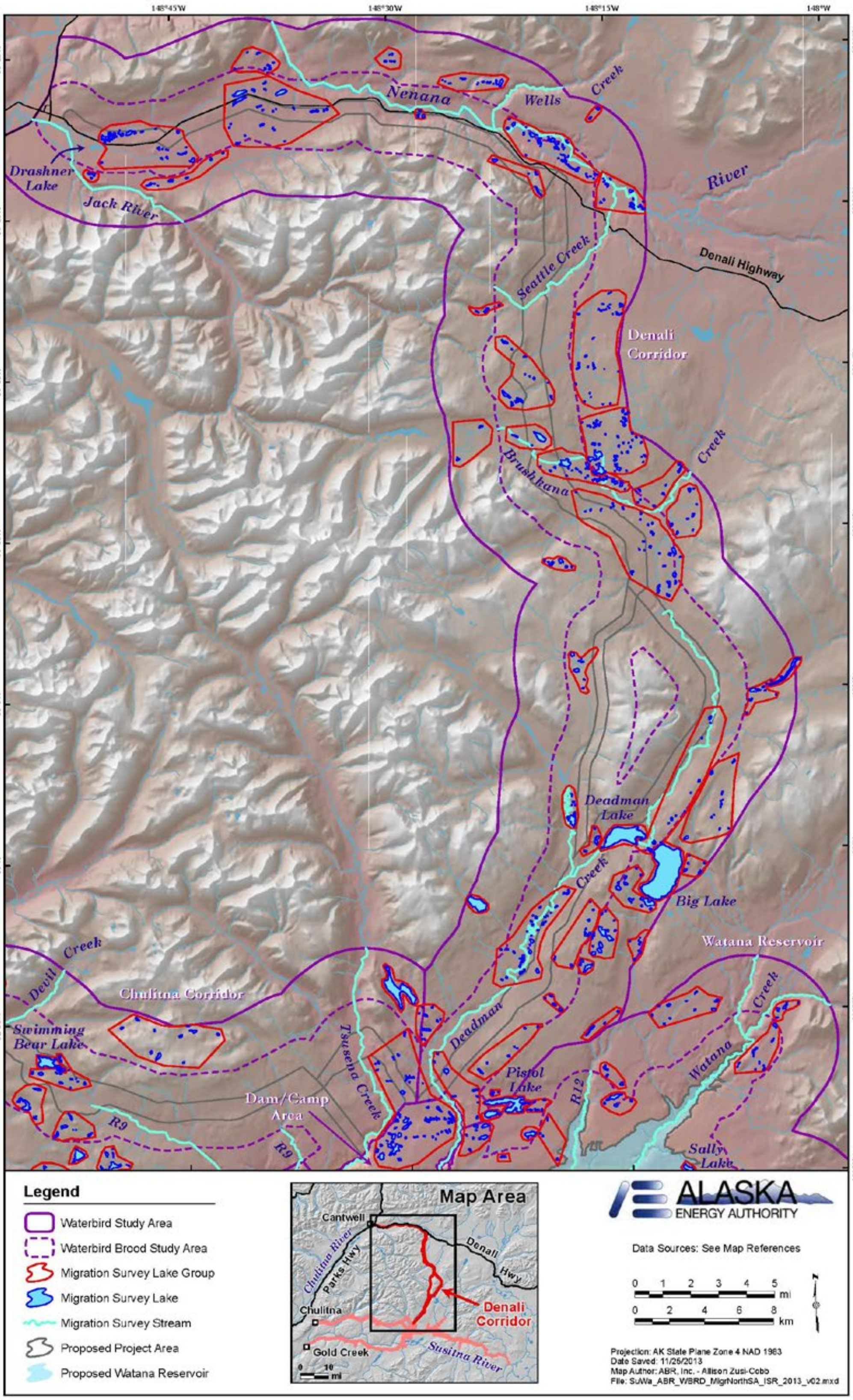

Figure 4.1-3. Water Bodies Surveyed for Waterbirds during Spring and Fall Migration in the Denali Corridor, 2013.

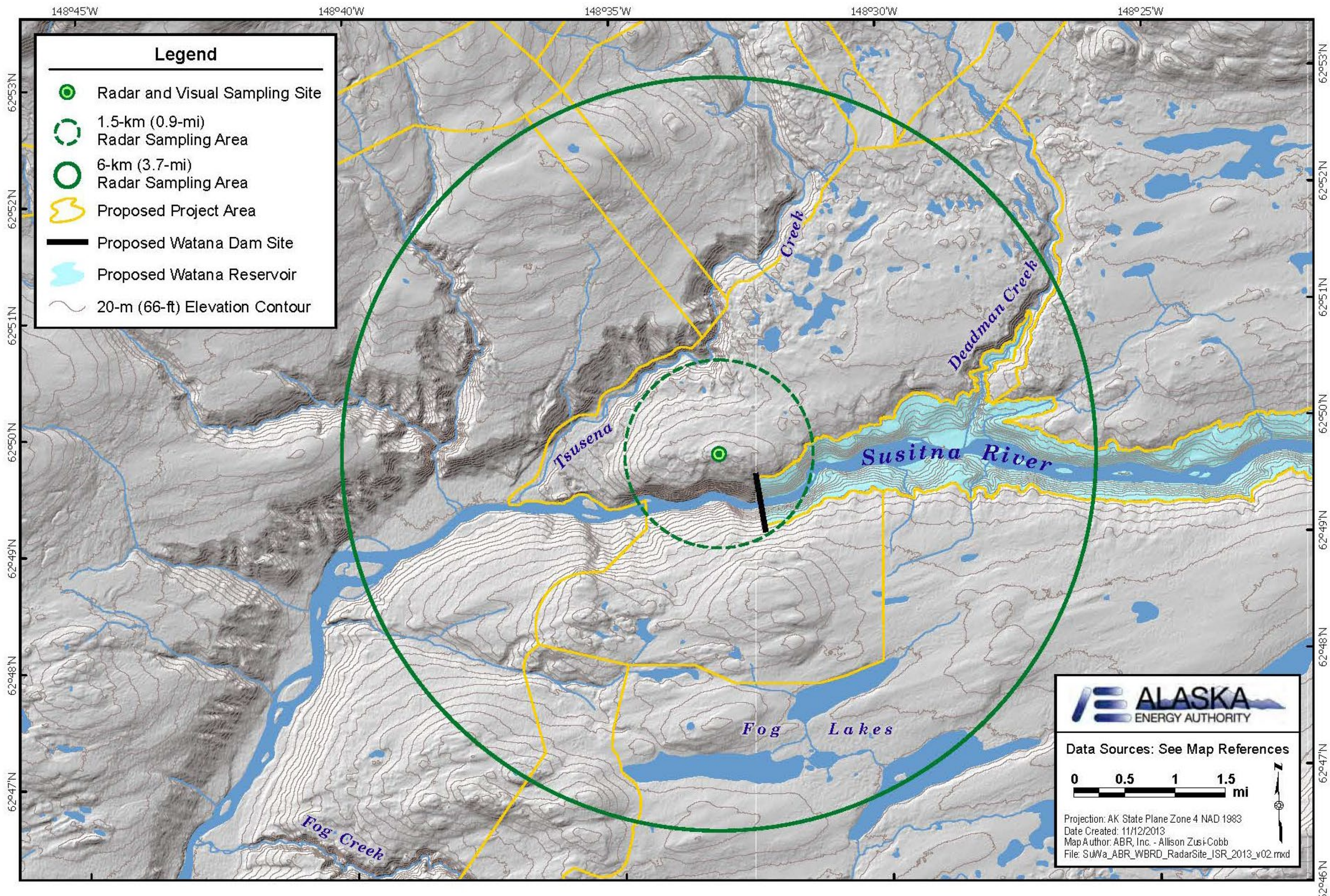

Figure 4.1-4. Radar and Visual Sampling Area for Ground-based Surveys of Migration, 2013.

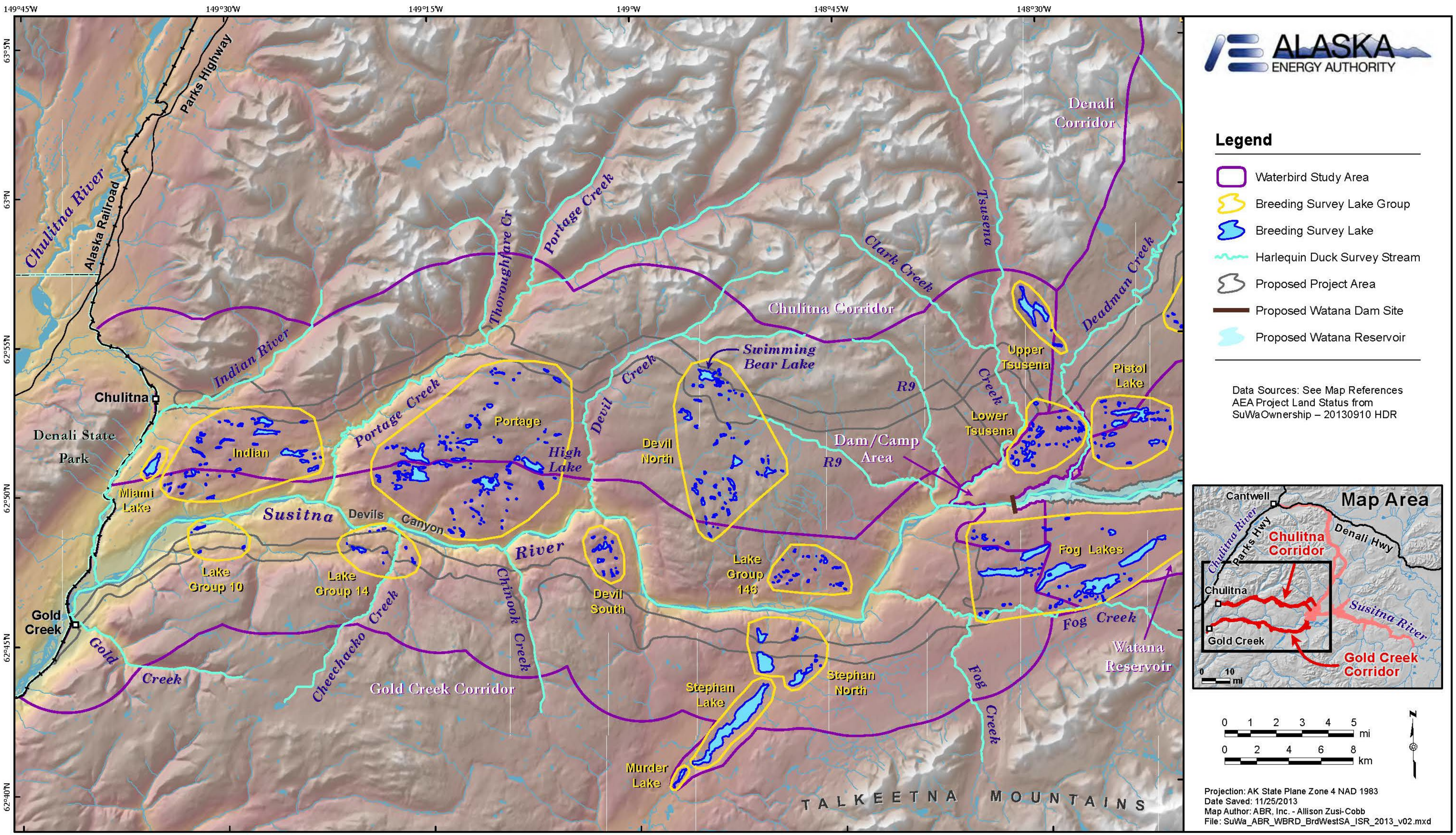

Figure 4.1-5. Water Bodies Surveyed for Breeding Waterbirds, and Streams Surveyed for Harlequin Ducks, in the Chulitna and Gold Creek Corridors, 2013.

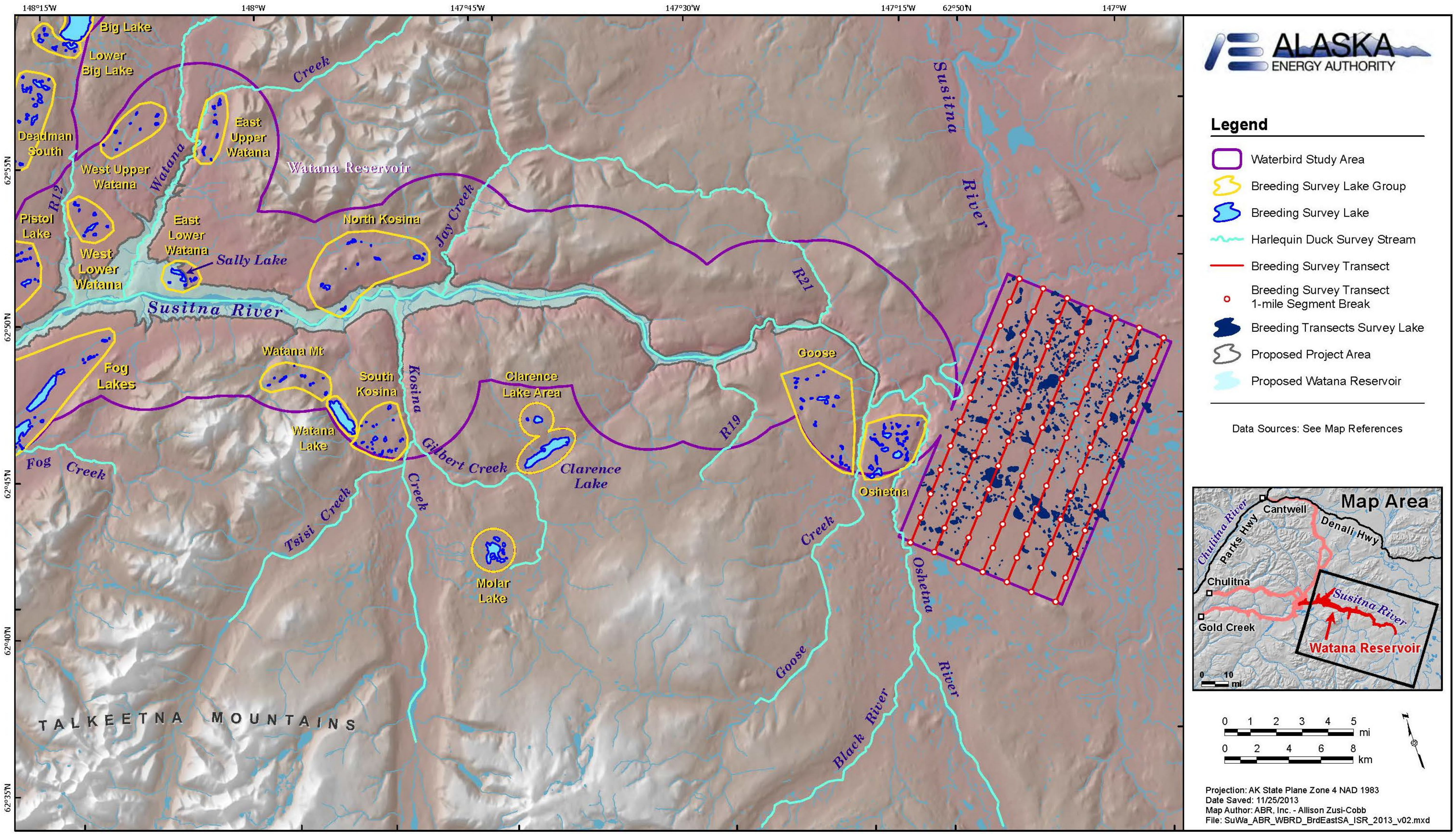

Figure 4.1-6. Water Bodies and Transect Lines Surveyed for Breeding Waterbirds, and Streams Surveyed for Harlequin Ducks, in the Reservoir Inundation Zone and Vicinity, 2013.

