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Susitna–Watana Hydroelectric Project
(FERC No. 14241)

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

Study Completion Report

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

ABR, Inc.—Environmental Research & Services

Fairbanks and Anchorage, Alaska, and Forest Grove, Oregon

October 2015

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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
SCR	Study Completion Report
SE	standard error
SPD	Study Plan Determination
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
V	volts

1. INTRODUCTION

The work described herein for the Waterbird Migration, Breeding, and Habitat Use Study (Waterbird Study, for short) was conducted according to Section 10.15 of the Revised Study Plan (RSP) approved by the Federal Energy Regulatory Commission (FERC or Commission) for the Susitna–Watana Hydroelectric Project, FERC Project No. 14241. The Waterbird Study focused 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.

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

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

- A second year of aerial surveys for waterbirds was conducted in 2014 during the spring and fall migration periods, along with breeding waterfowl population surveys, stream surveys for Harlequin Ducks, and brood-rearing surveys.
- On October 21, 2014, AEA held an ISR meeting for the Waterbird Study and the other studies in the wildlife program.

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

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 was 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 had 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 review of food habits and diets of piscivorous waterbirds was completed in 2013 and reported in the ISR Part A Section 5.3 (ABR 2014a). AEA has removed objectives and methods related to mercury analysis of piscivorous waterbirds (RSP Sections 10.15.1 and 10.15.4.3) and consolidated this work under the Mercury Assessment and Potential for Bioaccumulation Study (Study 5.7), including the objective to obtain tissue samples for laboratory analysis of mercury levels of piscivorous waterbirds (e.g., loons, grebes, mergansers, terns) for laboratory analysis of mercury levels.

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 reservoir inundation zone, the dam site and camp facilities area, and the alignments of the various 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 were not included in the study area because they are located well upstream from the area that may be affected by the Project.

As explained in Section 1.4 of the ISR Overview filed June 2014, AEA decided to pursue the study of an additional alternative north/south-oriented corridor alignment for transmission and access from the Denali Highway to the proposed dam site. Referred to the “Denali East Option,” this area and corresponding buffers were added to the Waterbird Study area in May 2014 (Figure 3-1). The Denali Corridor surveyed in 2013 and reported on in the ISR and in 2013 figures and tables in this report is essentially equivalent to the Denali West Corridor surveyed in 2014.

In addition, Section 1.4 of the ISR Overview noted that AEA was considering the possibility of eliminating the Chulitna Corridor from further study, so no surveys were conducted in that corridor in 2014 for the Waterbird Study. On September 17, 2014, AEA filed with FERC a formal proposal to implement this change. Thus, this report reflects a change in the study area to no longer include the Chulitna Corridor (Figure 3-1). Removal of the Chulitna Corridor resulted in minor changes to the 2014 study area buffer around the Gold Creek Corridor. Although the Chulitna Corridor was dropped from further study in 2014, lakes within the Chulitna Corridor that were surveyed for the APA Project in the 1980s were surveyed again in 2014 and those data are included herein for comparative purposes.

4. METHODS AND VARIANCES

The methods of data collection and analysis described in RSP Section 10.15.4 were followed during the spring, summer, and fall field surveys both years, although some variances from the methods proposed in the Study Plan occurred 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

In both 2013 and 2014, AEA implemented the methods described in the Study Plan, with the exception of the 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 some spring surveys included river and stream courses when they occurred prior to breakup of most water bodies. 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. Lake groups were identified by reviewing U.S. Geological Survey (USGS) 1:63,360-scale topographic maps and high-resolution aerial or satellite imagery. A route covering all water bodies in a lake group was flown on each migration survey using visual and Global Positioning System (GPS) navigation. The specific flight path varied from survey to survey to adjust for varying wind and light conditions, to aid in identifying and enumerating observed waterbirds, and to avoid disturbing hunting activities or occupied cabins. 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 4.1-1–4.1-3 for 2013; Figures 4.1-4–4.1-6 for 2014). 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 approximately five-day intervals during the spring (late April to late May) and fall (mid-August to mid-October) migration periods (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. In 2013, 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 2013–2014 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 both 2013 and 2014 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. Additionally, because the timing of events such as nest initiation and fall freeze-up and bird departure could not be predicted with precision prior to the field season, the number of 5-day intervals appropriate for migration surveys also could not be predicted. The RSP stated that spring migration surveys would transition directly into breeding-pair surveys with no break in timing, and this procedure was followed in both 2013 and 2014. For these reasons, although fewer surveys were conducted than described in the RSP, the duration of each migration period was captured (except for the departure of some birds from the study area during late fall), peak movements of waterbird species were successfully documented, and study objectives were met both years.

4.1.2. Ground-based Surveys

Ground-based surveys were conducted in 2013, but not in 2014. In 2013, AEA implemented the methods described in the Study Plan, with the exception of the variances explained below (Section 4.1.2.1). The 2013 methods and variances described below were also reported in ISR Part A, Section 4.1.2.

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 4.1-7). 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

The Study Plan provided for the use of four visual observers during both diurnal and nocturnal sampling periods, rather than the single observer as was initially proposed in the RSP. During a meeting with USFWS on March 1, 2013, AEA provided additional information on the scope, objectives, limitations, and historical justification of the visual and radar methodologies, as well as contingencies for alternative methods to be used in case individual observers determined that conditions warranted modifications to increase sampling efficiency. Based upon this additional information, USFWS agreed that a single observer would be sufficient to meet study plan objectives (M. DeZeeuw, USFWS Acting CPA/Energy Coordinator, email communication, March 22, 2013; Appendix A). Based upon USFWS's concurrence, 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

In both 2013 and 2014, 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 4.1-8–4.1-10 for 2013; Figures 4.1-11–4.1-13 for 2014). 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 for transect surveys 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 were scheduled by evaluating the chronology of spring break-up and snow- and ice-melt, 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 breeding population surveys were flown each year, spaced up to 9 days apart (from the end of one survey to the start of the next; (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. For the transect survey, the study team followed standard protocols (USFWS and CWS 1987, Smith 1995) to convert raw survey counts to indicated total population indices, and then applied species-specific correction factors (when available) to the indices to derive population estimates of each species detected in the 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. This variance was implemented in both 2013 and 2014, and is also described in ISR Part A, Section 4.2.1.1 (ABR 2014a). 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

In both 2013 and 2014, AEA implemented the methods described in the Study Plan, with the exception of the 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 4.1-8–4.1-10 for 2013; Figures 4.1-11–4.1-13 for 2014). The extent of suitable nesting habitat was assessed initially during the last migration survey before the first Harlequin Duck pre-nesting survey in 2013 and was continually reassessed on each Harlequin Duck survey that year. Habitats were not re-assessed in 2014, instead suitable habitats identified in 2013 were surveyed during all Harlequin Duck pre-nesting and brood-rearing survey in 2014, in addition to stretches of Brushkana and Monahan creeks in the newly added Denali East Corridor. River R18, which had no Harlequin Ducks during pre-nesting surveys in 2013 and was not surveyed for broods that year due to lack of water, was not surveyed in 2014. Rivers and streams that flowed through the 2013 Chulitna Corridor were surveyed to the same extent in 2014, and data from those waterways were assigned in 2014 to the 2014 survey area that the river flowed into (usually the Gold Creek Corridor).

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 each year, with 9–11 days intervening between each pair of surveys (Table 4.1-1). The survey timing was adjusted to the environmental conditions and breeding phenology observed each year.

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 in 2013 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, but linear densities were calculated in 2014. Because the surveys flown in 2013 and 2014 extended beyond the outer boundary of the study area by a distance equal to the reported linear home range of Harlequin Ducks (or exceeding the linear home range on some rivers due to the elimination of the Chulitna Corridor in 2014) the variance is consistent with study objectives.

4.2.3. Brood Surveys

In both 2013 and 2014, 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 4.1-1–4.1-3 for 2013; Figures 4.1-4–4.1-6 for 2014). The brood survey buffers were calculated somewhat differently between the two years. In 2013, the brood survey area was a 1-mile merged buffer around the 2,050-foot reservoir contour, and the 3 corridor alternatives and dam/construction camp polygon (source MWH Global: RSP_Corridors_10_26_12). In 2014, the survey area was a 1-mile merged buffer around the 2,050-foot reservoir contour and the roads and transmission lines (source MWH Global: Road_and_Transmission_CL_08182014). These differences in survey area construction resulted in slightly different survey areas in the two study years. 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. In 2013, 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. In 2014, a third brood survey was deemed necessary, and surveys were conducted on July 9–12, July 19–23, and August 1–6 (Table 4.1-1).

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 implemented during the 2013 and 2014 study seasons.

4.3. Information for Mercury Study

In 2013, AEA implemented the methods described in the Study Plan, with the exception of variances explained below (Section 4.3.1). Methods and variances from 2013 were also reported in ISR Part A, Section 4.3 (ABR 2014a). In 2014, the study plan modifications proposed in ISR Part C, Section 7.1.2 (ABR 2014b), were implemented; AEA removed the objectives and methods related to mercury analysis of piscivorous waterbirds (RSP Sections 10.15.1 and 10.15.4.3) and consolidated this work under the Mercury Assessment and Potential for Bioaccumulation Study (Study 5.7).

Prior to the 2013 field season, 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 in 2013, 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 in 2013 but, because it was located on Cook Inlet Regional Working Group (CIRWG) lands, it could not be visited that year.

4.3.1. Variances

In 2013, 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 in 2013 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 could be targeted for field collection of tissue samples, if warranted by the results of the pathways analysis for Study 5.7.

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.

Further discussion with USFWS in 2014 focused on 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 was discussed and evaluated, but tissue sampling of waterbirds was postponed further, pending the results of the pathways analysis for Study 5.7, and all mercury sampling was consolidated under that study.

5. RESULTS

Data developed in support of the Waterbirds Study are available for download in the following files at http://gis.suhydro.org/SIR/10-Wildlife/10.15-Waterbirds/.

See Table 5-1 for details.

5.1. Spring and Fall Migration

Forty species of waterbirds were observed during migration, breeding, and brood-rearing surveys in the waterbird study area in 2013–2014 (Table 5.1-1). Representatives from nine species or species-groups were recorded: geese (three species), swans (two species), ducks (23 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 are reported in Study 10.16 ISR (2013) and the Study Implementation Report (2014).