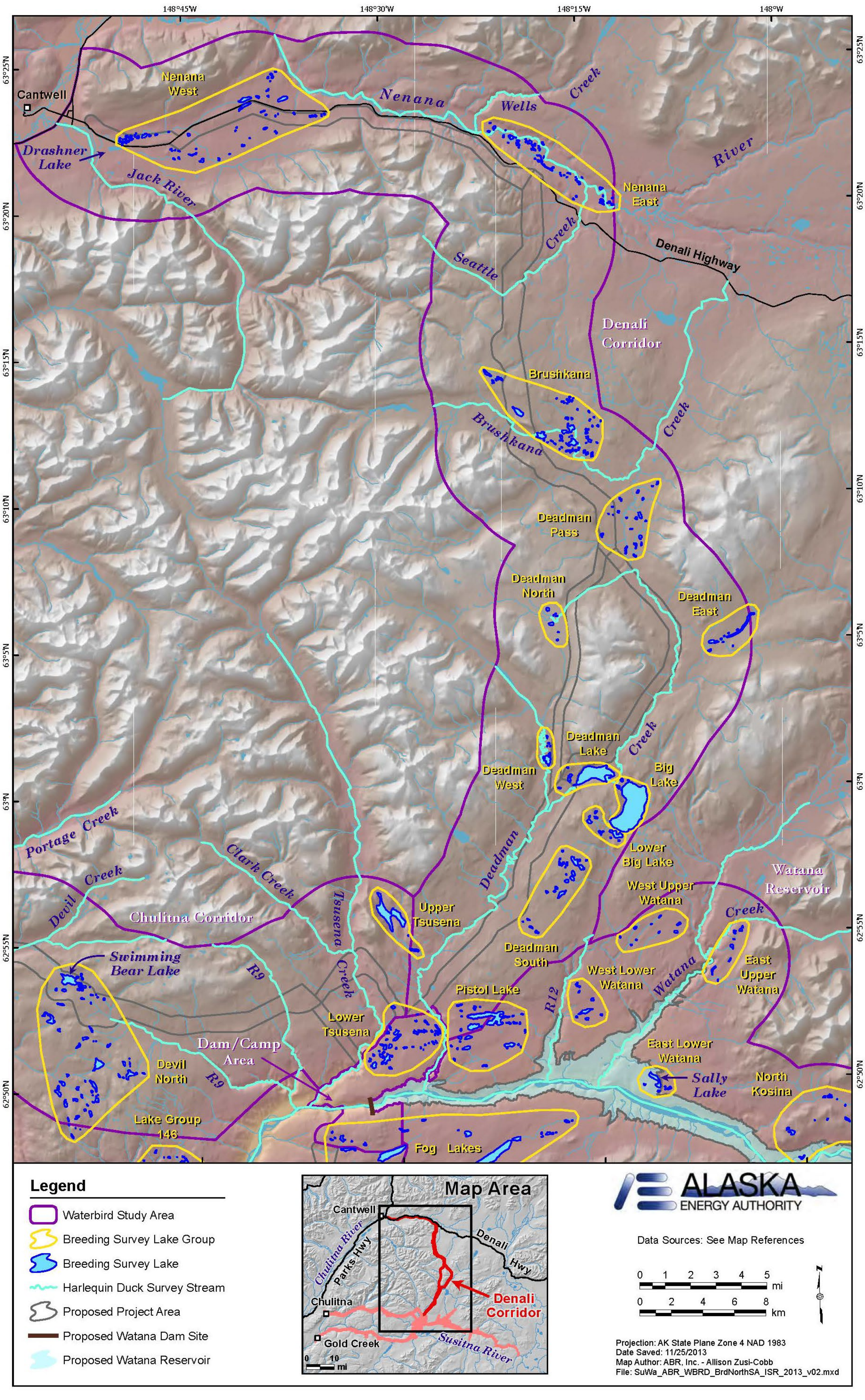

Figure 4.1-7. Water Bodies Surveyed for Breeding Waterbirds, and Streams Surveyed for Harlequin Ducks, in the Denali Corridor, 2013.

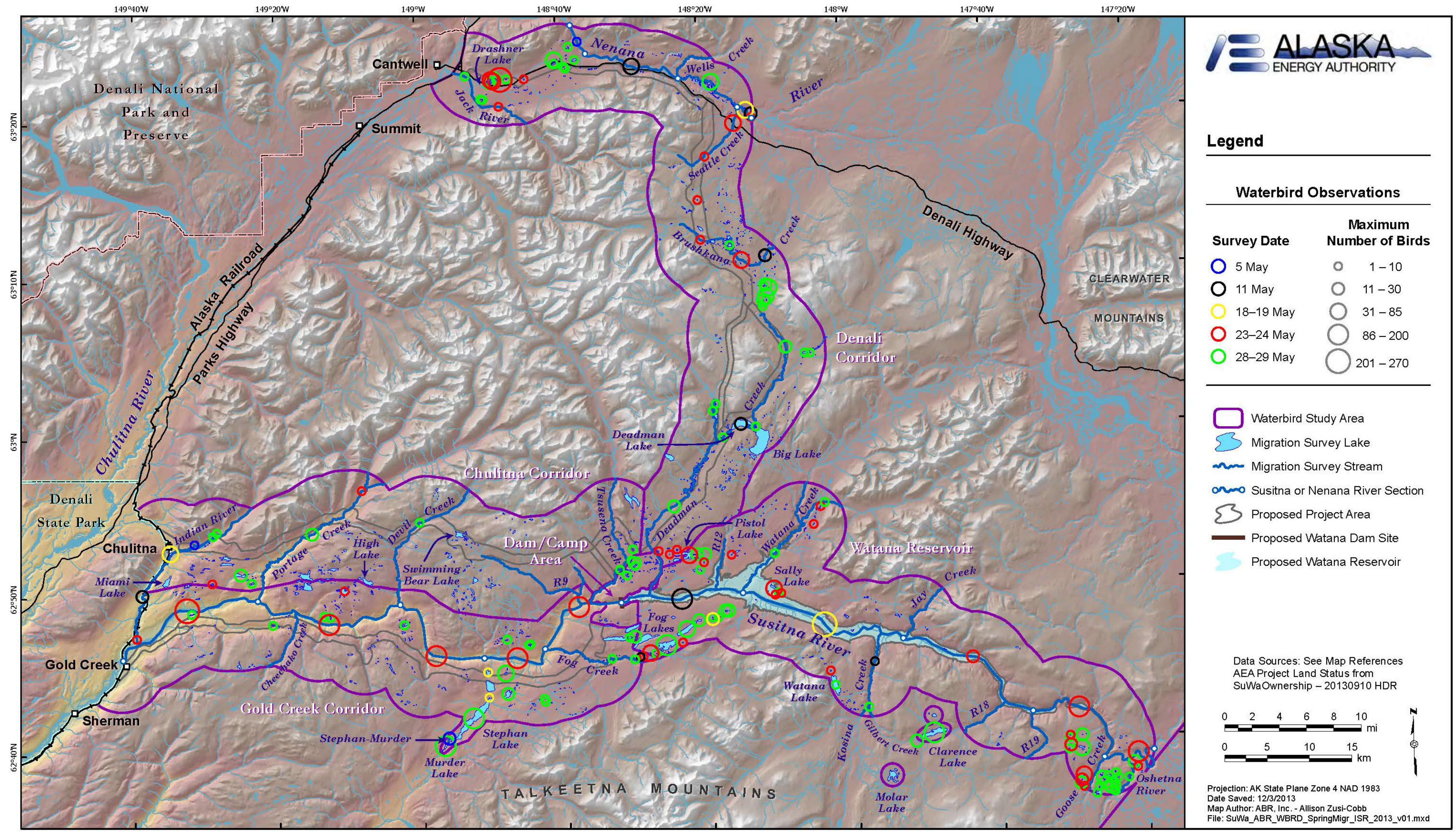

Figure 5.1-1. Locations and Maximum Number of Waterbirds Observed on Rivers and Water Bodies during Spring Migration Surveys, 2013. Locations are centerpoints of water bodies and midpoints of sections of river.

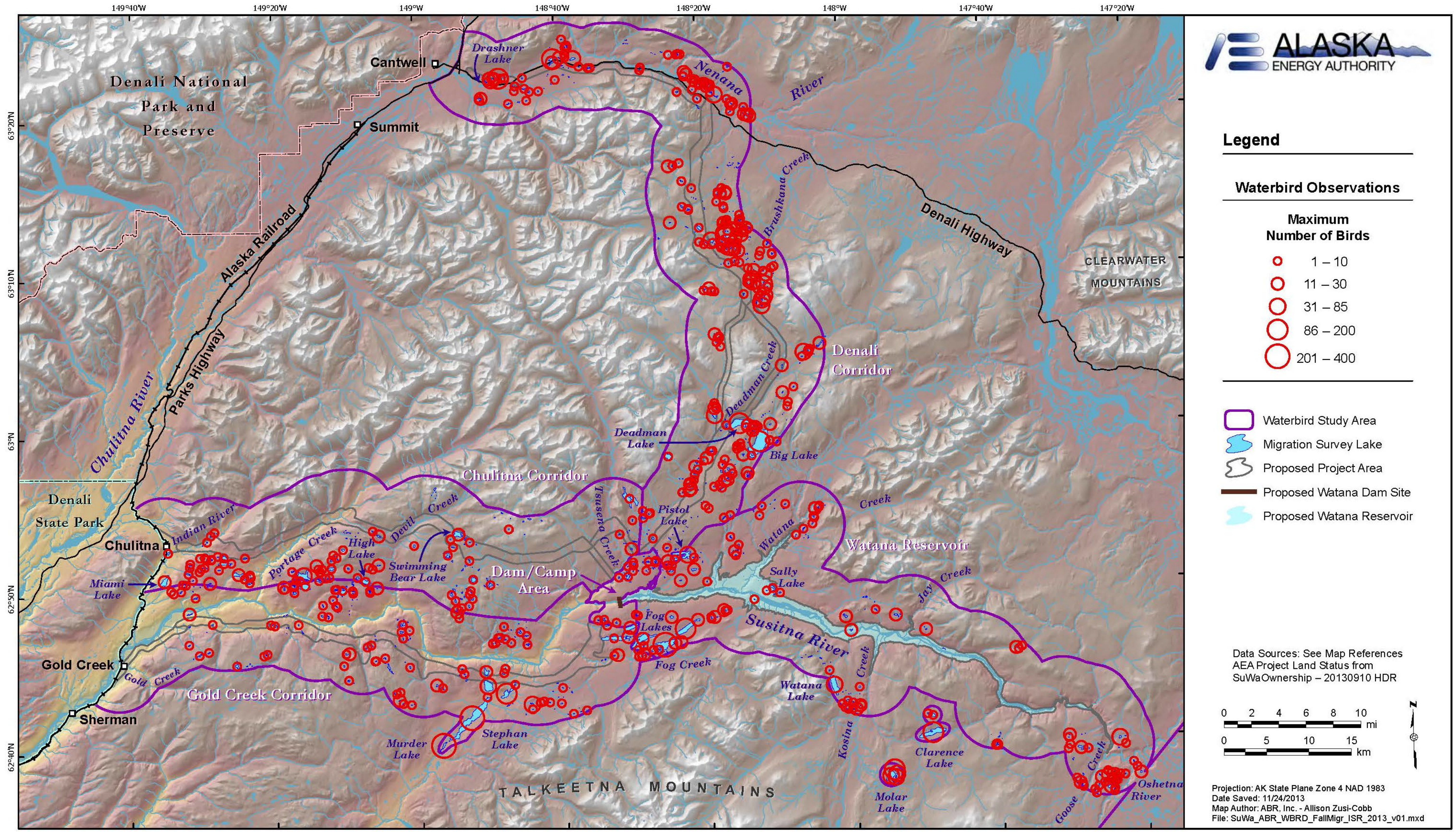

Figure 5.1-2. Locations and Maximum Number of Waterbirds Observed on Water Bodies during Fall Migration Surveys, 2013. Locations are centerpoints of water bodies.