Twenty-nine species of waterbirds were confirmed as breeders in the study area in at least one study year, 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 in at least one study year and the area is within their breeding range. Nine species observed only during spring and/or fall in one or both years and which were not classified as possible or confirmed breeders in either year 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

2013 Surveys

Results from 2013 spring migration aerial surveys were also presented in ISR Part A, Section 5.1.1.1.1. 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 in the Chulitna Corridor 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 11, and 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 during spring 2013 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 5.1-4). 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.

2014 Surveys

During the first migration survey on April 23, lakes and ponds were nearly 100 percent frozen. Holes of open water and discontinuous open channels and surface melt were found in stretches along the Nenana River, Susitna River, and Watana, Portage, and Fog creeks. Indian River and the short stream connecting Stephan and Murder Lakes were open. Higher elevation waterways, such as Deadman and Brushkana creeks, remained frozen, with stretches of refrozen surface melt. The only open water found on water bodies were at the inlets or outlets of a few large lakes, most notably Stephan and Murder Lakes, where 11 Trumpeter Swans were found near the Stephan-Murder lake connector channel (Tables 5.1-5 and 5.1-6). The only other waterbird observed on April 29 was a Common Merganser on the Susitna River in the Gold Creek Corridor.

On April 29, most rivers and large creeks in the study area had at least some open water. The Nenana River had open channels along most of its length, and the Susitna River had discontinuous channels and open areas, mostly but not exclusively below the Watana Creek confluence. In open water sections of larger waterways such as Oshetna River and Portage and Devil creeks, water flowed fast and turbid. In contrast, high elevation creeks including Brushkana, Deadman, Wells, and Monahan creeks remained almost completely frozen. Most water bodies above about 3,000 feet were frozen (i.e., much of the Denali East and Denali West corridors and higher elevation regions in the Gold Creek Corridor and eastern Watana Reservoir Area) but open water was found in many lake groups throughout the rest of the study area, including the Denali West Corridor south of Deadman Lake and much of the Watana Reservoir, Gold Creek Corridor and Dam/Camp areas. At lower elevations, small and medium sized water bodies were typically 5–10 percent open, and flooded tundra was found around the edges of many frozen water bodies and adjacent to some streams.

The total number of waterbirds observed in the study area jumped from 12 on April 23 to 359 on April 29. Just over half of all birds observed on April 29 were found on the Susitna River in small groups of 1–20 birds, mostly Mallards and Northern Pintails, but including Green-winged Teal, Bufflehead, goldeneye, Common and Red-breasted Merganser, Mew Gull and Trumpeter Swan (Tables 5.1-5 and 5.1-6, Figure 5.1-2). Most (133 of 172) waterbirds found in water bodies were located in three lakes: Drashner Lake in the Denali West Corridor adjacent to the Nenana River, and Stephan and Murder Lakes in the Gold Creek Corridor (Figure 5.1-2.) As with birds found on rivers, most birds observed on water bodies were Mallards and Northern Pintails, but there were also small numbers of American Wigeon, Green-winged Teal, Barrow's Goldeneye, Long-tailed Duck, Mew Gull, Trumpeter Swan, and unidentified goldeneye (Tables 5.1-5 and 5.1-6).

On May 5–6, considerable ice cover persisted throughout the study area, but most rivers and streams were open. The Nenana River was wide open with scattered chunks of floating ice, and the Susitna River was open through large sections with ice shelves along the edges. Formerly frozen Brushkana Creek in the central Denali corridors was flowing rapidly with open sections interspersed with stretches of surface melt. Deadman Creek remained frozen beneath flowing surface melt. Flowing water in most rivers and streams was swift and turbid. Ice cover on lake groups was generally high, but at least some open water was present on water bodies in most areas except for the central Denali corridors and in the higher elevations of western Gold Creek and Chulitna Corridors. Large lakes remained >95% frozen, and some contained only surface melt (e.g., some of the larger Fog lakes, High and Big Lakes) but most had at least small patches of open water near inlet/outlet streams and in some cases narrow moats around the edges. Low elevation lake groups with shallow water bodies had as much as 50% open water, and many small ponds were completely open. Murder Lake was approximately 75% open with a wide channel running through the center.

The number of waterbirds observed during aerial surveys increased from 359 on April 29 to 1,055 on May 5–6. Most waterbirds (85%) occupied water bodies rather than rivers or streams on May 5–6 (Table 5.1-5). By early May, waterbirds had dispersed onto many water bodies throughout the study area. Within the study area, the highest numbers of waterbirds were found in the Denali West Corridor, followed by the Watana Reservoir Survey Area (Table 5.1-7). The most abundant species was American Wigeon, followed closely by Green-winged Teal and Northern Pintail. Ten waterbird species made their first appearance during the May 5–6 survey, including Canada Goose, Northern Shoveler, Canvasback, Ring-necked Duck, scaup, Harlequin Duck, Surf Scoter, Horned Grebe, Bonaparte's Gull, and Herring Gull (Table 5.1-6).

On May 11–12, large, deep lakes remained about 90–98 percent ice-covered with open water found mainly at inlet and outlet areas and in narrow moats around the edges. Ice cover on all water bodies had thinned noticeably since the previous survey. Ice continued to be present on water bodies throughout the study area, but abundant open water was available to water birds in most lake groups except those at the highest elevations. In the 6 days since the May 5–6 survey, the total number of waterbirds approximately doubled, to 2,128, nearly all of which were found on water bodies rather than rivers or streams (Table 5.1-5). The most abundant species was Green-winged Teal, followed by American Wigeon and Northern Pintail. Within the study area, the highest numbers of waterbirds were found in the Denali West Corridor (937 birds), followed by the Watana Reservoir Survey Area (742 birds; Table 5.1-7). Newly arrived species included Greater White-fronted Goose, Snow Goose, Red-throated Loon, Common Loon, Red-necked Grebe, and Arctic Tern (Table 5.1-6).

On May 17–18, ice cover on large, deep lakes exceeded 80 percent in most of the study area, and continued to approach 95 percent at high elevations in the Denali West corridor and in deep water bodies in the Chulitna corridor. However, nearly all water bodies had open water. Substantial ice persisted in the central portion of the Denali West corridor, but open water was available, particularly on shallow ponds and water bodies connected to streams with moving water. Small and medium sized water bodies were completely thawed at lower elevations. Nearly all of the 2,422 birds observed during the May 17–18 survey occupied water bodies rather than rivers or streams, and the total observed was only slightly higher than the total on May 11–12. Relatively high numbers were again recorded on Stephan and Pistol lakes, and numbers increased from the previous survey on some other waterbodies, including some Fog lakes and Brushkana Lake. No waterbirds were observed on Murder Lake, and numbers on unnamed waterbodies throughout the study area were similar to those on May 11–12 (Table 5.1-5), suggesting that early nesting birds may have dispersed into possible nesting areas by the middle of May. Scaup were by far the most abundant species, followed by Northern Pintail and American Wigeon (Table 5.1-6). Among survey areas, the highest numbers of waterbirds occurred in the Watana Reservoir survey area (945 birds), followed closely by the Denali West survey area (874 birds; Table 5.1-7). Species observed for the first time on May 17–18 included White-winged Scoter, Black Scoter, Pacific Loon, and a pair of Gadwall (observed only once during 2014). The modest increase in waterbird numbers compared to the previous survey, coupled with the appearance of grouped male dabbling ducks at some locations during May 17–18, prompted the start of breeding pair surveys in late May, more than a week earlier than in 2013.

5.1.1.1.2. Taxonomic Patterns

2013 Surveys

Results from 2013 spring migration aerial surveys were also presented in ISR Part A, Section 5.1.1.1.2. 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 A). During late April, swans were 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 A). 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 A). 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 A). 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 A). 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 A). 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 A). 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 A). 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.

2014 Surveys

Trumpeter Swans were among the first species to arrive in the study area during spring 2014. Five pairs occupied small patches of open water in Murder and Stephan lakes during the first survey on April 23, near the stream connecting the two lakes. Total numbers grew over the next 2 surveys and then remained relatively stable (51–59 birds) throughout May. During May, over half of all Trumpeter Swans were found in the Denali West corridor (Table 5.1-7), and many of those occurred in discrete pairs in water bodies adjacent to the Nenana River. Single pairs were observed during multiple surveys on Pistol Lake, one of the Fog lakes, lake group 42 (NE of Stephan Lake), and on a section of Deadman Creek. The largest group (10 swans) was found on Drashner Lake on May 5. Small groups of 3–5 swans were found during spring at various sites, including Murder, Stephan, and Deadman lakes, Deadman Creek, 2 ponds adjacent to the Nenana River in the Denali West corridor, and a pond near Goose Creek in the Watana Reservoir survey area.

Three species of geese were recorded in small numbers in the study area during spring, with all observations occurring in the Denali West corridor, either on the Nenana River or on lakes adjacent to the river (Table 5.1-7, Appendix B). The first observations (totaling 4 Canada Geese) occurred on May 5. All other observations occurred on May 11 and included totals of 7 Canada Geese, 4 Greater White-fronted Geese, and 1 Snow Goose.

Ducks were the most abundant waterbird species-group in the study area and were represented by 23 species (Tables 5.1-1 and 5.1-7; Appendix B). Several species arrived during April, including American Wigeon, Mallard, Northern Pintail, Green-winged Teal, Long-tailed Duck, Bufflehead, goldeneyes, Common Merganser, and Red-breasted Merganser (Table 5.1-6). Six more species, including Northern Shoveler, Canvasback, Ring-necked Duck, scaup, Harlequin Duck, and Surf Scoter, were first seen on the May 5–6 survey. White-winged and Black scoters were not observed in the study area until the last spring migration survey on May 17–18. A single pair of Gadwall was recorded during 2014, on the May 17–18 survey. A male Eurasian Wigeon and a male Blue-winged Teal were observed only during the second breeding season in early June. Although a single Red-breasted Merganser was observed on April 29, the species was not seen again until May 11–12. Similarly, Long-tailed Ducks were first seen in the study area on April 29, but they were not seen again until May 11–12, and were present in very low numbers until May 17–18 (Table 5.1-6).