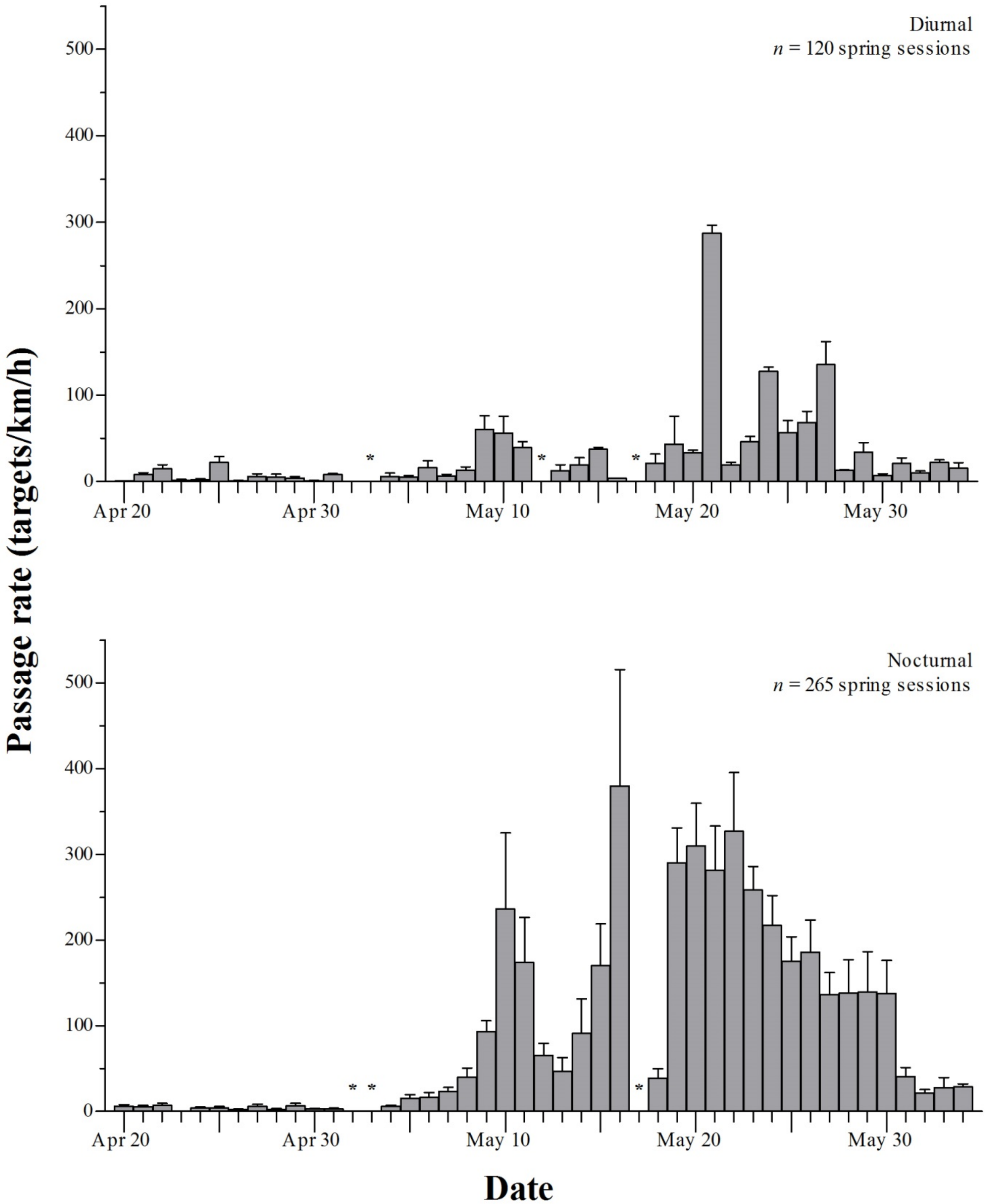

Figure5.1-3. Spring Diurnal and Nocturnal Passage Rates (mean ± SE) by Date for Targets Detected within the 1.5-km Radar Range. Asterisks indicate that no radar sampling occurred due to weather.

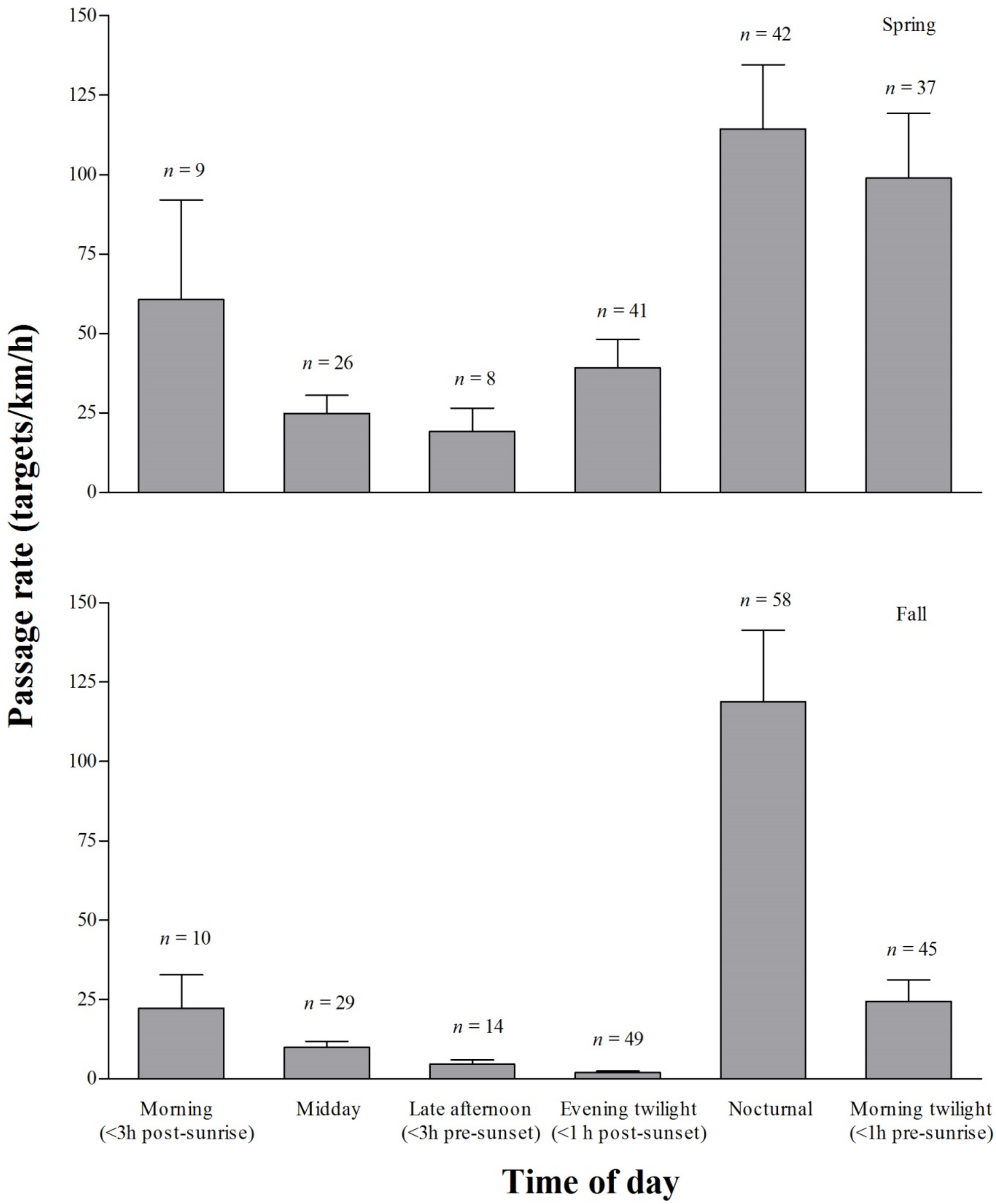

Figure 5.1-4. Passage Rates (mean ± SE) of Targets, Grouped by Time of Day, during Spring and Fall Migration, for Targets Detected within the 1.5-km Radar Range.

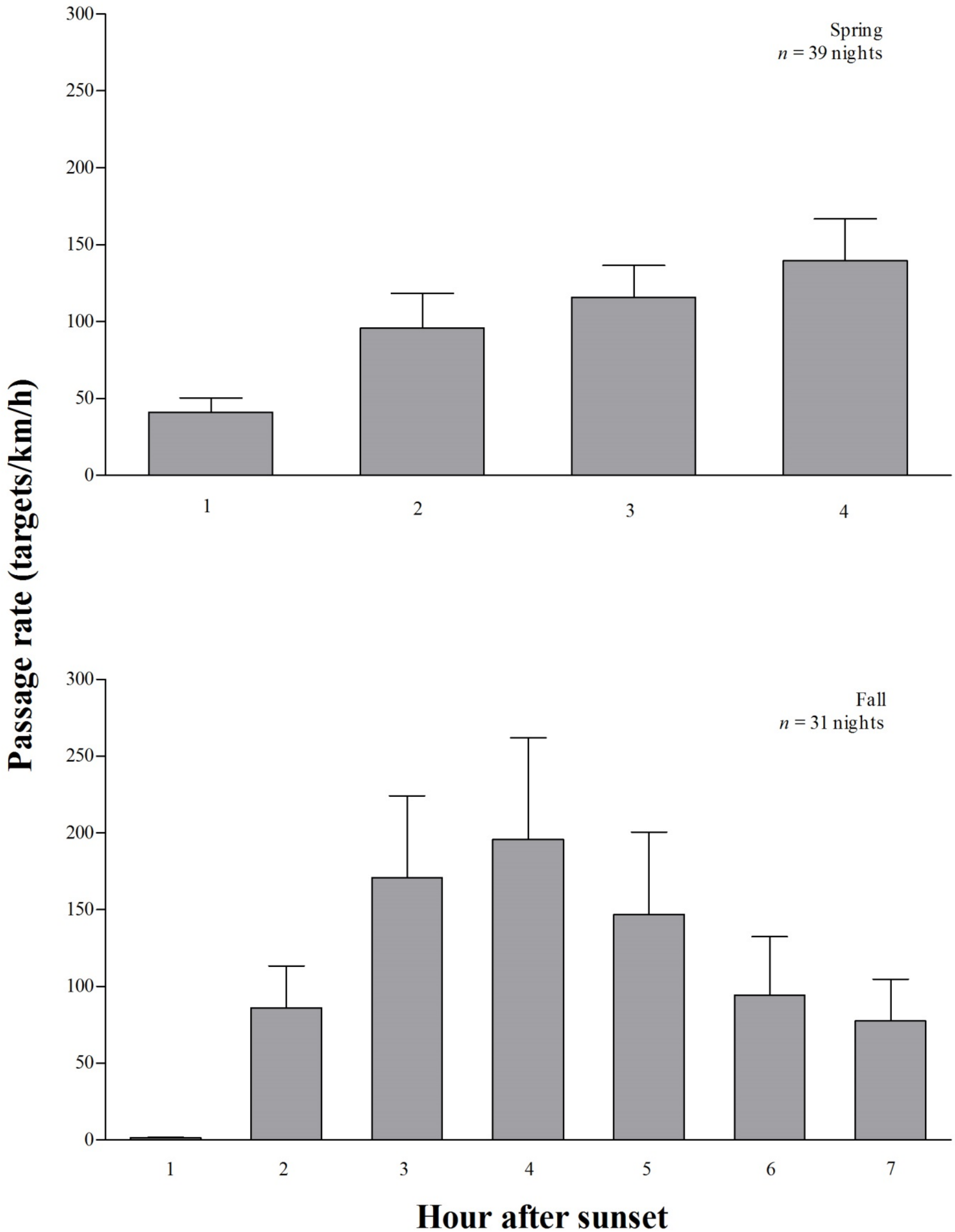

Figure 5.1-5. Passage Rates (mean ± SE) Relative to Hour Post-Sunset During Spring and Fall Migration, for Targets Detected within the 1.5-km Radar Range.

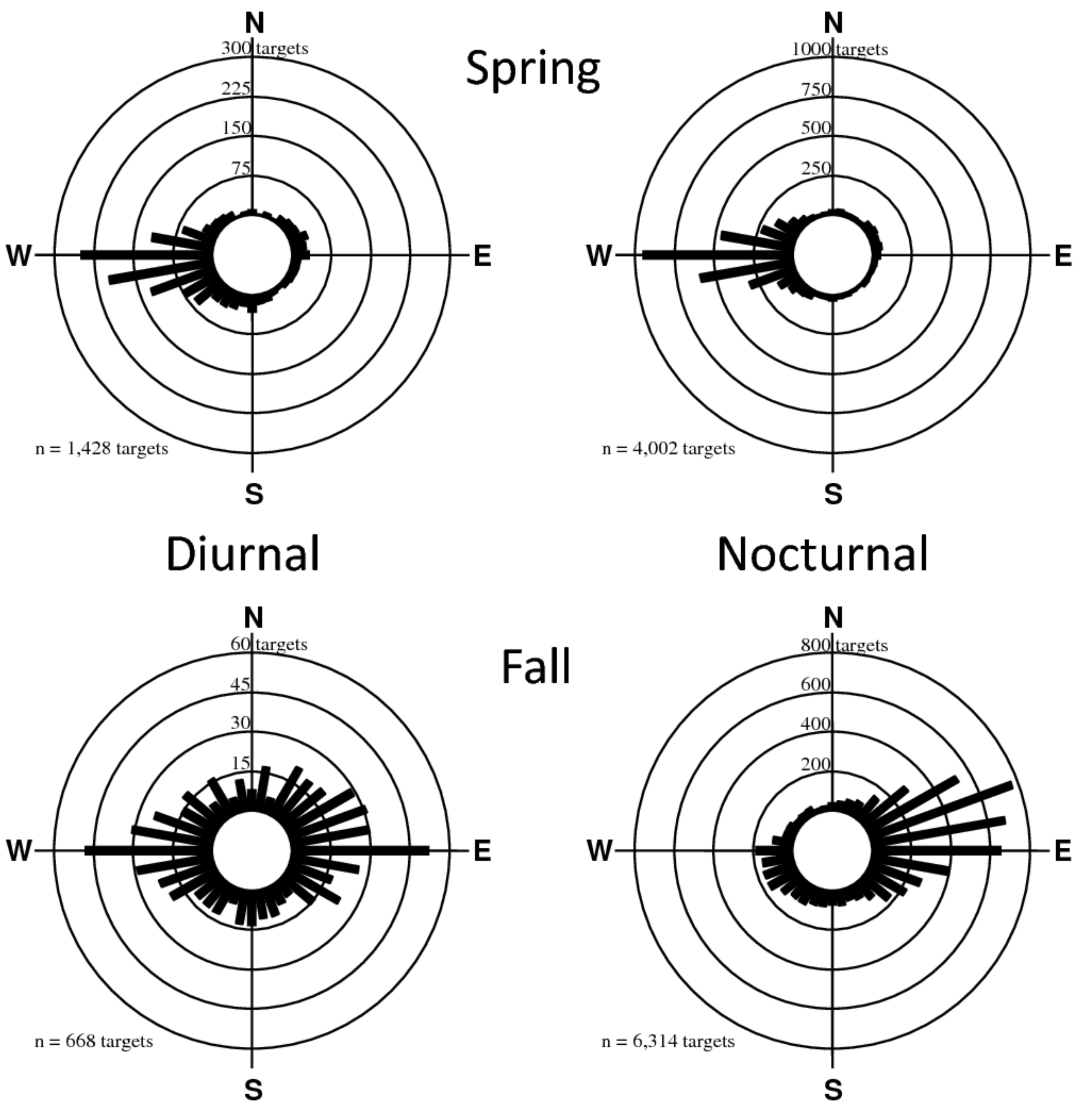

Figure 5.1-6. Diurnal and Nocturnal Flight Directions of Targets Detected within the 1.5-km Radar Range.