Most ducks in the study area were found in the Gold Creek Corridor survey area in April because of the occurrence of open water on the lower Susitna River and on Stephan and Murder Lakes (Table 5.1-5, Appendix B). Ducks were also found during this time on the Susitna River in the Watana Reservoir survey area and on Drashner Lake in the Denali West corridor survey area. Duck numbers increased modestly throughout spring in the Gold Creek corridor, from 157 birds on April 29 to 334 birds on May 17–18. Numbers increased more sharply in the Denali West survey area as water bodies thawed at lower elevations along the Nenana River, and eventually at streams and shallow water bodies at higher elevations. Numbers also increased rapidly during spring in the Watana Reservoir survey area, as birds moved into open water on Pistol, Fog, Clarence and Molar lakes, as well as smaller unnamed water bodies throughout the area (Table 5.1-5). The Denali West survey area contained the highest number of ducks during the May 5–6 and May 11–12 surveys, followed by the Watana Reservoir survey area. During the last spring survey on May 17–18, the Watana Reservoir survey area contained the most ducks, followed closely by the Denali West survey area (Table 5.1-7).

Maximal numbers of ducks were recorded during the last spring survey on May 17–18 (2,259 ducks), with the greatest increases occurring between April 29 (335 ducks) and May 11–12 (1,991 ducks; Table 5.1-7). Mallards and Northern Pintails arrived in large numbers in early April and remained relatively stable throughout the spring. Most dabblers that occurred in large numbers, including American Wigeon, Mallard, Northern Pintail, and Green-winged Teal reached maximal numbers on May 11–12. Northern Shovelers and most diving ducks, including scaup, Ring-necked Duck, scoters, Long-tailed Duck, and mergansers, reached maximal numbers during the last spring survey on May 17–18 (Table 5.1-6). As measured by the highest numbers counted on any one survey, the most abundant duck was scaup (599 birds on May 17–18), followed by Green-winged Teal (450 birds on May 11–12), and Northern Pintail (328 birds on May 11–12).

Red-throated and Common loons were observed in the study area on May 11–12, and Pacific Loons were first seen on May 17–18 (Table 5.1-6). A total of 7 loons were observed in the study area on May 11–12 and 32 loons were observed on May 17–18 (Table 5.1-7). Loons were observed in all survey areas except Denali East, and on May 17–18 they were evenly divided among 3 survey areas: Watana Reservoir (9 loons), Gold Creek corridor (9 loons) and Denali West corridor (8 loons). On that survey, 7 of 12 Red-throated Loons were recorded in the Denali West corridor, 12 of 15 Common Loons were recorded in either the Gold Creek corridor (7 loons) or Watana Reservoir survey area (5 loons), and 4 of 5 Pacific Loons were recorded in the Dam/Camp area (Appendix B). The number of Red-throated Loons in surveyed lake groups decreased between the last spring migration survey on May 17–18 and the first breeding survey on May 24–28, but numbers of both Pacific and Common loons increased. Relatively shallow water bodies used for breeding by Red-throated Loons were likely thawed by the middle of May, whereas many deep water bodies potentially used by Pacific and Common loons still had substantial ice cover.

Horned Grebes arrived in the study area by May 5–6 and Red-necked Grebes by May 11–12 (Table 5.1-6). Twenty-five Horned Grebes were observed on 5–6 May, including 2 groups of 12 grebes each staging on water bodies near the Nenana River in the Denali West corridor (Drashner Lake and an unnamed water body). Ten Horned Grebes were observed on 11–12 May, and 24 were observed on 17–18 May. Most Horned Grebes recorded on 17–18 May were found in discrete pairs, and over half were located in the Watana Reservoir survey area (Appendix B). Two Red-necked Grebes were observed on 11–12 May, and 16 on 17–18 May. Pairs or small groups of Red-necked Grebes were observed on Stephan Lake, Brushkana Lake, and one of the Fog lakes, and they were found in every survey area except the Denali West corridor.

Three species of gulls were recorded in the study area during spring 2014 (Table 5.1-1). Four Mew Gulls were sighted on April 29, and peak numbers occurred on May 5–6 (45 birds; Table 5.1-6). Small numbers of Bonaparte's Gulls were seen on surveys on May 5–6, 11–12, and 17–18; and 2 Herring Gulls were observed on each of the first two migration surveys in May. Two Arctic Terns were seen on each of the last 2 migration surveys, but higher numbers (up to a total of 12 terns) were observed during breeding surveys in late May and early June. All four species breed in small numbers in the study area, but Herring Gulls were classified as migrants in 2014 because none were seen after 11–12 May. The highest number of gulls recorded during a spring migration survey occurred on May 5–6, when 57 gulls were recorded (Table 5.1-7). Thirty-three (58%) of gulls observed during that survey occurred on the Gold Creek corridor, and all of those were found on Murder Lake, Stephan Lake, or lower Susitna River. No gulls or terns were observed in the Dam/Camp area or on any of the few lakes surveyed in the Chulitna corridor in 2014.

5.1.1.2. Fall Migration

5.1.1.2.1. Temporal and Spatial Patterns

2013 Surveys

Results from 2013 fall migration aerial surveys were also presented in ISR Part A, Section 5.1.1.2.1. 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 5.1-3). 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 5.1-3, 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).

2014 Surveys

Maximal numbers of waterbirds were recorded during the first fall migration survey, August 24–26 (2,640 birds; Table 5.1-7). Numbers varied thereafter between about 2,200 and 2,600 birds with no apparent trends until the fourth week of September, when totals dropped to about 1,300–1,400 birds. Numbers again remained steady until the first week of October when totals dropped to just under 900 birds. Just over 500 birds were observed during the last fall migration survey on 17–18 October. As in 2013, broods from most species groups were observed during migration surveys in August and early September, and small groups of birds and individuals were located on water bodies of various sizes throughout the study area.

As in 2013, Stephan and Murder lakes were heavily used during fall migration, although use of Murder Lake was low during some surveys (Figure 5.1-4). Also heavily used in 2014 were the series of shallow unnamed water bodies connected to Brushkana Creek in the Denali West corridor survey area (Figure 5.1-4, Table 5.1-5). Other water bodies that supported high numbers of waterbirds at some point during the fall included 2 lakes in the Fog Lake group, and Clarence Lake in the Watana Reservoir survey area.

Broad patterns were similar to those observed in 2013. Peak waterbird numbers occurred between mid-August and mid-September in most survey areas (Table 5.1-7). Ice was first observed on lakes in the study area during the September 23–25 survey, and waterbird numbers began to decline in the Watana Reservoir, Denali West, and Denali East survey areas. Similar to 2013, waterbird numbers increased in the Gold Creek Corridor survey area in late September and peaked in early–mid October, partly due to increased use of Stephan and Murder lakes which remained ice-free. The amount of ice cover in the study area increased through the middle of October, and waterbird numbers declined in all areas. Most birds observed in October occurred in the Gold Creek Corridor survey area.

Cumulatively, across all fall surveys, duck numbers were highest and nearly identical in the Denali West and Gold Creek corridor survey areas, and were only slightly lower in the Watana Reservoir survey area (Table 5.1-7). The Denali West survey area contained the highest number of ducks during 4 of the first 5 fall surveys through mid-September, followed by the Watana Reservoir survey area. After mid-September, the highest numbers of ducks occurred in the Gold Creek corridor survey area.

Cumulative fall swan numbers were similar between the Gold Creek and Denali West survey areas, but as in 2013, patterns of use differed between the two areas. Numerous nesting pairs were found in the Denali West corridor, and this area contained the highest number of swans through mid-September (Table 5.1-7). After mid-September, swan numbers dropped in the Denali West area, but climbed dramatically in the Gold Creek corridor as groups of staging swans moved into the area, particularly on Stephan Lake. The highest number of swans observed in any area on a single survey was 112, observed in the Gold Creek corridor on September 29–October 1 (96 were on Stephan Lake) and again on October 4–6 (79 were on Stephan Lake).

Cumulative fall loon numbers were highest in the Gold Creek corridor survey area, primarily due to large numbers in August (Table 5.1-7). Although relatively few water bodies were surveyed in the Chulitna corridor in 2014, nearly as many loons were observed there, cumulatively, as in the Gold Creek corridor. Between 6 and 9 loons were observed on each survey in the Chulitna corridor through the end of September, and these likely represented repeated observations of the same individual Common and Pacific Loons, including a Common Loon brood observed on the same lake on multiple surveys. Cumulative grebe numbers were highest in the Watana Reservoir survey area, followed by the Gold Creek survey area (Table 5.1-7).

5.1.1.2.2. Taxonomic Patterns

2013 Surveys

Results from 2013 fall migration aerial surveys were also presented in ISR Part A, Section 5.1.1.2.2. 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 A). 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 A). 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 A). 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 A). 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.

2014 Surveys

Trumpeter Swan counts were steady through mid-September (Table 5.1-6, Appendix B) and swans occurred mostly in pairs and family groups. Swan numbers increased during the last two surveys in September as flocks of up to 34 swans arrived on Stephan Lake. The highest count of swans on a single waterbody was 104 swans on Stephan Lake on October 5. Swan numbers decreased through October, and half of all swans observed during the last two fall surveys (59 of 117) were brood-rearing adults and young.

Scaup were again the most numerous ducks observed during fall surveys (Table 5.1-6). Counts were relatively stable between 835 and 915 birds through the second week of September, after which numbers dropped with each successive survey until the end of the season. Similar patterns were observed for several dabbling duck species, including American Wigeon (except for a spike on September 17–19), Northern Pintail and Green-winged Teal, all of which peaked between mid-August and mid-September (Table 5.1-6, Appendix B). Mallard numbers varied through the third week of September, peaked near the end of September, and remained relatively high through the end of the season.

Numbers were highly variable for all species of scoters and mergansers (Table 5.1-6, Appendix B), and may reflect movements within or through the study area. Bufflehead numbers were level throughout the season, except for a spike at the end of September. Goldeneyes were variable, with maximal numbers occurring during the September 17–19 survey. Long-tailed Ducks peaked at the end of September and declined steadily thereafter. Only 1 Long-tailed Duck was observed during the last 3 surveys in October. Loon numbers decreased throughout the season; the last Red-throated Loons were recorded in early September, and the last Pacific Loons in mid-September. Only 1 Common Loon was observed in October. Grebes were variable, but very few were observed after 23–25 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 and 2014, information on the mean number of birds, density, and species richness (see Tables 5.1-8 and 5.1-9) on 25 of those lakes (or lake groups) was used to calculate relative importance values for both spring and fall migration, following the same method used in the 1980s (Table 5.1-10). Based on these factors and the duration of use by waterbirds, these 25 lakes (or lake groups) appeared to include the majority of the most important water bodies used during spring and fall. Four of those lakes or lake groups fall entirely or partially within the project footprint (2 in the Denali East Corridor, and 1 each in Chulitna and Denali West corridors); however, none of those 4 water bodies were among the most highly ranked for importance (see below). Lakes of apparent importance not analyzed include the aforementioned unnamed water bodies in the Denali Corridor survey area (heavily used during fall especially; some of these water bodies fall within the Denali West Corridor footprint) and river habitats (important during spring 2013).

Similar to results from the APA study, Murder Lake ranked as the most important water body in both fall and spring, except for spring 2014 when Murder Lake ranked fourth. Stephan Lake ranked second in all seasons except for spring 1981 when it ranked third (Table 5.1-10) Murder Lake has a comparatively small surface area, but it contained by far the highest density of waterbirds—especially dabbling ducks—in both fall and spring (Tables 5.1-8 and 5.1-9). Although Murder Lake is shallow, stream flow from Stephan Lake created open water in early spring 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. At their nearest points, Murder and Stephan lakes are approximately 7.8 and 1.8 km, respectively, outside the Gold Creek Corridor footprint.

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, especially in 2013, when most lakes were ice covered.

Stephan Lake ranked second in importance in spring and fall 2013 and 2014 (Table 5.1-10). 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; and fifth in spring and third in fall 2014 (Table 5.1-10). 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, swans, loons, grebes and gulls. The range of species was greater in the fall, and included some species not seen during spring, including Black Scoter, Bufflehead, Horned Grebe and Red-necked Grebe. Species seen in at least one year and only during spring included Mew Gull and Red-throated Loon. At its nearest point, Clarence Lake falls about 6.5 km outside the reservoir footprint.

Pistol Lake ranked fourth in importance in spring 2013 and third in spring 2014. In 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 first use of Pistol Lake in 2014 occurred on May 5, when 7 species of dabbling and diving ducks were observed. During spring 2014, Pistol Lake was used by 17 species, including numerous dabbling and diving ducks, Trumpeter Swan, Common Loon and Mew Gull. The lake ranked only eleventh in importance in fall 2013, and fourteenth in fall 2014, primarily because of low overall waterbird numbers and density (Tables 5.1-8, 5.1-9 and 5.1-10); but it was used regularly by low numbers of several species of diving and dabbling ducks until early October each year, after which no birds were present despite available open water. Pistol Lake falls about 1.5 km outside the dam and camp facilities footprint.

The southernmost Fog Lake (WB 059) consistently ranked between third and sixth in importance during spring and fall 2013–2014 (Table 5.1-10). Scaup were the most numerous species in both seasons, but the lake also was used by other diving ducks and dabbling ducks; and in at least one season by Trumpeter Swan, Common Loon, Horned Grebe, Red-necked Grebe, and Herring Gull. WB 059 lies about 3.3 km outside the dam and camp facilities footprint.

One unnamed lake in the Watana Reservoir survey area (WB 069 in the APA study) ranked first in importance in spring and sixth in fall 2014. In 2013, the lake had no birds in spring and ranked fourteenth in fall, and never ranked higher than eighth in the APA study (Table 5.1-10). WB069 has a small surface area, and its high rank in 2014 resulted mostly from a high density of waterbirds rather than total numbers or species richness (Tables 5.1-8 and 5.1-9). Very few birds were observed in WB 069 during spring or fall 2013, but in 2014 the lake was used during spring by 5 species of dabbling duck, 4 species of diving duck, Pacific Loon and Mew Gull. During fall 2014, the lake was used by 4 species of dabbling duck, 5 species of diving duck, Trumpeter Swan, Pacific Loon, and Horned Grebe. Total numbers were generally lower in fall than spring, and very few birds were recorded there after September 2014. WB 069 falls about 1 km outside the reservoir footprint.

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 5.1-4, 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 mid-late September. Some of the water bodies connected to Brushkana Creek and some of those east of Cantwell fall within the footprint of the Denali West Corridor.

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 5.1-5). 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 5.1-6) 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 5.1-5). 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 5.1-6).

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 5.1-5). 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 5.1-7). 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 5.1-8). 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 5.1-9). 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 5.1-11), 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 5.1-12). 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 5.1-10). 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 5.1-11).

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 (ISR 10.15 Part A, 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 5.1-13), with rates increasing starting May 9 (Figure 5.1-12) 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; Table 5.1-13) 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 (Table 5.1-13). 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 5.1-13) 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 5.1-13). 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 5.1-14). 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 5.1-15).

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 5.1-16).

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 5.1-17). 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 5.1-18). 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 5.1-18), 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 5.1-13, Appendices D–J). Of these, 57.8 percent crossed south of the observation station, whereas 42.2 percent crossed to the north (Table 5.1-13). 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 5.1-13). 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 5.1-14). 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 5.1-6) 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 5.1-19). 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 5.1-19). 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 5.1-6).

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 5.1-19). 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 5.1-6) The mean passage rates of nocturnal targets increased for the first four hours after sunset and declined subsequently (Figure 5.1-7).

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 5.1-8). 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 5.1-9). 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 5.1-11). 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 5.1-12). Mean diurnal altitudes ranged from 136 to 486 m during the study and mean nocturnal altitudes ranged from 237 to 681 m (Figure 5.1-20).

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 5.1-11). 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 5.1-11).

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 5.1-12). 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 5.1-15). 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 5.1-14). 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 5.1-14). Overall, waterfowl movement rates were low throughout the season. The seasonal mean movement rate of swans was 0.52 ± 0.20 birds/h

(Table 5.1-13), with only a small pulse of swan activity occurring during late September (Figure 5.1-13). 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 5.1-21). 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 5.1-21). 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 5.1-22). 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 5.1-23). 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 5.1-13). 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 5.1-13). 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 5.1-15) 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 surveys (hereafter breeding surveys), total waterbird densities (by water body surface area) in 2013 were highest in the Watana Reservoir and Denali West corridor 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 in 2013, but were variable and highly sensitive to small changes in abundance due to the area's small aggregate water body size. In 2014, densities were highest during the first breeding survey in areas with small water body surface area (Dam/Camp and Denali East), but densities were again highly variable between the two surveys in these areas. Scaup were by far the most abundant species during both the first and second breeding surveys each year. Total bird density decreased between the first and second surveys both years, driven in 2013 primarily by a large decrease in scaup numbers (Table 5.2-1), and in 2014 by decreases in several species, including White-winged Scoter, scaup, Northern Pintail and Ring-necked Duck (Table 5.2-2). Waterbird densities were higher in both surveys in 2014 than in either survey in 2013. 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 in the transect block each year, although after correcting for visibility, Green-winged Teal surpassed scaup during the first transect survey in 2014 (Tables 5.2-3 and 5.2-4). In 2014, waterbird densities decreased between the first and second surveys in the transect block, as they did in the lake-to-lake breeding surveys both years. In contrast, densities increased in the transect block in 2013. Patterns may have 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

5.2.1.2.1. 2013 Surveys

Results from 2013 breeding population surveys were also presented in ISR Part A, Section 5.2.1.2. Scaup were mostly paired during the first breeding survey in early June, and large groups were found on lakes typically used by migrants. Total numbers decreased from 1,080 birds during the first breeding survey to 761 birds during the second (Table 5.2-1); 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 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 5.2-1). 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 5.2-1), 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 5.2-1) 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 5.2-1). 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 5.2-1) 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 5.2-1). 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 5.2-1).

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 5.2-1).

5.2.1.2.2. 2014 Surveys

Unlike 2013 when the breeding season was compressed due to the late spring, dispersal to breeding areas and nest initiation occurred over a relatively extended period in 2014. For some species it appears likely that some pairs still occupied staging areas after others had initiated nests and males were staging and/or departing nesting areas. For example, nesting areas for Mallards were best identified during the first breeding survey, May 24–28, but Mallard nests were initiated as early as May 10 and as late as June 7 in 2014 (see brood section); thus local breeding Mallards were likely observed near nest sites during spring migration surveys on May 11–12 and May 17–18, and also during the second breeding survey on June 2–6. This is especially problematical for dabbling ducks such as Northern Pintail and Mallard, which arrive early and initiate nests as soon as nest sites become available.

The total number of dabbling ducks decreased slightly between the first and second surveys (Table 5.2-2). The first breeding survey was timed appropriately to describe the breeding distribution of dabbling ducks in the study area. For all dabblers combined, the number of pairs decreased between the first and second surveys; the number of unpaired males increased and the number of water bodies used by dabbling ducks decreased as males grouped up, presumably after initiating nests. Similar patterns were detected for individual dabbler species, with the exception of Green-winged Teal, which showed slight increases in total numbers and of occupied lakes; teal pairs declined from 43 pairs during the first survey to only 3 during the second, and the number of unpaired males more than doubled. Increased total numbers may have resulted from greater detectability of grouped males during the second survey.

Scaup numbers decreased from 1,298 birds during the first breeding survey to 1,050 birds during the second (Table 5.2-2); the number of pairs decreased from 466 to 328, and the number of unpaired males increased from 366 to 391. During both surveys, flocks of paired birds were found in the study area, and the number of occupied lakes increased from 157 on the first survey to 178 on the second, suggesting that some scaup were still dispersing into breeding areas during the second breeding survey in early June. Results from brood surveys indicate that scaup nests were initiated between late May and early July, with the peak occurring in mid-late June. The highest numbers of scaup were found in the Watana Reservoir survey area, and the highest densities occurred in Denali East corridor, largely due to the presence of grouped pairs in Brushkana Lake and in the group of small lakes north of the Denali Highway on the north end of the corridor (Figure 4.1-13).