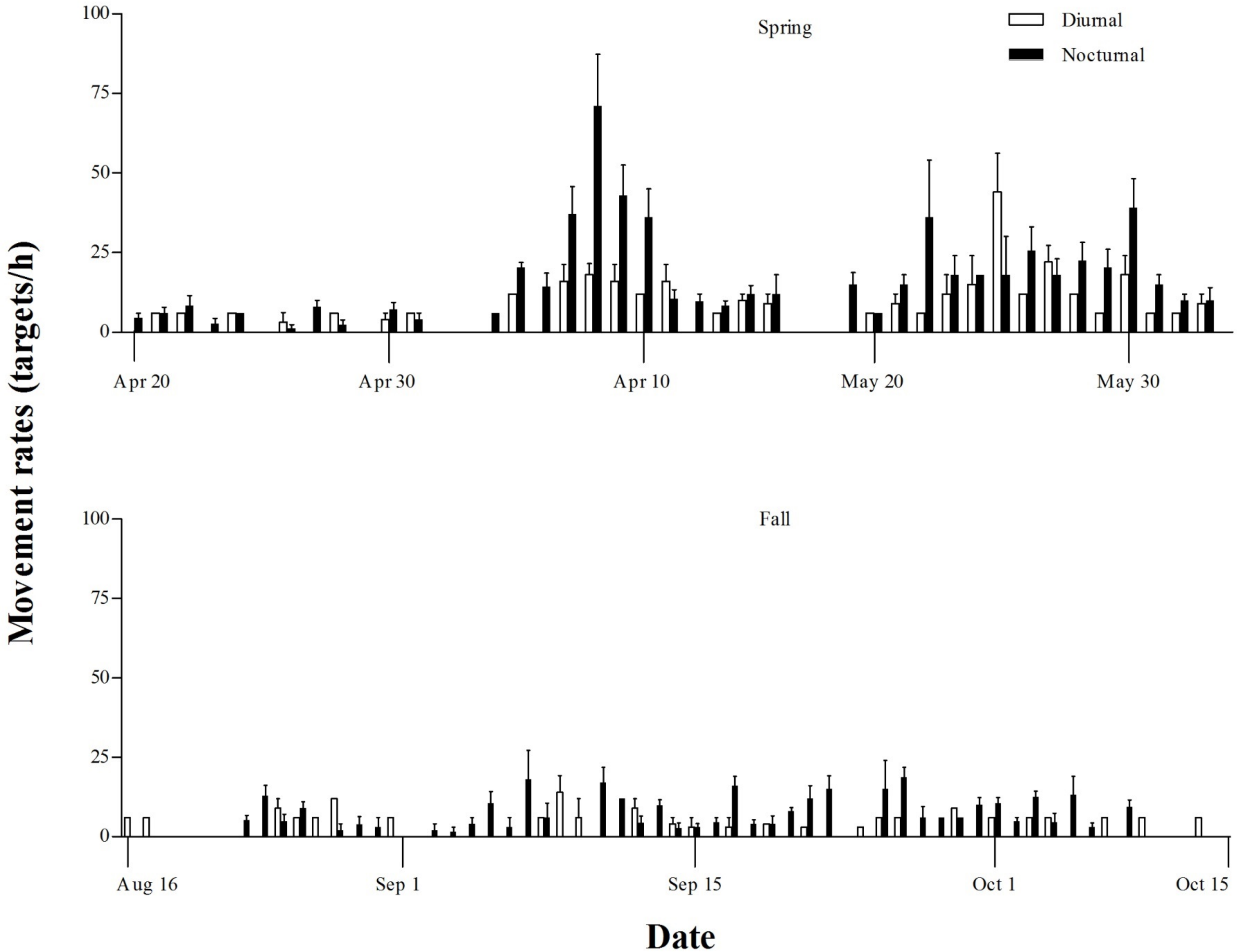

Figure 5.1-7. Radar Targets Detected >1.5 km from the Sampling Station during Spring and Fall Migration.

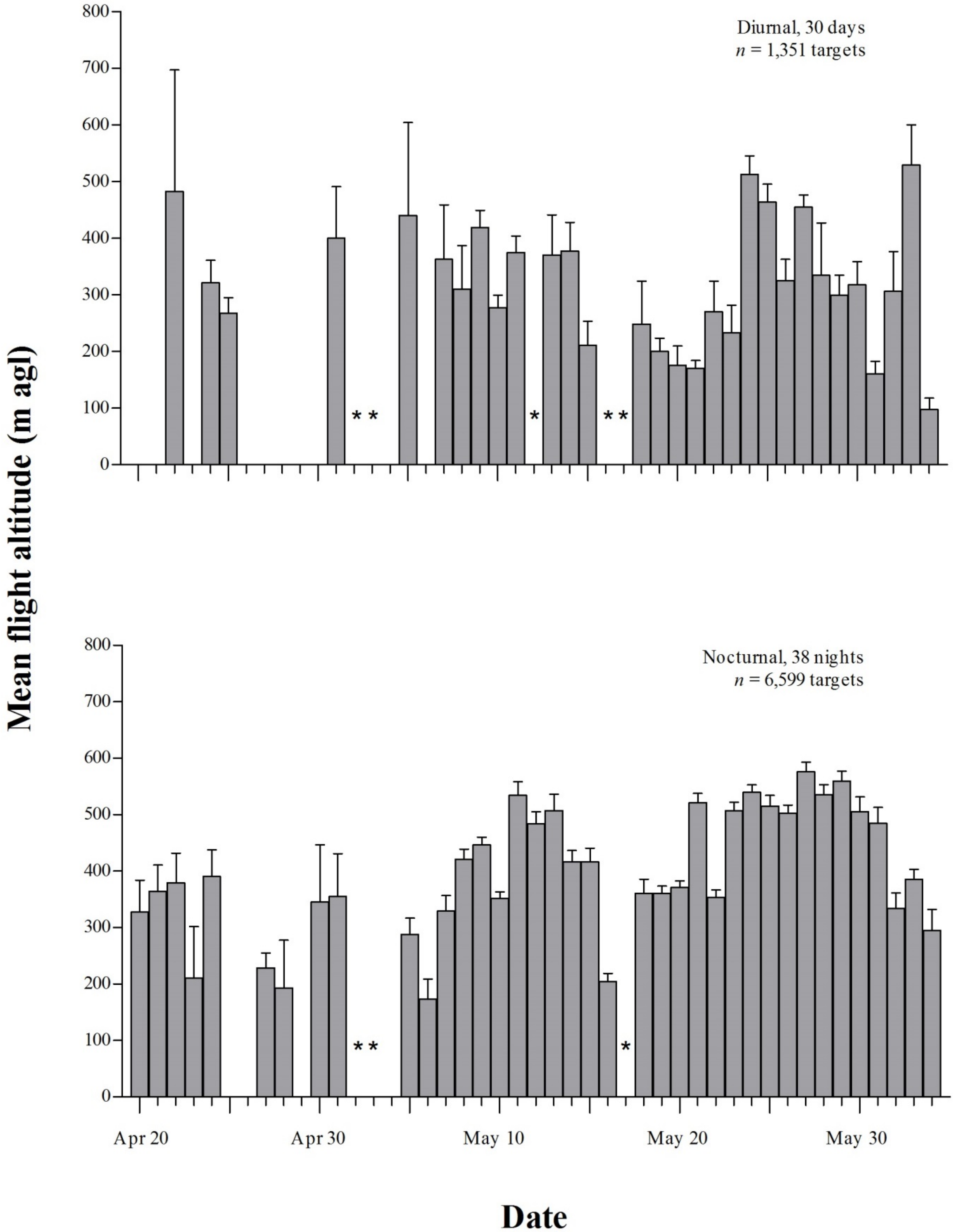

Figure 5.1-8. Mean Diurnal and Nocturnal Flight Altitudes (m agl) of Targets during Spring Migration, by Date for Targets Detected within the 1.5-km Radar Range. Asterisks (*) indicate that no radar sampling occurred (due to weather), and blanks indicate dates with sample sizes too small (<5 targets) to calculate meaningful values.

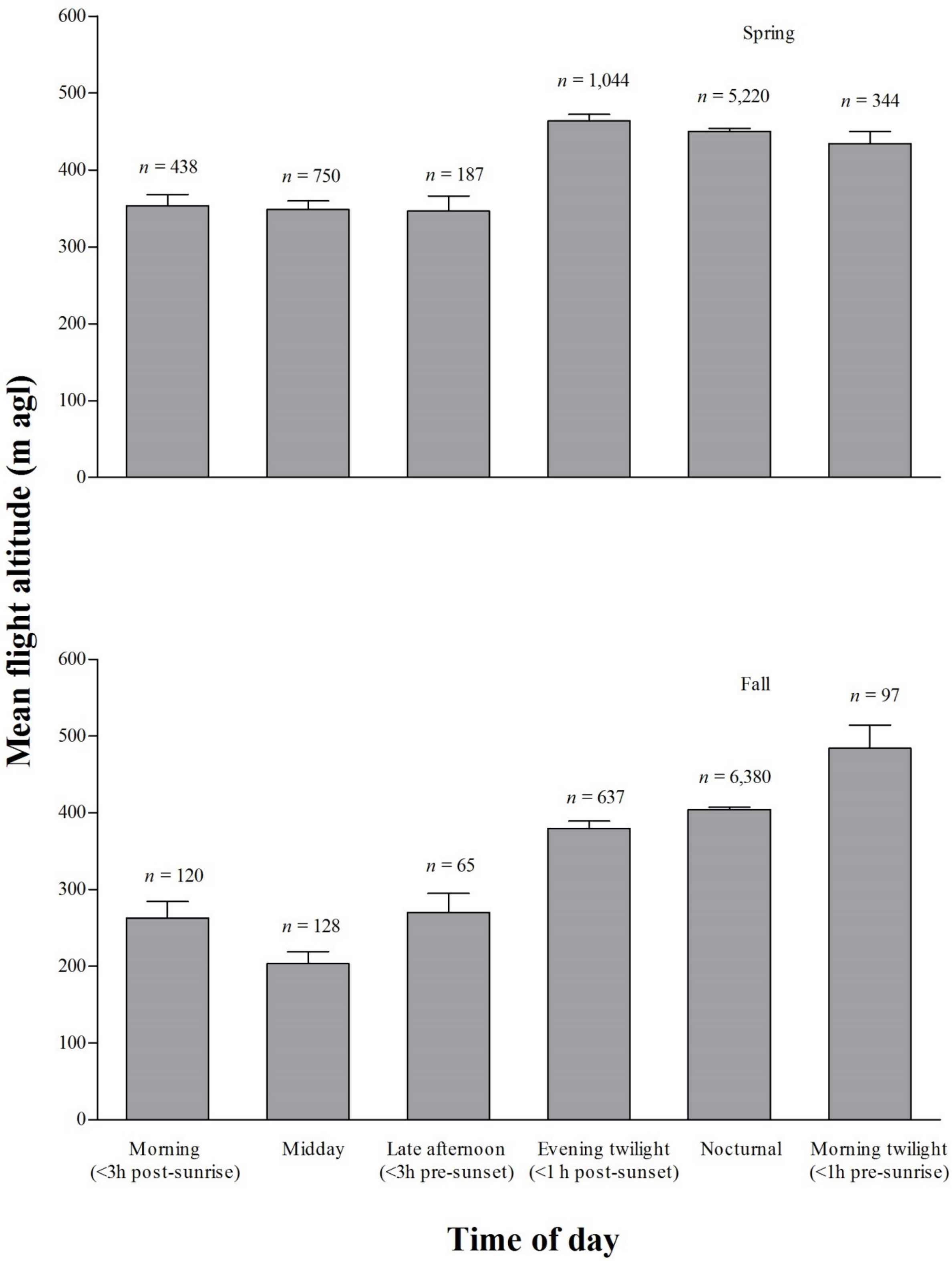

Figure 5.1-9. Mean Flight Altitudes (m agl) of Targets, Grouped by Time of Day, during Spring and Fall Migration for Targets Detected within the 1.5-km Radar Range.

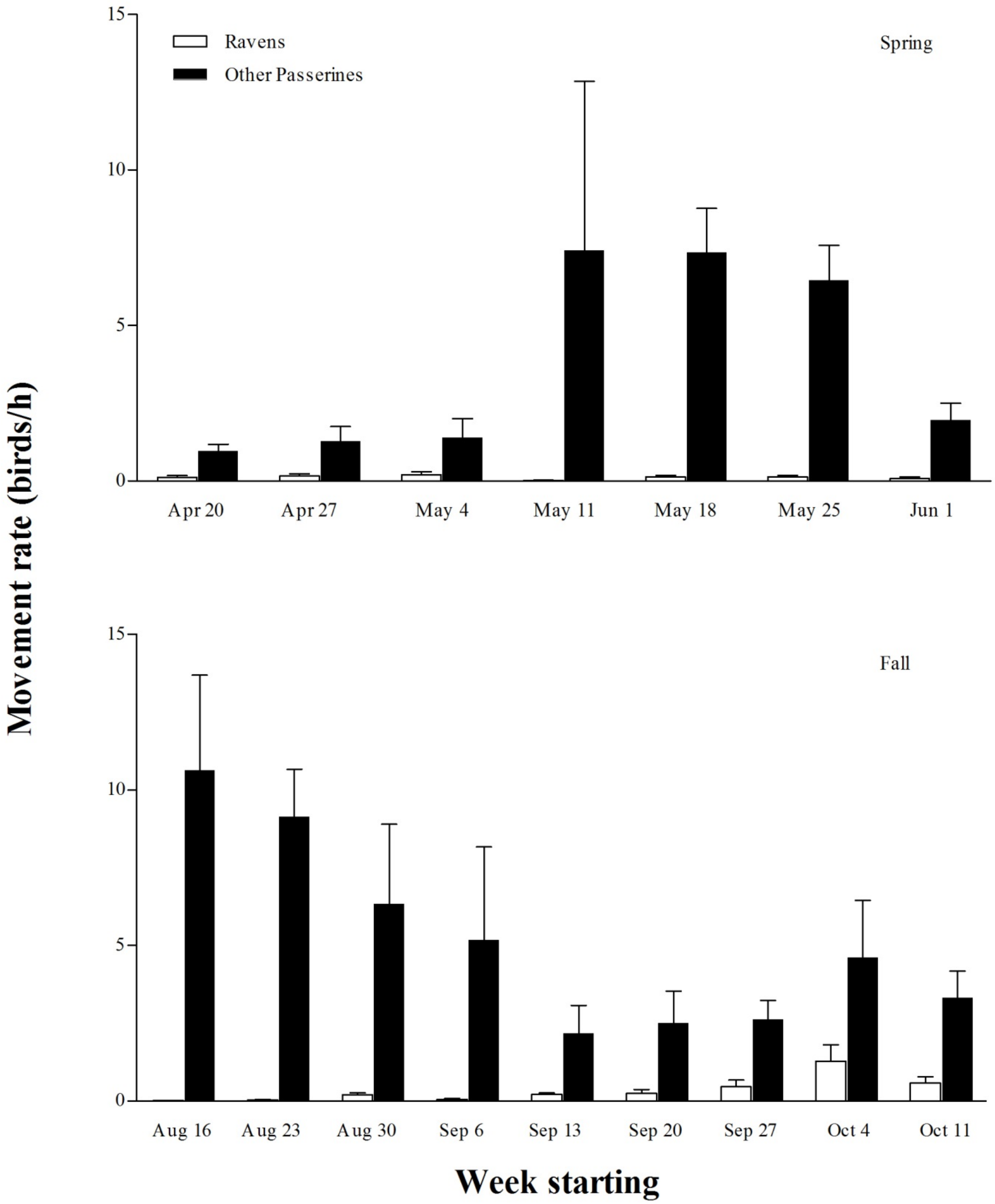

Figure 5.1-10. Mean Movement Rates (birds/h) of Passerines by Week of the Spring and Fall Migration Survey Seasons.