The breeding distribution of goldeneyes may have been captured more effectively by the first breeding survey than the second. The total number of goldeneyes decreased between the surveys (Table 5.2-2); the number of occupied water bodies decreased from 51 to 44, and the number of pairs decreased from 48 to 25. However, like many other species in 2014, results from brood surveys indicate a broad range of initiation dates for goldeneyes. The highest numbers of goldeneyes occurred in the Watana Reservoir survey are during the first breeding survey, and in the Denali West survey area during the second survey (Table 5.2-2)

The total number of White-winged scoters decreased substantially between the two breeding surveys, from 392 during the first survey to 80 during the second (Table 5.2-2). The species first appeared in the study area on May 17–18; during the first breeding survey less than a week later, they occurred largely in groups, suggesting that many were migrating through the area during the first breeding survey. The number of Surf Scoters dropped from 153 during the first survey to 99 during the second. Some Surf Scoters may also have been migrating through the area during the first breeding survey, but that species first arrived in the study area in early–mid may, and during the second breeding survey numerous unpaired males were observed, suggesting that some females may have been attending nests at that time. Few Black Scoters were observed during breeding surveys; most occurred in the Gold Creek corridor survey area during the second breeding survey.

Total Bufflehead numbers were fairly stable between the two breeding surveys, but with variation within survey areas that could indicate local movements within and among areas. Between the first and second survey, Bufflehead numbers decreased from 43 to 25 birds in the Denali West corridor, and increased from 12 to 24 birds in the Denali East corridor (Table 5.2-2). Mixed sex groups of up to 16 birds were recorded during both surveys.

Long-tailed Duck numbers decreased substantially, from 134 birds during the first breeding survey to 76 during the second. Decreases were observed in the Denali West, Denali East, and Chulitna corridors (Table 5.2-2). Thirty-four Long-tailed Ducks (17 pairs) were observed on Miami Lake, in the 2013 Chulitna Corridor, during the first breeding survey in 2014, but none were seen in the corridor during the second survey. Several flocks of paired Long-tailed Ducks were seen during the first breeding survey, and it is possible that some of these groups were migrating through the study area.

Trumpeter swan numbers and densities were similar between the two surveys and highest in the Denali West corridor survey area (Table 5.2-2). Most observations were single swans and pairs, except for a group of 11 swans near the Nenana River in the Denali West corridor on the first breeding survey. Eight nests were identified during the first breeding survey (5 in the Denali West corridor, 2 in the Watana Reservoir, and 1 in the Chulitna corridor); and 12 nests were identified during the second survey (8 in the Denali West corridor, 2 in the Watana Reservoir, and 1 in the Chulitna corridor).

Grebes were found in small numbers during both surveys, almost always as discrete pairs or single birds, except for two pairs of Red-necked grebes found together on a water body in the Gold Creek corridor and a group of 3 Red-necked Grebes on Brushkana Lake in the Denali East corridor, both during the first breeding survey. Most Horned Grebes were found in the Watana Reservoir survey area, and most Red-necked Grebes were found in the Gold Creek corridor survey area (Table 5.2-2).

Patterns were difficult to detect for some species that occurred in low densities, where apparent changes within survey areas could reflect movements among areas, variable detection rates or both. Area-wide numbers were relatively stable for Common Merganser, Red-throated Loon, Pacific Loon, Bonaparte's Gull, and Mew Gull, whereas Red-breasted Mergansers and Common Loons decreased somewhat on the second survey (Table 5.2-2). Loons tended to occur as discrete pairs and were observed on the same waterbodies throughout the season, so to a certain extent, small changes in loon numbers likely reflected differential detection rather than real changes in abundance.

5.2.2. Harlequin Duck Surveys

5.2.2.1. Spring Migration

Results from 2013 Harlequin Duck spring migration surveys were also presented in ISR Part A, Section 5.2.2.1. In 2013, 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 (Figure 5.2-1, Table 5.2-5). In 2014, Harlequin Ducks were first seen on May 5, when a total of 5 pairs were observed at 4 locations on the Susitna River, in the Gold Creek Corridor. On May 17, 2014, seven groups totaling 27 Harlequin Ducks were observed on Deadman Creek in the Denali Corridor. After May 5, 2014, the focus of spring migration surveys shifted primarily to water bodies, so information on spring arrival and distribution described below is based on surveys in 2013.

On May 18–19, 2013, 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, 2013, 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 5.2-5). 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, 2013, 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 5.2-5). 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

5.2.2.2.1. 2013 Surveys

Results from 2013 Harlequin Duck pre-nesting surveys were also presented in ISR Part A, Section 5.2.2.2. Thirty streams were surveyed for Harlequin Ducks during pre-nesting surveys, which consisted of 25 named streams and 5 unnamed streams (Figure 5.2-2, Table 5.2-6). 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 (Figure 5.2-2, Table 5.2-6,). 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 5.2-6). 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 5.2-6).

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 5.2-6). 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 5.2-6). 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.

5.2.2.2.2. 2014 Surveys

The same streams that were surveyed consistently in 2013 were surveyed again in 2014, except for river R18 as described earlier. Because of the addition of the Denali East Corridor after the 2013 season, an additional section of Brushkana Creek and a section of Monahan Creek were added to the study area in 2014 (Figures 4.1-13 and 5.2-3, Table 5.2-7).

Harlequin Ducks were found on 26 of the 30 streams surveyed during pre-nesting and were distributed throughout the study area, occurring in all 5 survey areas (Figure 5.2-3). Substantially more Harlequin Ducks were recorded during the first pre-nesting survey on May 24–28 (431 ducks) than during the second survey June 2–6 (265 ducks). The distribution of ducks among survey areas was similar between the two surveys (Figure 5.2-3, Table 5.2-7). The Watana Reservoir survey area had the most Harlequin Ducks during both survey periods (48% during the May 24–28 survey, and 52% during the June 2–6 survey), followed by the Denali West Corridor (32 and 33 percent, respectively). Brushkana Creek, in the Denali West survey area, had the highest concentration of Harlequin Ducks during the first pre-nesting survey (2.57 birds/mile), followed in descending order by Tsisi Creek, Fog Creek and Black River in the Watana Reservoir, and Deadman Creek, in Denali West (Table 5.2-7). Densities decreased between the first and second survey on most streams, but the number of Harlequin Ducks doubled on Gilbert Creek in the

Watana Reservoir survey area (from 10 to 20 birds). In contrast, Fog Creek, which had 13 birds and one of the highest densities during the first survey, had no Harlequin Ducks during the second survey. Gilbert Creek had the highest concentration of Harlequin Ducks during the first survey (1.92 birds/mile), followed by Deadman Creek (Denali West section), and Tsisi Creek, Black River, and Brushkana Creek (Denali West section).

Most 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, compared to 60 percent on the second survey (Table 5.2-7). During May 24–28 , a total of 78 Harlequin Ducks were found in small groups of 2–3 pairs (usually 2), and on June 2–6, there were 76 ducks in groups of this size, suggesting that some birds may have still occupied staging sites during both surveys. No grouped males and a total of 49 unpaired males (lone males or single males accompanying a pair) were observed during the first survey. On the second survey, the number of unpaired males climbed to 188, and included a group of 9 males on the Susitna River (Figure 5.2-3, Table 5.2-7). Numerically, the transition from pairs to single males accounts for most of the difference in total Harlequin Ducks between the first and second survey, and suggests that some females were attending nests by early June. As in 2013, 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

5.2.2.3.1. 2013 Surveys

Results from 2013 Harlequin Duck brood-rearing surveys were also presented in ISR Part A, Section 5.2.2.3. During brood-rearing, Harlequin Ducks were found on 21 of the 28 streams surveyed (Figure 5.2-4). 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 streams in 2013. The highest number on any one stream during a single survey was four broods on Devil Creek, followed by three broods each on Goose, Deadman, and Seattle creeks, all during the second brood survey on August 14–18. (Table 5.2-8). 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 5.2-4). 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 5.2-8). 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 5.2-4). 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 each on Deadman and Seattle creeks, and three and five females without young, were found on Jack River and Brushkana Creek, respectively (Figure 5.2-4, Table 5.2-8). 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 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 was 4.2 young/brood on the first survey 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 34 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.

5.2.2.3.2. 2014 Surveys

During brood-rearing, Harlequin Ducks were found on 21 of the 28 streams surveyed (Figure 5.2-5). The Nenana and Susitna rivers were not surveyed because they were very turbid and were considered to be poor brood-rearing habitat.

Broods were found on 15 streams in 2014. The highest number on any one stream during a single survey was 7 broods on Deadman Creek during the second survey (Table 5.2-9). Deadman Creek and R21 each had 4 broods on the first survey, and Goose Creek, Indian River and R21 each had 3 broods on the second survey. Twelve broods were observed on the first brood-rearing survey on August 2–6 on 5 different streams, and 31 broods were seen on the second survey on August 17–19 on 14 different streams. The highest density of broods was recorded on R21 during the first survey (0.40 broods/mile; Table 5.2-9), followed by several streams during the second survey, including R19 and R21 (0.3 broods/mile), Deadman Creek (the short section occurring in the Dam/Camp area; 0.25 broods/mile), and Goose Creek (0.20 broods/mile). After accounting for potential re-sightings of broods between surveys (based on similarity of location and estimated hatch date), at least 37 individual broods were found in the entire area surveyed. About half of the broods found on each survey (6 of 12 broods on the first survey and 14 of 31 on the second) were within the 3-mi buffer of the waterbird study area (Figure 5.2-5). The highest number of broods found in a survey area during a single survey was 15 broods in the Watana Reservoir on August

17–19, followed by 10 broods in the Denali West Corridor on the same survey (Table 5.2-9). Broods were recorded in all survey areas except Denali East.

On August 2–6, 12 of 30 females were associated with 50 young, and the average brood size was 4.2 young/brood. On August 17–19, 30 of 31 females were associated with 120 young, and 1 brood of 1 duckling was unaccompanied by an adult, resulting in an average brood size of 3.9 young/brood. Most broods seen on the first survey were about 18 days old (range = approximately 12 to 42 days old) and on the second survey about 34 days old (range = approximately 12 to 42 days old). Based on these ages, the earliest start date of incubation in 2014 was estimated to be May 27, and the latest was estimated to be July 9. Although incubation started as early as late May for 1 nest (on Kosina Creek), incubation had commenced for only 3 additional nests by June 5 (2 on Deadman Creek and 1 on R21).

5.2.3. Brood Surveys

5.2.3.1. 2013 Surveys

Results from 2013 brood surveys were also presented in ISR Part A, Section 5.2.3. 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 West, Chulitna, and Gold Creek corridor survey areas (Figures 4.1-1–4.1-3). A total of 499 water bodies were searched for broods 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 3 surveys, including 1 species of swan, 15 species of ducks, 3 species of loons, 2 species of grebes, 2 species of gull, and 1 species of tern (Table 5.2-10). A total of 111 broods were observed on July 20–22 and a total of 151 broods on August 1–5. 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 5.2-6, Table 5.2-10). 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 5.2-10).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 5.2-10).

Although the total number of broods was lower than in the Denali Corridor, the brood density was higher in the Watana Reservoir than in any other survey area (40.7 broods/mi^2; Table 5.2-10). 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 had the lowest amount of water body surface area among the 2013 survey areas, except for the Dam/Camp Area, and the number of broods relative to the amount of water was 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 5.2-10). 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 5.2-6). 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 5.2-6). 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 5.2-6). 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 5.2-6).

During brood-rearing surveys, chicks from duck broods were classified into seven different age subclasses based on plumage development (Table 5.2-11). 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 1954, 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 June 6 (*n* = 9). Three species had a median incubation start date of June 10, 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.

5.2.3.2. 2014 Surveys

Three brood-rearing surveys were conducted during summer 2014 within a 1-mi area around and including the Dam/Camp Area, the Watana Reservoir, and the Denali West, Denali East and Gold Creek corridor survey areas of the study area (Figures 4.1-4–4.1-6). A total of 527 water bodies were searched for broods on each survey, which resulted in an area of 6.6 mi^2 of water bodies surveyed. The survey team recorded broods of 21 species on the 3 surveys, including 1 species of swan, 13 species of ducks, 3 species of loons, 2 species of grebes, and 2 species of gull (Table 5.2-12). Totals of 80, 181 and 116 broods were observed on July 9–12, July 19–23, and August 2–6, respectively. Across the 3 surveys, at least 309 individual broods were found in the waterbird brood survey area. Cumulatively, the 5 most common species with broods were scaup, Green-winged Teal, goldeneyes, American Wigeon and Northern Pintail.

The Denali West Corridor survey area contained most of the broods in the waterbird brood survey area on all 3 brood-rearing surveys: 50 percent of the broods on July 9–12, 70 percent on July 19–23, and 66 percent on August 2–6 (Figure 5.2-7, Table 5.2-12). Broods of 14 species were observed among the three surveys in the Denali West Corridor survey area and a total of 40 broods were observed on July 9–12, 127 broods on July 19–23, and 77 broods on August 2–6. Across the 3 surveys at least 204 individual broods were recorded, which was more than 5 times the number recorded in any other survey area. Across all surveys, the number of broods found in the Dam/Camp, Watana Reservoir, Denali East and Gold Creek corridor survey areas ranged from 7 to 22 broods.

Although the total number of broods was lower than in the Denali West Corridor, the brood density was highest in the Denali East and Watana Reservoir survey areas (45.5 broods/mi2 during both July surveys in Denali East, and during the second July survey in the Watana Reservoir; Table 5.2-12). The Denali East brood survey area had the lowest amount of water body surface area among all survey areas in 2014, and the number of broods relative to the amount of water was high.

Broods of 6 species (Common Merganser, Red-breasted Merganser, Common Loon, Bonaparte's Gull and Mew Gull) were found only in the Denali West Corridor survey area (Table 5.2-12). Three other species were found in only 1 of the other 4 survey areas: Black Scoter in the Watana Reservoir survey area, Red-throated Loon in the Denali East Corridor, and Pacific Loon in the Gold Creek Corridor. Broods of Green-winged Teal and scaup were found in all 5 survey areas in 2014.

Nineteen water bodies in the Denali West Corridor survey area contained three or more different broods on at least 1 survey (Figure 5.2-7). A total of seven broods were observed on 1 waterbody on July 19–23, and on a different water body on August 2–6. One was a pond near Drashner Lake, adjacent to the Denali Highway and Nenana River at the northwest end of the study area, and the other was a broad shallow pond connected to Deadman Creek west of Deadman Lake. High concentrations of broods, primarily scaup and dabbling ducks, were observed in multiple ponds in those areas, and near Brushkana Creek and in the divide between the Brushkana and Deadman creek drainages (Figure 5.2-7). In the Gold Creek corridor, a water body near the Susitna River contained 4 broods (3 goldeneye and a scaup) on July 19–23. Within the rest of that survey area and the other 3 survey areas (excluding Denali West), broods were found on lakes throughout each survey area with no more than three broods found on 1 lake during a survey.

During brood-rearing surveys, chicks from duck broods were classified into seven different age subclasses based on plumage development (Table 5.2-13; See 2013 results for description of age classes). During the first brood survey on July 9–12, 76 percent of broods were in the Class 1 category, and no class 3 (fully feathered) young were recorded. During the second brood survey on July 19–23, 44 percent of broods were in Class 1, and 46 percent were in class 2. During the third brood survey on August 2–6, 35 percent of broods were in class 1, 44 percent were in class 2, and 21 percent were in class 3. Class 3 broods were most likely under-counted late in the season because very old broods can become difficult to distinguish from grouped adults. Only 23 percent of the class 1 broods during the August survey were in the earliest subclass (1A), but the persistence of class 1 broods into the third brood survey illustrates the prolonged period of nest initiation in 2014. Nearly all subclass 1A broods in the August 2–6 survey were scaup.

As in 2013, 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. Northern Pintails and Mallards were the earliest nesters, each with a median incubation start date of 20 May (n = 20 broods for Northern Pintail and 7 broods for Mallard). Northern Shoveler had a median incubation start date of May 31 (n = 6). Three species had median incubation start dates in the first week of June, including goldeneye (June 1; n = 26), American Wigeon (June 4; n = 24) and Green-winged Teal (June 5; n = 51). Median incubation start dates were June 10 for Long-tailed Duck (n = 10) and June 23 for scaup (n = 92).Dabbling ducks like Northern Pintail, Mallard, American Wigeon, and Green-winged Teal are usually considered early nesters and diving ducks like scaup, Long-tailed Duck and goldeneyes are considered late nesters. The median incubation start date for goldeneyes was similar to those for Northern Shoveler, American Wigeon, and Green-winged Teal in 2014, but Long-tailed Duck and Scaup were about 1–4 weeks later than dabbling ducks.

5.3. Information for Mercury Study

As reported in the ISR Part A Sections 5.3 and 6.3, 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, and no feathers were collected (see ISR

Part A, Section 5.3). Following the 2013 season, a modification was proposed (ISR Part C, Section 7.1.2) to move the objectives and methods related to mercury analysis of piscivorous waterbirds (RSP Sections 10.15.1 and 10.15.4.3) to the Mercury Assessment and Potential for Bioaccumulation Study (Study 5.7). This modification was implemented in 2014.

6. DISCUSSION

6.1. Spring and Fall Migration

6.1.1. Aerial Surveys

The data collected in 2013 and 2014 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.

The two years of this study differed substantially in the timing of waterbird arrival and distribution in the study area. Spring breakup was delayed in 2013 and waterbirds predominantly occupied rivers until late May that year. In contrast, waterbodies were available approximately 2–3 weeks earlier in 2014 and most waterbirds were observed on waterbodies rather than rivers during spring surveys. In both years, waterbirds appeared to move from rivers and streams to water bodies as soon as the latter became available, and as a result, more effort was expended surveying rivers and streams in 2013 than in 2014.

Because snow and ice cover persisted much longer than average in Southcentral Alaska during spring 2013, the duration of spring migration was compressed and the arrival of early migrant waterbirds occurred later than in 2014. From late April to mid-May 2013, 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 2013, rivers supported more waterbirds than lakes. The Nenana and Susitna rivers were the most important rivers for staging waterbirds during May 2013 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. In 2013, 47 percent of waterbirds in the study area were still staging on the Susitna River by May 23–24, compared to the same time in 2014 when large numbers of waterbirds had dispersed to breeding areas and some dabbling ducks had initiated nests.

To the extent that comparisons are possible, the pattern of use of the study area during spring 2013–2014 appeared 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. Smaller water bodies and streams also were not surveyed in the 1980s, and dispersal to those areas in early May (as was seen in 2014) may have been overlooked. The selection of lakes surveyed in the 1980s during spring and fall migration was considerably less compared to 2013–2014, 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 Study 7.6, Ice Processes in the Susitna River, 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. The study team monitored field reports from Study 7.6 in 2014, but survey dates in spring 2014 were planned in advance to parallel survey dates in 2013 for direct comparison between years, and again migration surveys were commenced in mid-April at about the same time that results from the first ice processes survey flight became available.

Fall migration surveys documented the use of water bodies by waterbirds in the study area from mid-August to mid-October 2013–2014. Unlike spring, patterns in fall were similar between the two years. 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. Two large lakes with open water late in the fall and partially within the Project footprint were Big and Deadman lakes (Denali East and Denali West Corridors, respectively), but these lakes contained few birds during fall each year. Numbers of waterbirds in the study area were highest from mid-August until about the third week of September. Numbers plateaued in late September and early October, before declining again to fewer than 600 birds by mid-October. In general, the pattern of fall movement for most waterbirds species in 2013–2014 was similar to the pattern recorded in the 1980s (Kessel et al. 1982), wherein 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 2013–2014. A relative importance value was determined for these lakes based on calculations that were developed for the APA Project (Kessel et al. 1982). Five lakes that ranked among the top 4 in importance during at least one season in the 1980s also ranked in the top 4 during one or more seasons during spring and fall 2013–2014: Murder, Stephan, Clarence, Pistol, and WB 059 (in the Fog Lakes group). None of these lakes fall within the Project footprint. Counts of waterbirds on those five lakes in 2013–2014 during peak periods ranged from about 60–200 during spring and 150–450 during fall (excluding Pistol Lake, which had relatively low fall numbers in both years of the Waterbird Study and in the 1980s).