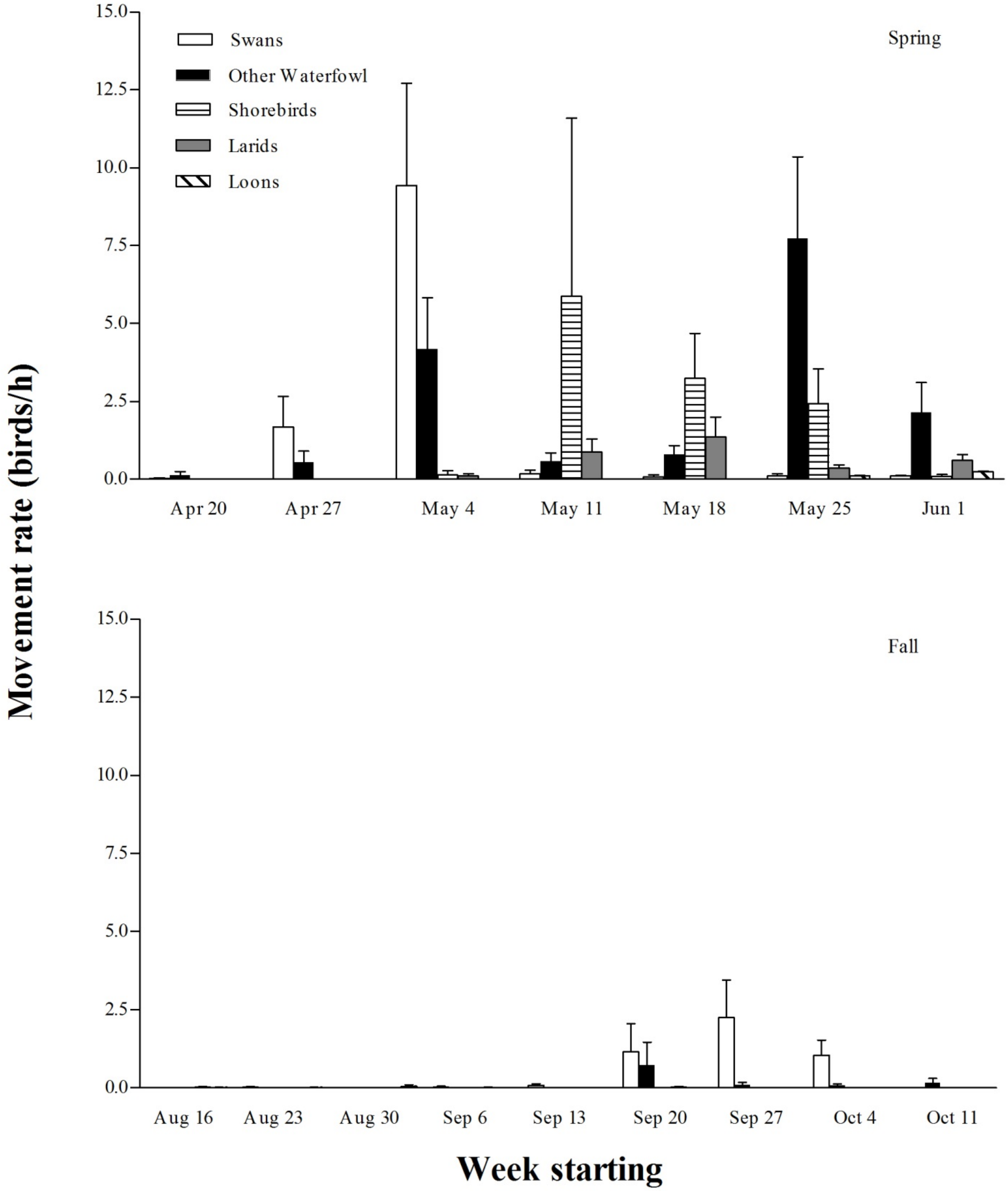

Figure 5.1-11. Mean Movement Rates (birds/h) of Waterbirds by Week of the Spring and Fall Migration Survey Seasons.

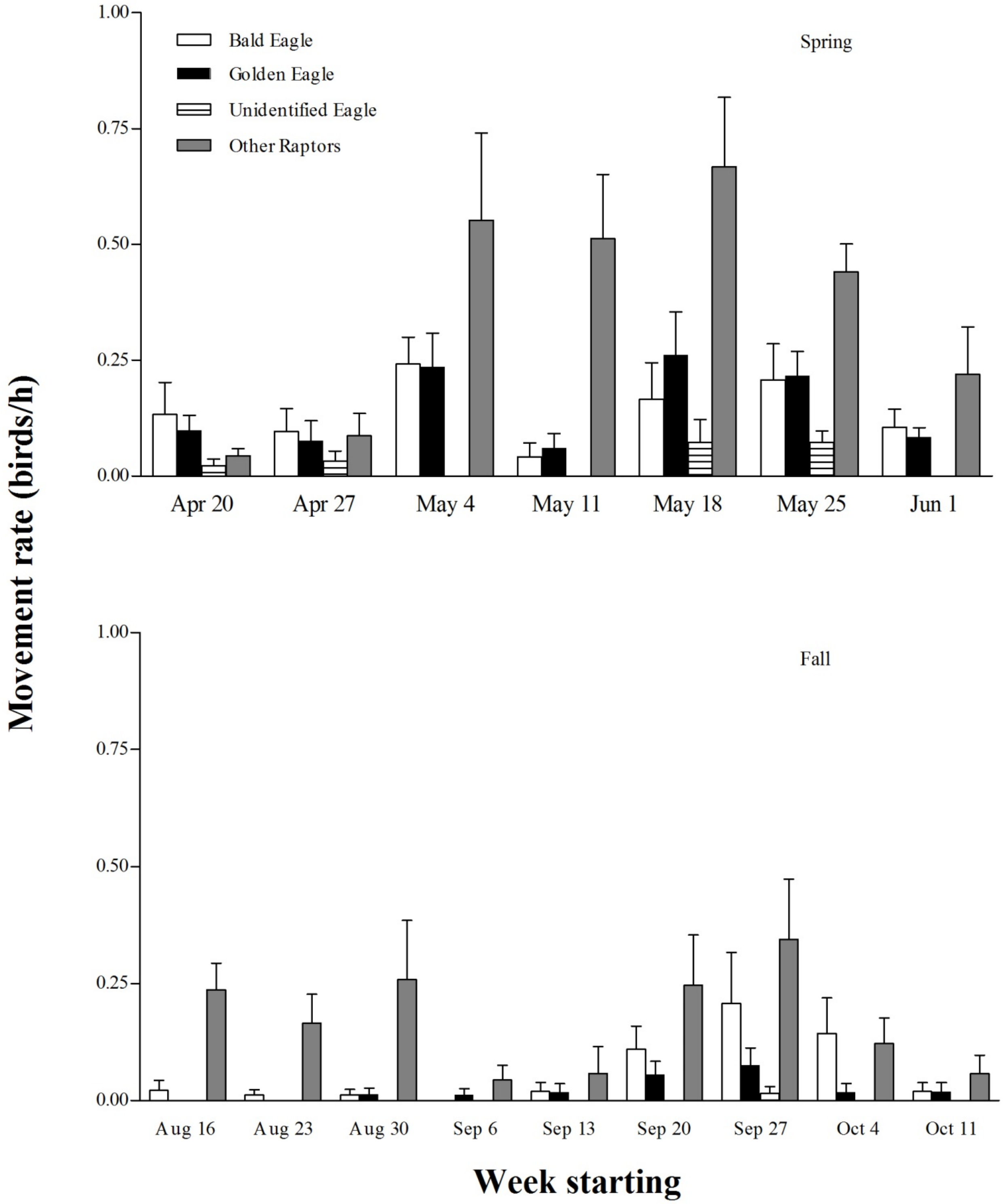

Figure 5.1-12. Mean Movement Rates (birds/h) of Raptors by Week of the Spring and Fall Migration Survey Seasons.

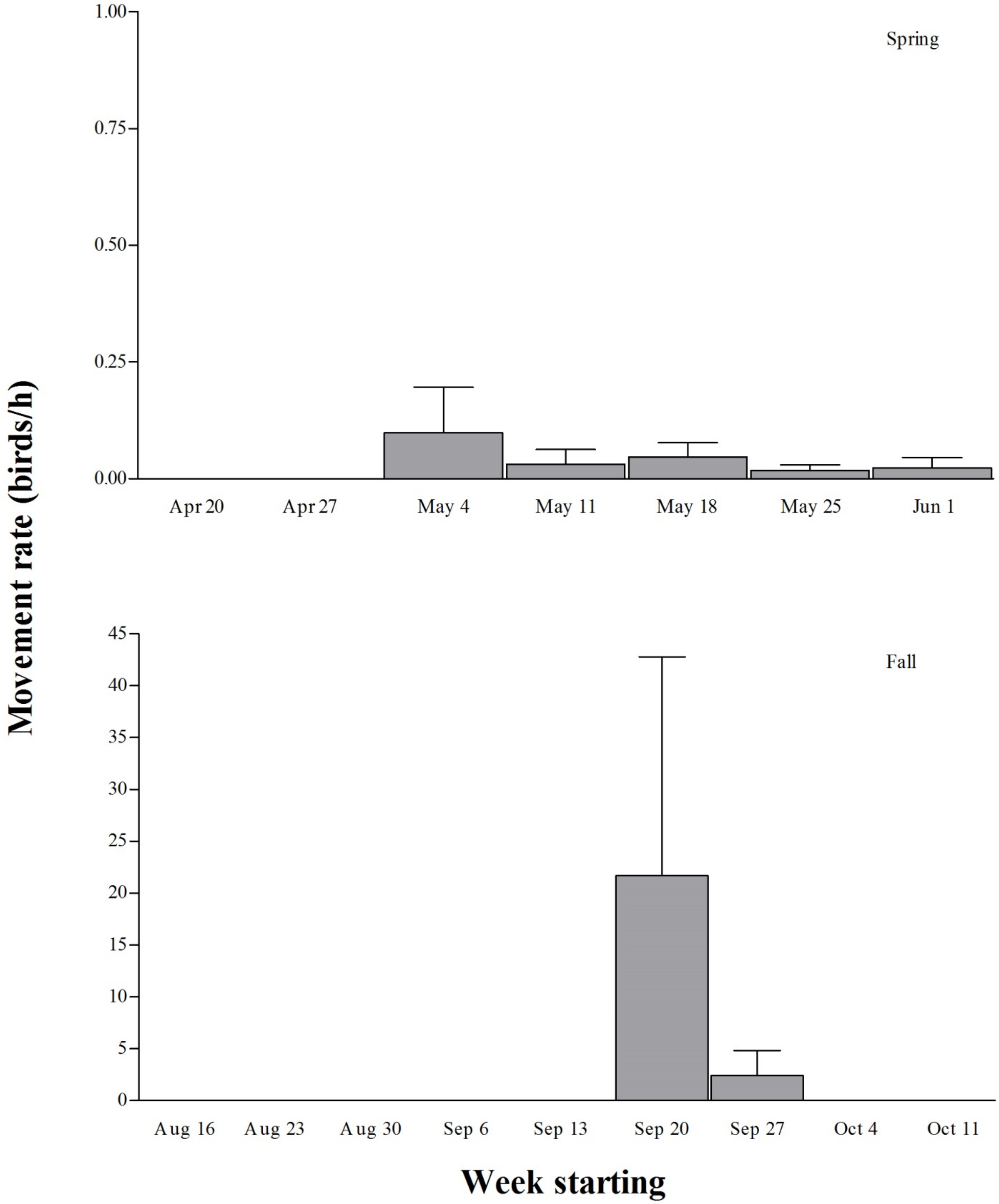

Figure 5.1-13. Mean Movement Rates (birds/h) of Sandhill Cranes by Week of the Spring and Fall Migration Survey Seasons.

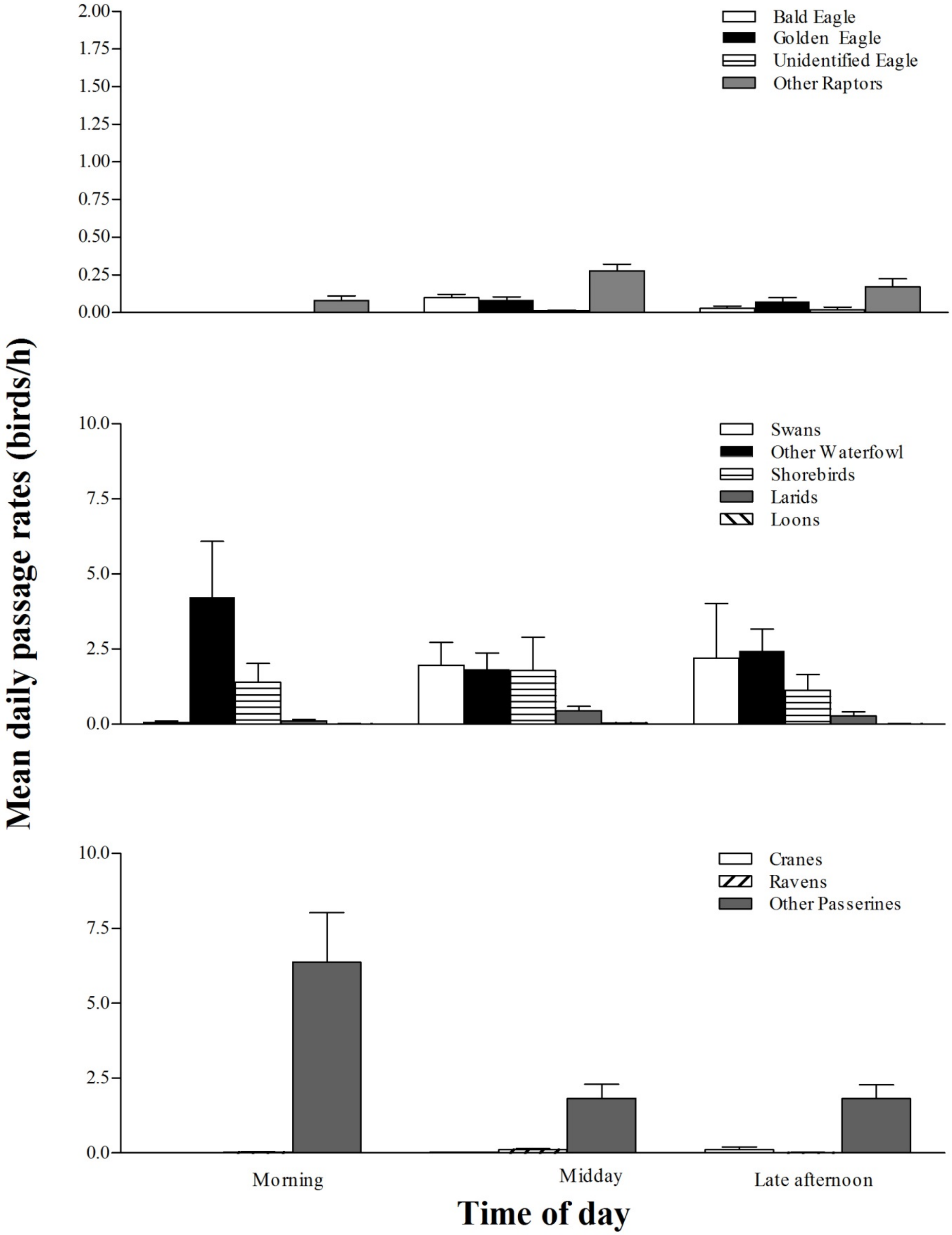

Figure 5.1-14. Mean Movement Rates (birds/h) of Bird Groups by Time of Day during Spring Migration Survey Season.