The highest counts of waterbirds recorded on a single survey during spring each year was between about 2,300 and 2,400 birds, and during fall was between about 2,600 and 3,000 birds. Peak spring counts occurred in mid–late May, and fall counts were highest on the first fall survey each year and remained relatively high from mid-August to mid-September. Ducks were the most abundant species group during spring and fall, followed in order by swans, loons, and grebes. Geese and gulls were mostly observed during spring. Swans were observed in pairs or small groups during spring. During fall, three to four groups of 20–76 swans each year were seen on Murder and

Stephan lakes in late September or the first week of October. 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 2013. Snow Geese are migrants in the study area and were not present during the breeding season. Eight species were recorded only as migrants because they were seen only during the migration season. Thirty-one species were recorded in the study area during the breeding season and 28 of those species were confirmed breeders. Additionally, although Sandhill Cranes were not seen in the study area during breeding or brood surveys, they were confirmed breeders in 2014 when a brood was observed during a fall migration survey on September 1 in the Gold Creek Corridor survey area. 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

This study provided 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 (ISR 10.15 Part A, Appendices Q–S). Comparisons of the results of this radar study with those of other studies are presented below (see Figure 6.1-1 for locations of other studies and geographical features discussed).

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.

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 (ISR 10.15 Part A, 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 5.1-10) 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. 1991b). 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 approximately 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. 1991b), 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. 1991b, 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 5.1-13).

In the spring, swans generally flew at higher altitudes than most species, with a mean flock flight height of approximately 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. 1991b).

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. 1991b; 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. (1991b) 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. 1991b). 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. 1991b)]; Eva Creek (12,757; 48,276; Shook et al. 2011); Delta Junction (31,163 spring only; Parrett and Day 2009a, 2009b); 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 discussions of raptor migration in the study area are presented in ISR Study 10.14 and SIR 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. 1991b). 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, suggesting that some early season fall migration of passerines may have been missed. The 10 species seen during spring but not fall were: Tree Swallow, Violet-green Swallow, Bank Swallow, Cliff Swallow, Northern Wheatear, Lapland Longspur, Smith's Longspur, Snow Bunting, Gray-crowned Rosy-finch, and Pine Siskin (Appendix C). The four swallow species, in particular, tend to migrate early in the fall.

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, provide useful 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 and Day 2009b); 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. 1991b); 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. 1991b), 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. 1991b; Cooper and Ritchie 1995; Day et al. 2005; Day et al. 2011; Shook et al. 2011), 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 2009b), 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. 1991b), 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. 1991b); 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 and 2014 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, 2013, and May 24–28, 2014) appeared to be timed appropriately to describe the breeding distribution of most dabbling ducks in the study area. For most species, large aggregations of migrants were not observed, and pairs and lone males were dispersed widely across the study area. Some grouping of male dabbling ducks was observed during the first breeding survey in 2014, but nest initiation occurred over a broad period that year and some early nests were being incubated as early as the middle of May. Nevertheless, the first breeding survey was timed appropriately for the peak of nest initiation for dabbling ducks, and the second survey captured later nesting dabblers. In 2013, the median start of incubation for Green-winged Teal was June 20, thus the second breeding survey in mid–June likely documented nesting areas for many pairs of Green-winged Teal. The first breeding survey also appeared to capture likely nesting areas for goldeneyes in both years.

Some scoters may not have been present in their nesting locations during the first survey each year, and some scoters may have been migrating through the study area during the first survey in both 2013 and 2014 (especially White-winged Scoters, which were found in large groups during the first survey and in much smaller numbers during the second survey each year). Some Surf Scoters may also have been migrating during the first breeding surveys; however the median start of incubation for Surf Scoters in 2013 was June 10, indicating that many Surf Scoters likely occupied breeding sites during the first breeding survey that year. Similarly, Surf Scoters arrived in the study area earlier than White-winged Scoters in 2014, and some pairs likely occupied nesting areas during the first survey that year as well.

The second breeding survey (June 14–17, 2013, and June 2–6, 2014) seemed to best identify breeding areas for scaup, Long-tailed Ducks, and Bufflehead. However, groups of paired scaup were observed during both breeding surveys in 2014, and the median start of incubation for scaup nests was June 23, suggesting that some scaup still occupied staging areas during the second breeding survey in 2014. Swans and loons appeared to occupy known or likely breeding areas during both breeding surveys in both years. 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 (see Nelchina Stratum in Mallek and Groves 2011). During that survey, scaup occurred at the highest density of all waterfowl in the Nelchina Stratum, followed by Green-winged Teal and Mallard. In the transect block, Mallard, scaup, and Ring-necked Duck occurred at similar densities and were the most abundant waterbirds during the first survey in 2013, and scaup were by far the most abundant species during the second survey. In 2014, Green-winged Teal were the most abundant species during the first survey (after correcting for visibility), followed by scaup and Mallard. During the second survey, scaup and Green-winged Teal occurred at similar densities and were the most abundant species.

Compared to the USFWS survey (2011 Nelchina Stratum), lower densities of most dabbling ducks were observed in the transect block in 2013, including Mallard, Green-winged Teal and Northern Pintail. Slightly higher densities of Northern Shoveler and Long-tailed Duck were observed in the transect block; and similar densities (on at least one of two surveys) of Ring-necked Duck, goldeneyes, mergansers and swans. Densities of Bufflehead, scoters and scaup in the transect block were lower than reported for the Nelchina Stratum in the first survey, and higher during the second survey in 2013. In 2014, compared to the USFWS survey, densities of Green-winged Teal were higher in the transect block during both surveys, and densities of swans were lower during both surveys. Densities of American Wigeon, Northern Shoveler, scaup and scoters were similar between the USFWS survey and the transect survey for this study during at least one transect block survey; and densities of Mallard and Northern Pintail were higher in the transect block during the first survey and lower during the second. Because the transect block covered a smaller area and likely occurred 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. Results among years and between surveys within in a year are likely sensitive to differences in survey timing relative to spring chronology.

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 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. In 2013, over 500 ducks were distributed all along the Susitna River on May 23–24. By that time in 2014, Harlequin Ducks had already dispersed from the Susitna River to streams throughout the study area, and 431 Harlequin Ducks were seen on the first pre-nesting survey on May 24–28. By the May 28–29 spring migration survey in 2013, the number of Harlequin Ducks on the Susitna River had dropped to 87 ducks as pairs moved to occupy breeding territories on nearby streams. 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 regular spring migration surveys, which included river habitats through late May in 2013, documented the importance of the Susitna River to Harlequin Ducks as a staging location prior to nesting, especially during a late year. The first pre-nesting survey in 2013 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. In 2014, smaller tributaries became available earlier than in 2013, and results of the first pre-nesting survey on May 24–28 were similar to those from the June 1–5, 2013 survey with respect to group size, general distribution, and percentage of pairs. In 2013, 87 percent of Harlequin Ducks were found in pairs during the first pre-nesting survey, and 68 percent during the second. In 2014, those figures were 87 and 60 percent, respectively. Although many pairs had apparently moved into nesting areas during the first pre-nesting survey each year, the locations the locations of Harlequin Ducks on the second 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 each year in the Project area covered the window of time that pairs were visible on breeding streams.

Streams in the Watana Reservoir and the Denali West Corridor survey areas supported the highest number of pre-nesting Harlequin Ducks in the study area. High densities of ducks were found on a number of streams on one or both years, including Deadman, Brushkana, Tsisi, Fog, Kosina, Goose, R21 and Tsusena and Watana creeks, and Black, Susitna, Oshetna and Jack rivers. Although most Harlequin Ducks were in pairs during the second survey both years, 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 in 2013 (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.

Most broods were estimated to be 12 days old on the August 1–5, 2013 survey, and 18 days old on the August 2–6, 2014 survey. Young broods are very secretive, and if the first surveys had been conducted earlier, the detection of broods probably would have been very low. Only 12 broods were observed on the first survey each year, and no subclass 1A Harlequin Duck broods were observed during any survey in the course of this study. More than twice as many broods were seen on the second survey (27 broods in 2013 and 31 broods in 2014) than on the first survey, and between the two surveys at least 30 individual broods were found in the study area in 2013, and 37 broods in 2014. In both years, most broods were found in the Watana Reservoir survey area. The stream with the highest number of broods in 2013 was Devil Creek with four broods, followed by Goose, Deadman, and Seattle creeks, which had three broods each. In 2014, seven broods were recorded on Deadman Creek during the second survey, and four broods each were recorded on Deadman Creek and R21 on the first survey. Goose Creek, Indian River and R21 each had 3 broods on the second survey in 2014.

Some broods probably were missed on each survey because 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. 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.

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 during brood surveys for at least 25 of the 40 species recorded in the study area. The dates of the first and second brood survey in 2013 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 that year. In both years, 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. Brood surveys were conducted earlier in 2014 than in 2013, and a third brood survey was necessary due to the extended period of nest initiation that year. There was a great deal of overlap in the age of broods between dabbling and diving ducks in both years, but in general, earlier nesters appeared to be more affected by the late spring in 2013 than later nesters. The median start of incubation for Mallards, Northern Pintails, and Green-winged Teal was 11–15 days earlier in 2014 than in 2013, compared to 9 and 6 days for goldeneyes and American Wigeon, respectively. The median start of incubation for scaup was 2 days later in 2014 (June 23, compared to June 21 in 2013). 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 others, which may also be a reason for the variation in brood ages within a species and between species.

More broods by far were found in the Denali West Corridor survey area than in any other survey area each year, although the highest densities of broods occurred in areas with low total waterbody surface area. The Denali West area supports a large number of water bodies, many of which are shallow, interconnected by streams, and have abundant emergent vegetation. In contrast, the 1-mile brood survey buffers in three of the other survey areas (Gold Creek, Dam/Camp, and Watana Reservoir) largely follow the Susitna River and encompasses areas of steep relief with relatively few, discrete water bodies. The total number of broods observed in the Denali West Corridor was higher during the second brood survey in 2014 than in either survey in 2013, but the density was lower, primarily due to the addition of Big Lake to the brood survey area in 2014 (a consequence of adding the Denali East Corridor in 2014). Big Lake has a very large surface area, but supports relatively few broods compared to the smaller, shallower water bodies located throughout much of the survey area.