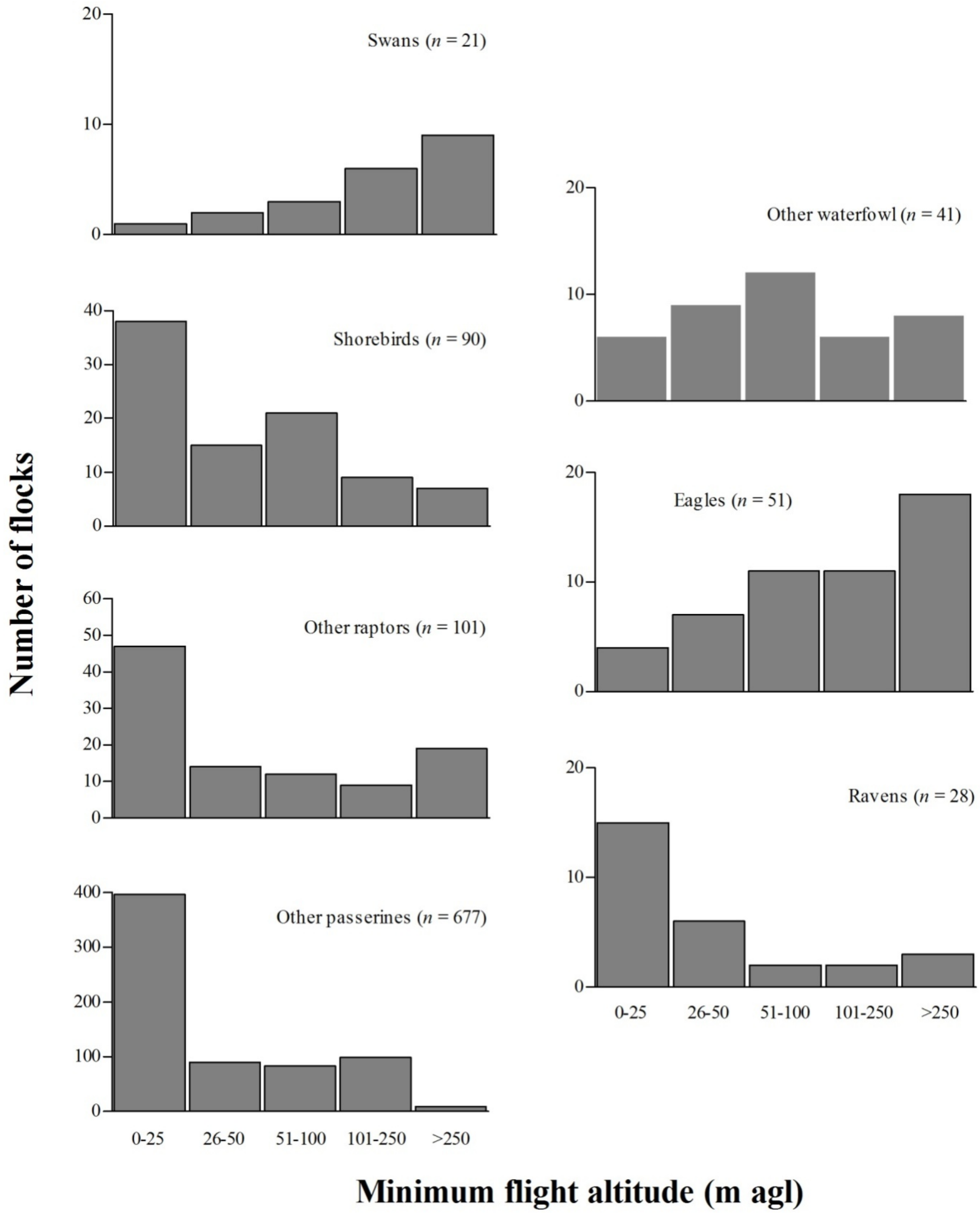

Figure 5.1-15. Flight Altitude Categories for Species Groups Observed during Diurnal Visual Surveys in Spring.

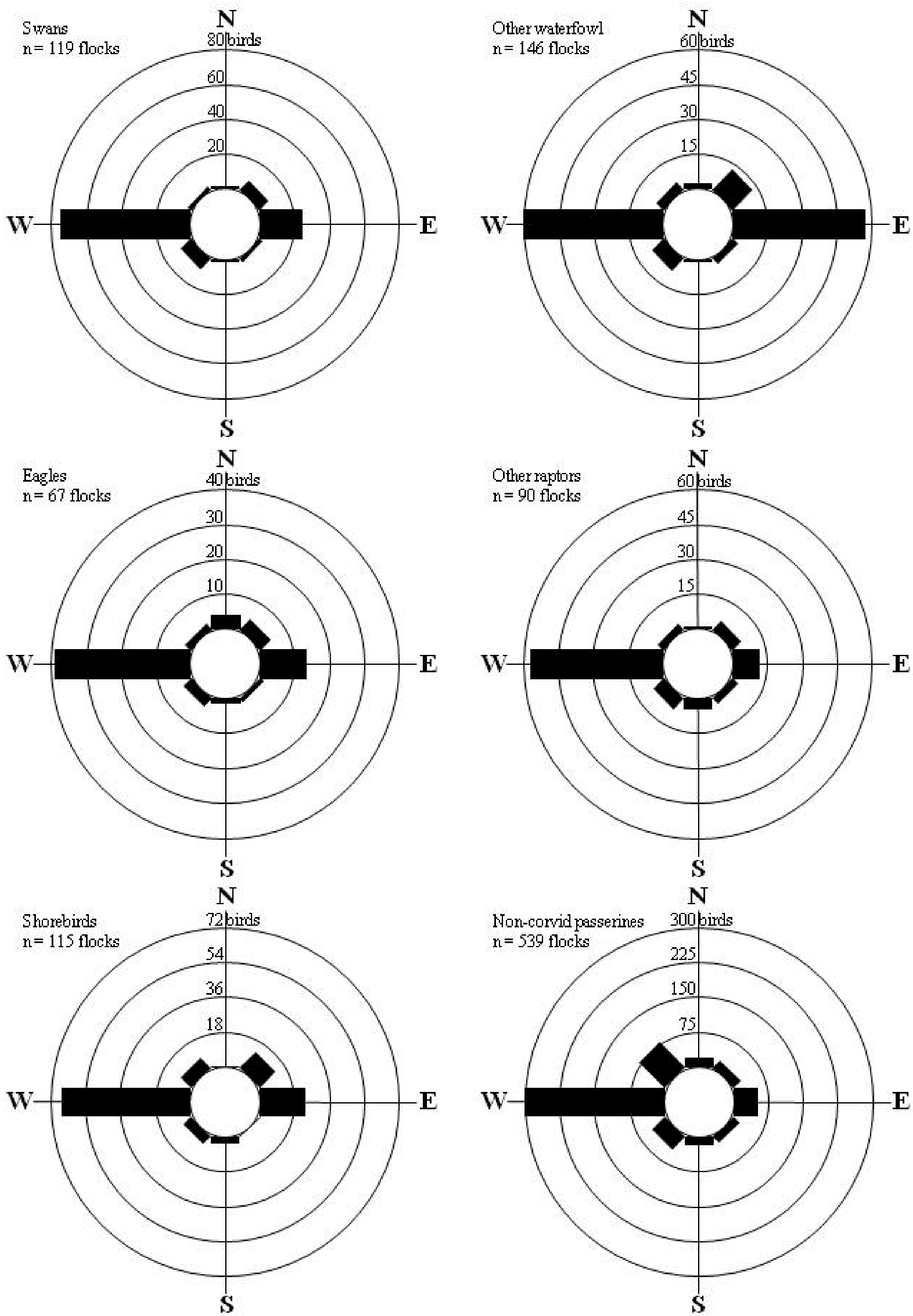

Figure 5.1-16. Ordinal Flight Directions of Bird Flocks Observed during Spring Diurnal Visual Surveys.

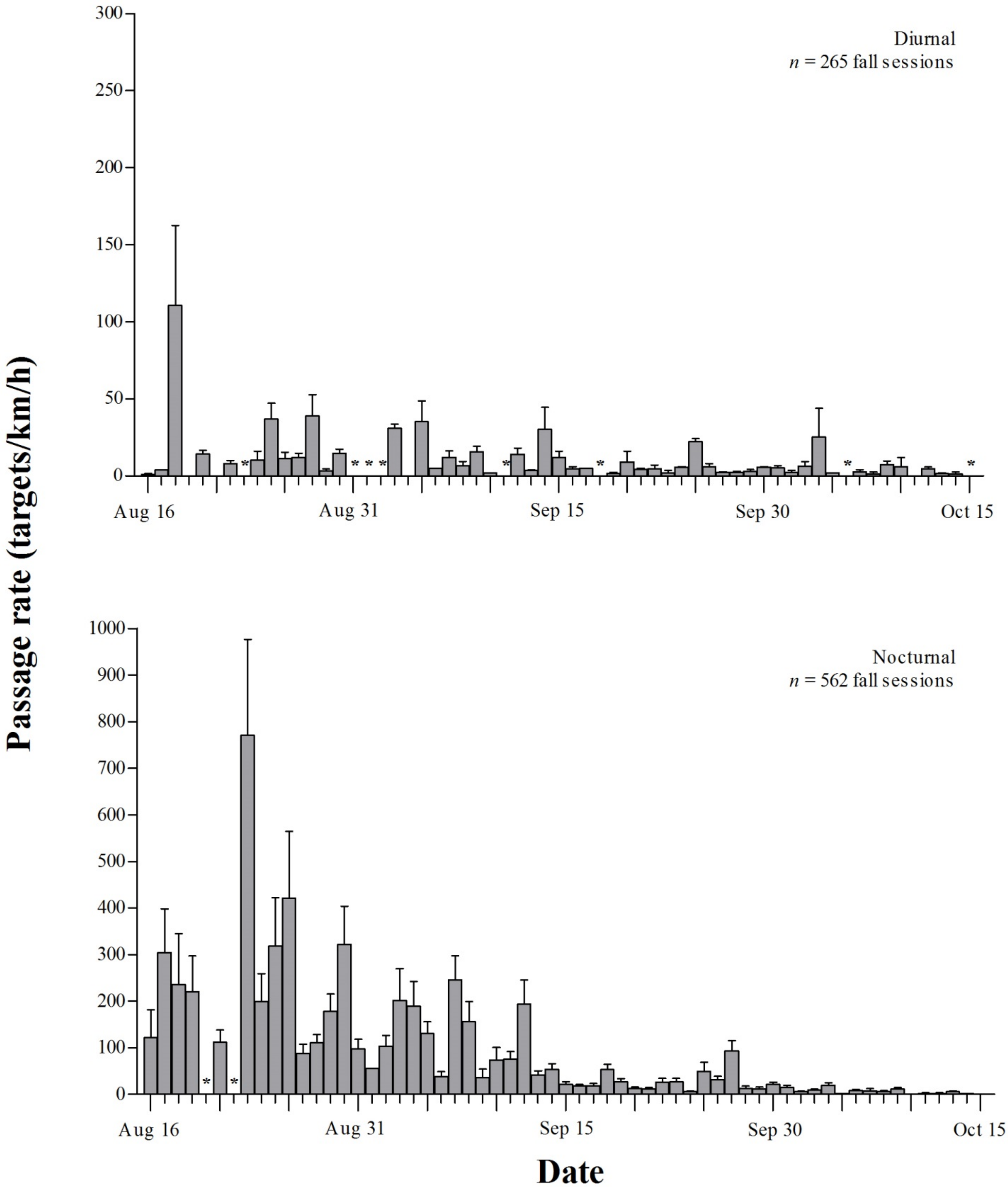

Figure 5.1-17. Fall Diurnal and Nocturnal Passage Rates (targets/km/h) by Date for Targets Detected within the 1.5-km Radar Range. Asterisks indicate that no radar sampling occurred due to weather.

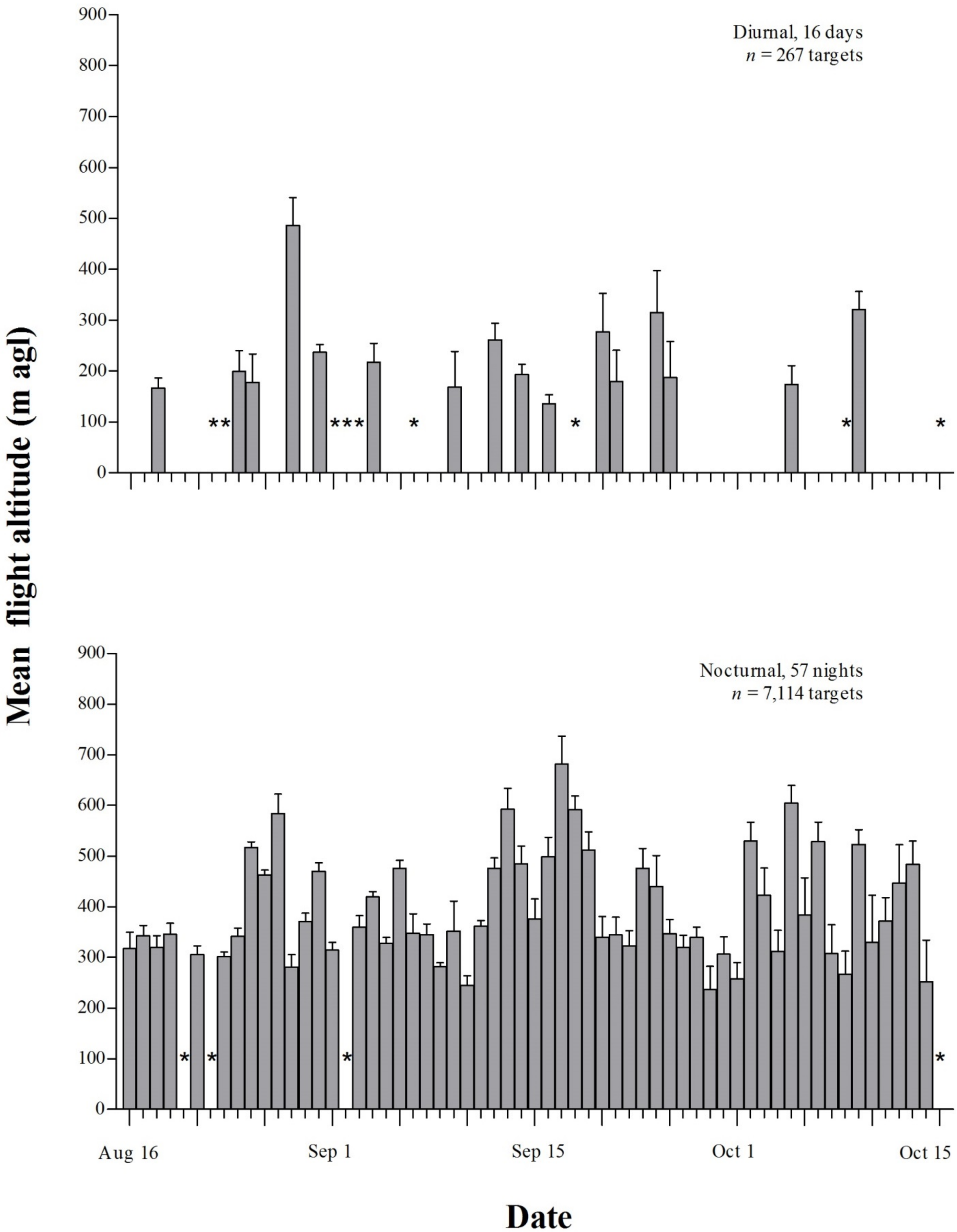

Figure 5.1-18. Mean Diurnal and Nocturnal Flight Altitudes (m agl) of Targets during Spring Migration, by Date for Targets Detected within the 1.5-km Radar Range. Asterisks (*) indicate that no radar sampling occurred (due to weather), and blanks indicate dates with sample sizes too small (<5 targets) to calculate meaningful values.

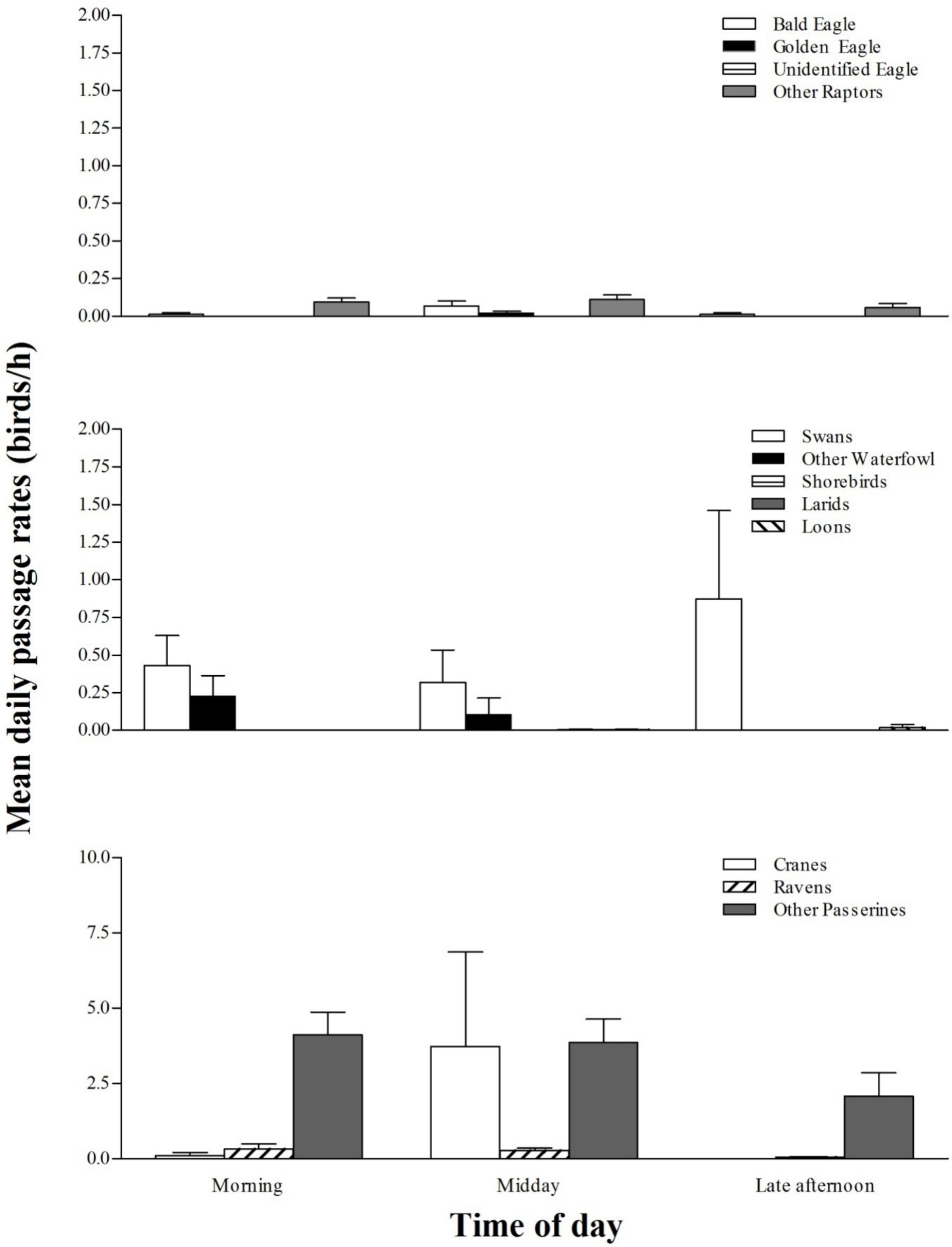

Figure 5.1-19. Mean Movement Rates (birds/h) of Bird Groups by Time of Day during Fall Migration Survey Season.

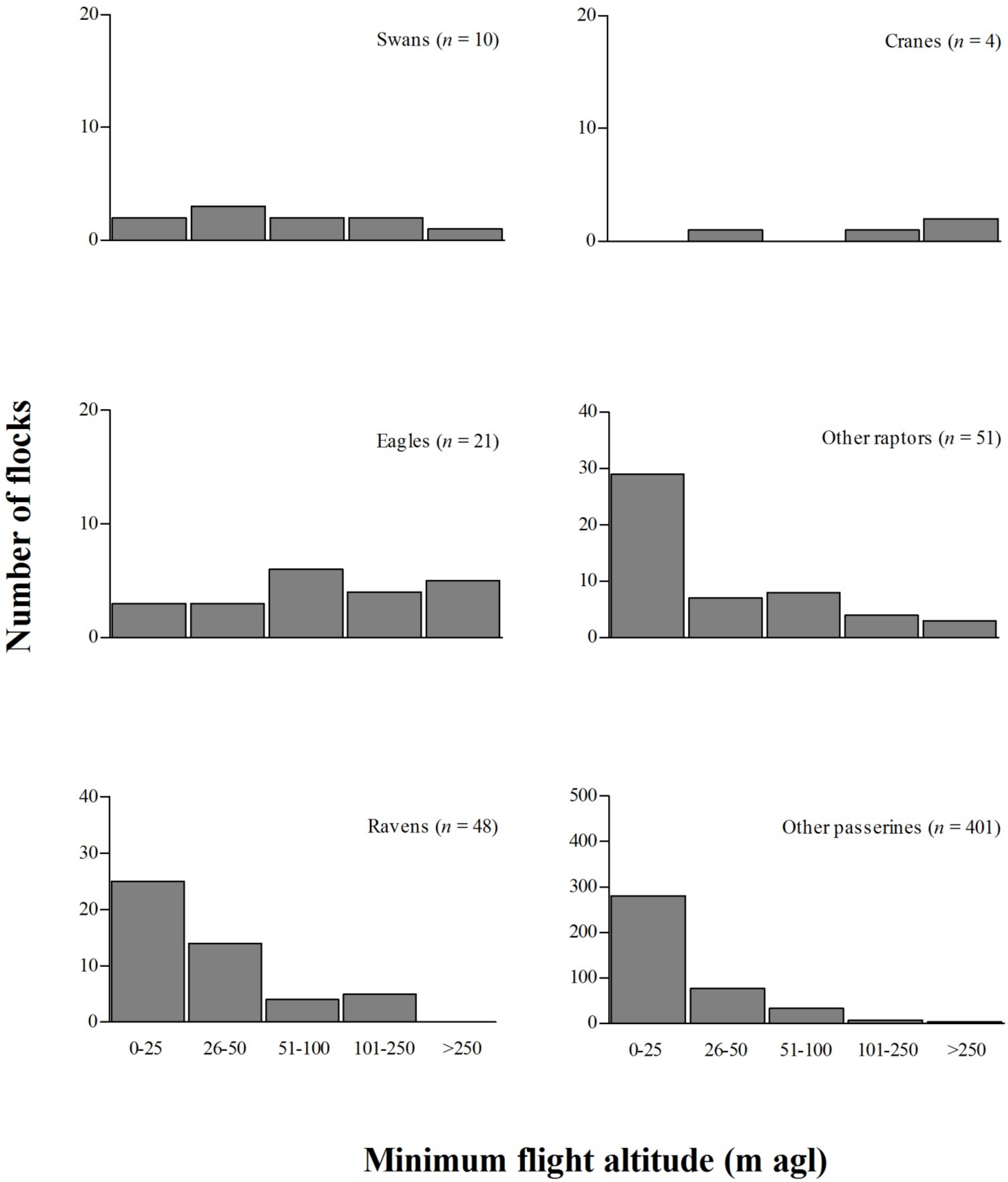

Figure 5.1-20. Flight Altitude Categories for Species Groups Observed during Diurnal Visual Surveys in Fall.

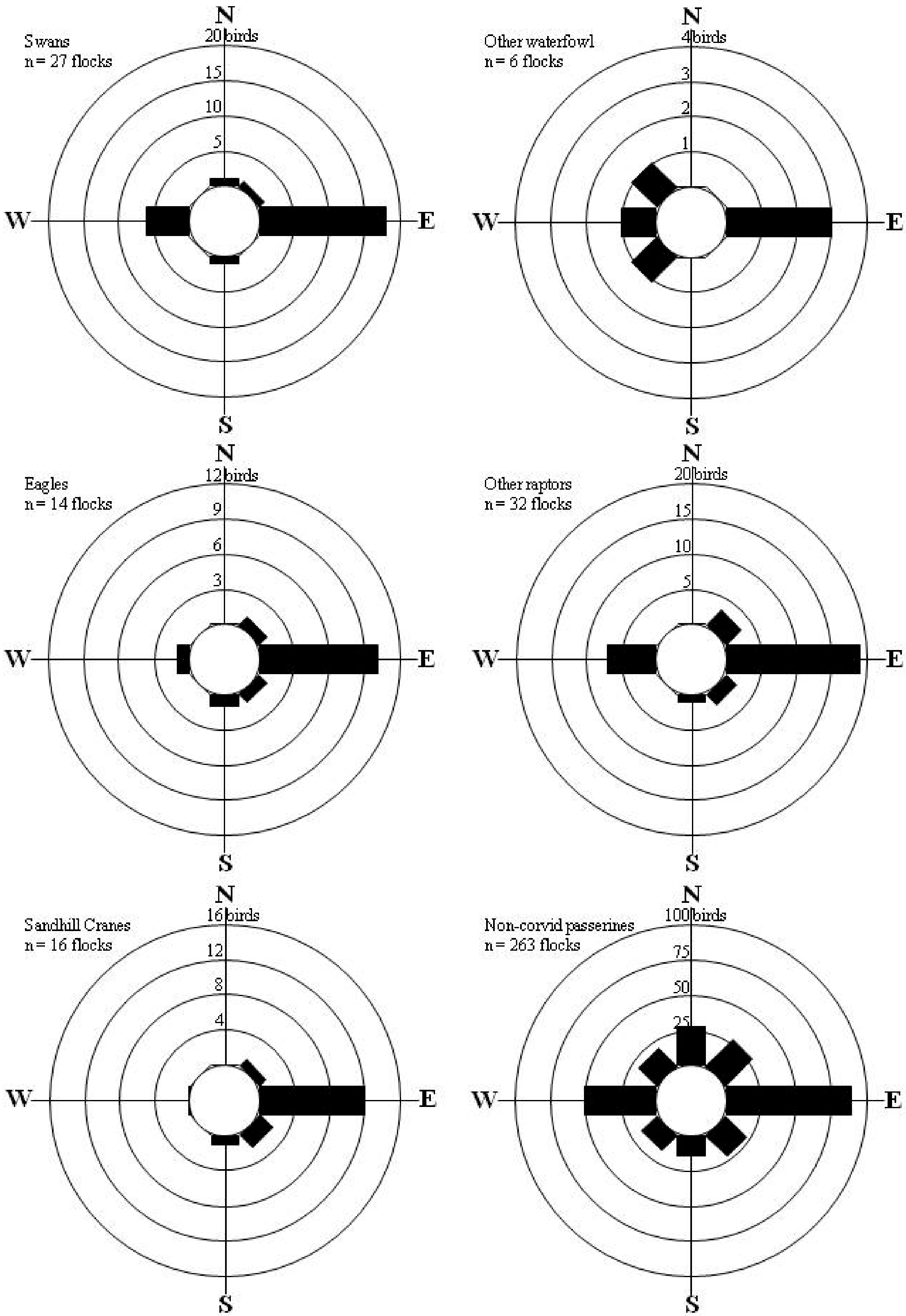

Figure 5.1-21. Ordinal Flight Directions of Bird Flocks Observed during Fall Diurnal Visual Surveys.

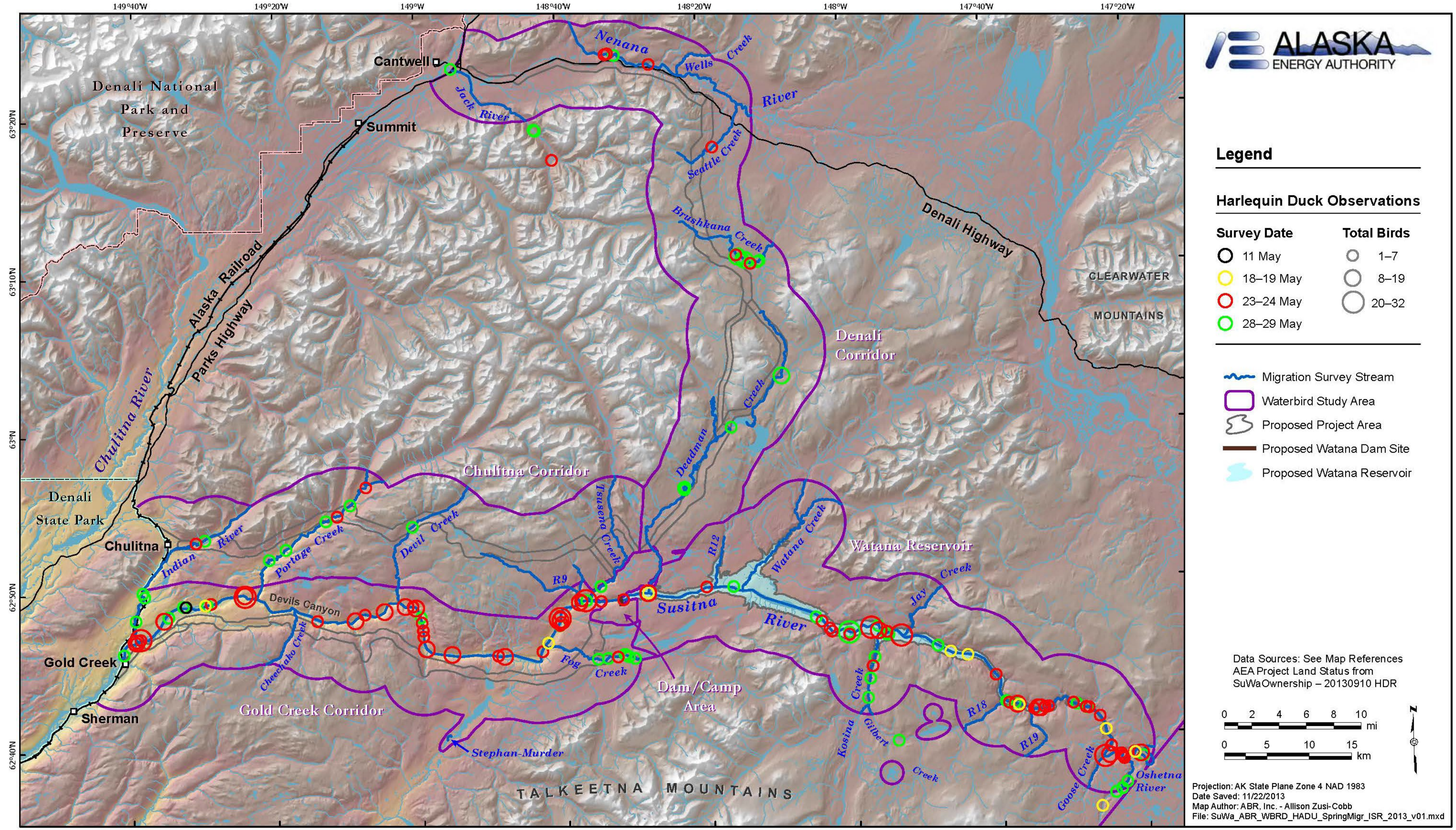

Figure 5.2-1. Locations of Harlequin Ducks Observed during Spring Migration Surveys, 2013.

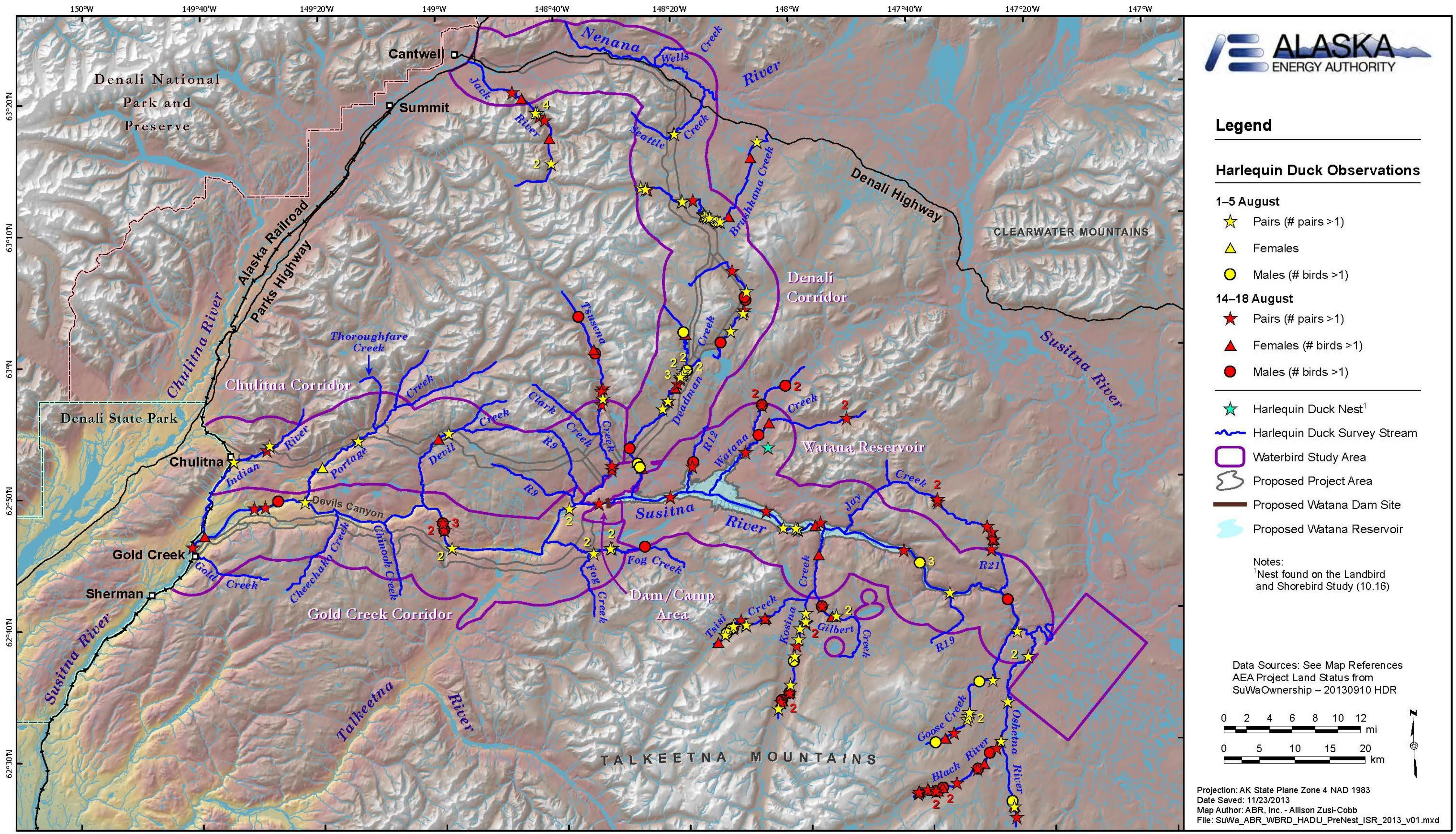

Figure 5.2-2. Locations of Harlequin Duck Observed during Pre-nesting Surveys, 2013.

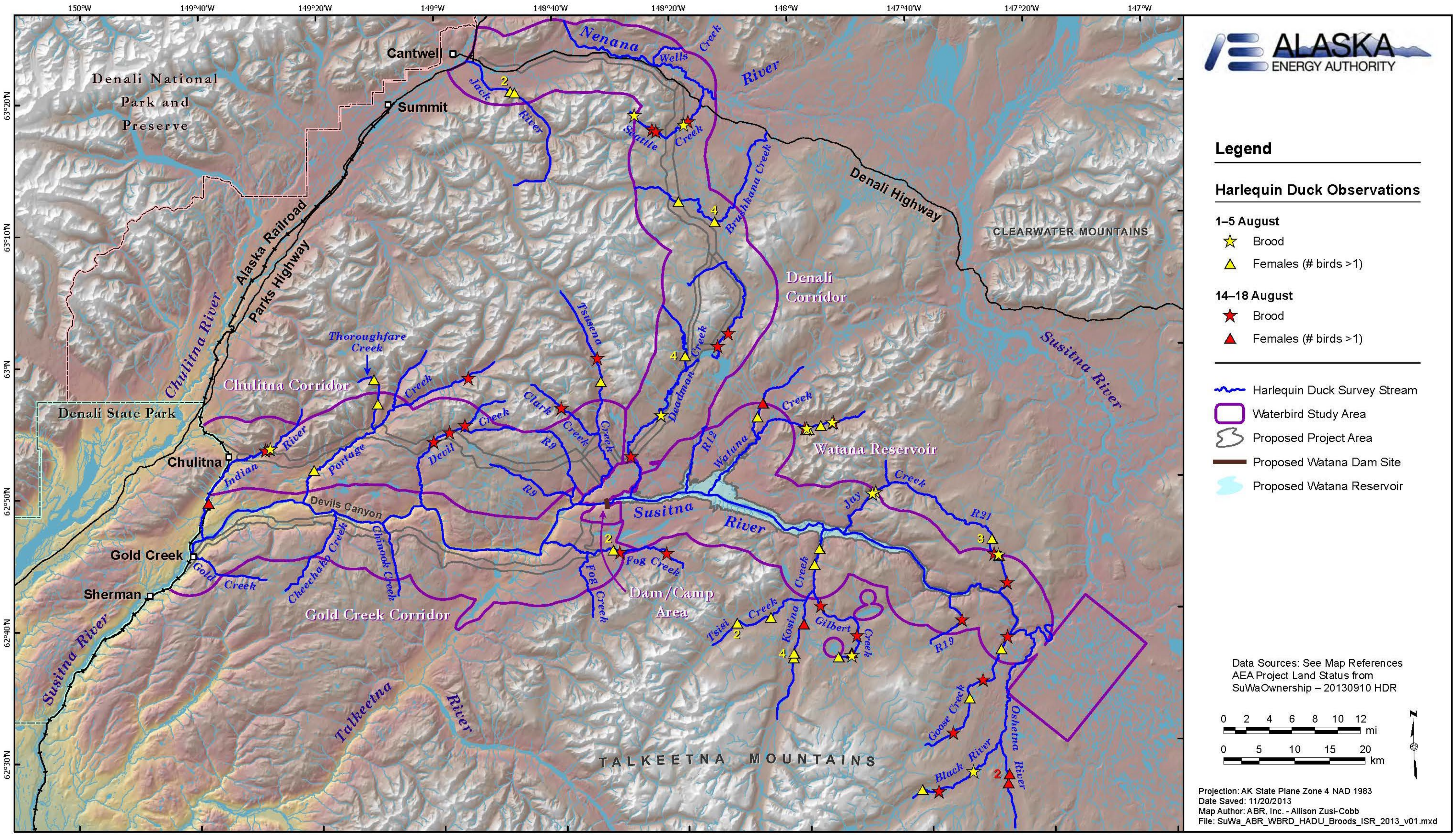

Figure 5.2-3. Locations of Harlequin Duck Observed during Brood-rearing Surveys, 2013.

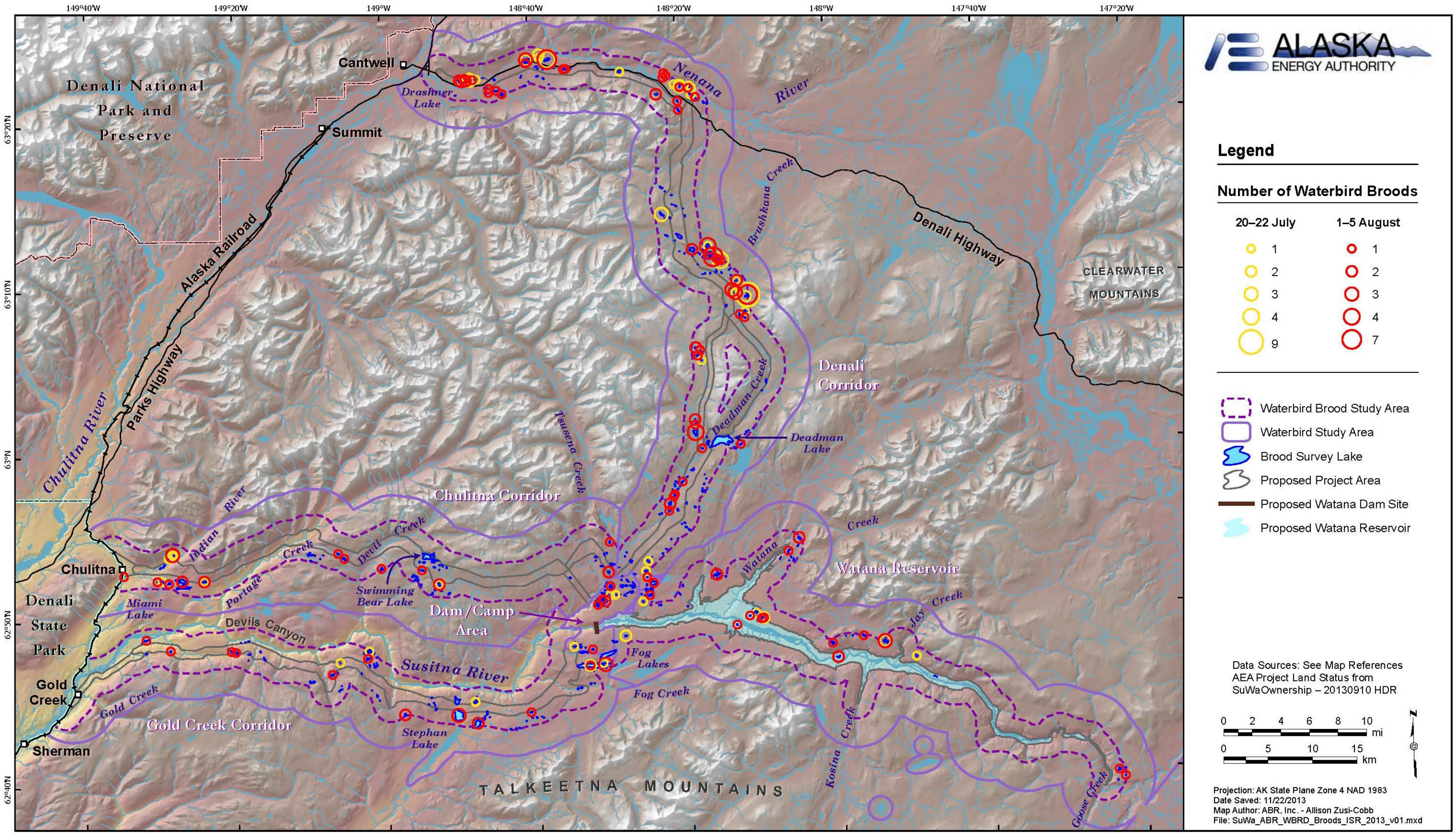

Figure 5.2-4. Locations and Numbers of Waterbird Broods Observed during Brood-rearing Surveys, 2013.