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 2013–2014. waterbird brood study area were about 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 and 527 in 2014. Long-tailed Duck and Black Scoter were reported as the most productive waterfowl in 1981 on those 28 water bodies (Kessel et al. 1982). During surveys in 2013 and 2014, scaup were the most productive waterbird species, followed in descending order by goldeneyes, Green-winged Teal, and American Wigeon in 2013, and Green-winged Teal, goldeneyes, and American Wigeon in 2014.

6.3. Information for Mercury Study

RSP Sections 10.15.1 and 10.15.4.3 provide objectives and methods for the study team to review available information on food habits and diets of piscivorous waterbirds as background for Study 5.7, Mercury Assessment and Potential for Bioaccumulation Study, and to obtain tissue samples for laboratory analysis of mercury levels of piscivorous waterbirds (e.g., loons, grebes, mergansers, terns) for laboratory analysis of mercury levels. Results reported in ISR Part A Sections 5.3 and 6.3 (ABR 2014a) summarized the results of the literature search and described the distribution of candidate avian species for any future potential mercury sampling. As reported in the ISR Part C (ABR 2014c), after further consideration of all mercury studies for the proposed Project, AEA removed these objectives and methods related to mercury analysis of piscivorous waterbirds from the Waterbirds Study and consolidated this work under Study 5.7.

7. CONCLUSION

During 2013–2014, AEA completed comprehensive aerial surveys to document the distribution, abundance, and use of water bodies during spring and fall migration; timing of arrival, nesting, and departure of waterbirds; use of water bodies for breeding and brood-rearing; and use of streams by Harlequin Ducks. Intensive ground-based monitoring of both diurnal and nocturnal migration near the proposed dam site in spring and fall 2013 documented the species composition, timing, direction, and magnitude of migratory activity. The field work, data collection, data analysis, and reporting for the Waterbird Study successfully met all study objectives in the FERC-approved Study Plan. The results of the Waterbird Study are reported herein and earlier by AEA (ABR 2014a, 2014b, 2014c). With this report, AEA has now completed Study 10.15, Waterbird Migration, Breeding, and Habitat Use.

7.1. Modifications to Study Plan

Two study modifications were implemented in 2014:

- One year of ground-based migration monitoring (reported in ISR 10.15 Part A) was adequate to meet study objectives, and a second year was not conducted. RSP Section 10.15.6 stated that the decision to continue the ground-based migration monitoring task would be based on evaluation of the results obtained in 2013, the first year of study. Further discussions with USFWS, ADF&G, and other licensing participants were conducted in technical meetings prior to the 2014 field season, and the modification to omit the second year of ground-based surveys was proposed in ISR 10.15 Part C, Section 7.1.2.

- As described in ISR Study 10.15 (see ISR Part C, Sections 7.1.2 and 7.3), field work, data collection, data analysis, and reporting for mercury analysis has been removed from the Waterbirds Study and consolidated under Study 5.7, the Mercury Assessment and Potential for Bioaccumulation Study.

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9. TABLES

Table 4.1-1. Details of Aerial Surveys for Migrating and Breeding Waterbirds, 2013–2014.

Target Species	Purpose	2013 Survey Date	2014 Survey Date	Method
Waterbirds	Spring Migration	April 23	April 23	Lake-to-Lake
Waterbirds	Spring Migration	April 29	April 29	Lake-to-Lake
Waterbirds	Spring Migration	May 5	May 5–6	Lake-to-Lake
Waterbirds	Spring Migration	May 11	May 11–12	Lake-to-Lake
Waterbirds	Spring Migration	May 18–19	May 17–18	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	May 24–28	Lake-to-Lake
Waterbirds	Breeding	June 2	May 27	Transect
Harlequin Duck	Pre-nesting	June 1–5	May 24–28	Stream
Waterbirds	Breeding	June 14–17	June 2–6	Lake-to-Lake
Waterbirds	Breeding	June 15	June 5	Transect
Harlequin Duck	Pre-nesting	June 14–17	June 2–6	Stream
Waterbirds	Brood-rearing	July 20–22	July 9–12	Lake-to-Lake
Waterbirds	Brood-rearing	August 1–5	July 19–23	Lake-to-Lake
Waterbirds	Brood-rearing		August 2–6	Lake-to-Lake
Harlequin Duck	Brood-rearing	August 1–5	August 2–6	Stream
Harlequin Duck	Brood-rearing	August 14–18	August 17–19	Stream
Waterbirds	Fall Migration	August 14–18		Lake-to-Lake
Waterbirds	Fall Migration	August 23–25	August 24–26	Lake-to-Lake
Waterbirds	Fall Migration	August 29–30	Aug 30–Sep 1	Lake-to-Lake
Waterbirds	Fall Migration	September 4-6	September 5–7	Lake-to-Lake
Waterbirds	Fall Migration	September 10–12	September 11–13	Lake-to-Lake
Waterbirds	Fall Migration	September 16–18	September 17–19	Lake-to-Lake
Waterbirds	Fall Migration	September 22–23	September 23–25	Lake-to-Lake
Waterbirds	Fall Migration	September 27–29	Sep 29–Oct 1	Lake-to-Lake
Waterbirds	Fall Migration	October 4-6	October 5–6	Lake-to-Lake
Waterbirds	Fall Migration	October 10–12	October 11–12	Lake-to-Lake
Waterbirds	Fall Migration	October 17–18	October 17–18	Lake-to-Lake

Table 5-1. Server Location and File Names for the Field Data for the Waterbirds Study Collected in 2013–2014.

Server Pathway or File/Folder Name	Description
http://gis.suhydro.org/SIR/10-Wildlife/10.15-Waterbirds/	Pathway to data files
10_15_WBRD_Cumulative_GIS_Data_ABR.zip	Zip file containing geodatabase (WBRD_10_15_Data_2013_2014_ABR.gdb) of geographic information system (GIS) spatial layers for the waterbird study: 4 feature classes of brood, migration, and breeding waterbird locations; 10 feature classes of survey lakes, survey lake groups, survey streams, and 1981 survey lakes; 11 feature classes of study areas and study corridors.
10_15_WBRD_Cumulative_Excel_Data_ABR.zip	Zip file containing Microsoft Excel data tables for the waterbird study: 6 tables with data from Breeding Lake, Breeding Transect, Brood, Spring Migration, Fall Migration, and Harlequin Duck Breeding Surveys.

Table 5.1-1. Status of Waterbird Species Observed during Waterbird Migration and Breeding Surveys, 2013–2014.

SPECIES-GROUP SPECIES-SUBGROUP Common Name	Scientific Name	2013 Status	2014 Status
WATERFOWL			
GEESE			
Greater White-fronted Goose[1]	*Anser albifrons*	Migrant	Migrant
Snow Goose[1]	*Chen caerulescens*	Migrant	Migrant
Canada Goose[1]	*Branta canadensis*	Migrant	Confirmed Breeder
SWANS			
Trumpeter Swan[1]	*Cygnus buccinator*	Confirmed Breeder	Confirmed Breeder
Tundra Swan[1,2]	*Cygnus columbianus*	Migrant	
DABBLING DUCKS			
Gadwall[1]	*Anas strepera*	Confirmed Breeder	Migrant
Eurasian Wigeon	*Anas penelope*		Migrant
American Wigeon[1]	*Anas americana*	Confirmed Breeder	Confirmed Breeder
Mallard[1]	*Anas platyrhynchos*	Confirmed Breeder	Confirmed Breeder
Blue-winged Teal[1]	*Anas discors*		Migrant
Northern Shoveler[1]	*Anas clypeata*	Confirmed Breeder	Confirmed Breeder
Northern Pintail[1]	*Anas acuta*	Confirmed Breeder	Confirmed Breeder
Green-winged Teal[1]	*Anas crecca*	Confirmed Breeder	Confirmed Breeder
DIVING DUCKS			

SPECIES-GROUP SPECIES-SUBGROUP Common Name	Scientific Name	2013 Status	2014 Status
Canvasback[1]	*Aythya valisineria*	Migrant	Migrant
Redhead[1]	*Aythya americana*	Migrant	
Ring-necked Duck[1]	*Aythya collaris*	Confirmed Breeder	Confirmed Breeder
Greater Scaup[1]	*Aythya marila*	Confirmed Breeder	Confirmed Breeder
Lesser Scaup[1]	*Aythya affinis*	Confirmed Breeder	Confirmed Breeder
Harlequin Duck[1]	*Histrionicus histrionicus*	Confirmed Breeder	Confirmed Breeder
Surf Scoter[1]	*Melanitta perspicillata*	Confirmed Breeder	Confirmed Breeder
White-winged Scoter[1]	*Melanitta fusca*	Confirmed Breeder	Possible Breeder
Black Scoter[1]	*Melanitta nigra*	Confirmed Breeder	Confirmed Breeder
Long-tailed Duck[1]	*Clangula hyemalis*	Confirmed Breeder	Confirmed Breeder
Bufflehead	*Bucephala albeola*	Confirmed Breeder	Confirmed Breeder
Common Goldeneye[1]	*Bucephala clangula*	Possible Breeder	Possible Breeder
Barrow's Goldeneye	*Bucephalai slandica*	Confirmed Breeder	Confirmed Breeder
Common Merganser	*Mergus merganser*	Confirmed Breeder	Confirmed Breeder
Red-breasted Merganser	*Mergus serrator*	Confirmed Breeder	Confirmed Breeder
LOONS			
Red-throated Loon[1]	*Gavia stellata*	Confirmed Breeder	Confirmed Breeder
Pacific Loon	*Gavia pacifica*	Confirmed Breeder	Confirmed Breeder
Common Loon	*Gavia immer*	Confirmed Breeder	Confirmed Breeder
Yellow-billed Loon	*Gavia adamsii*	Migrant	
GREBES			
Horned Grebe[1]	*Podiceps auritus*	Confirmed Breeder	Confirmed Breeder
Red-necked Grebe	*Podiceps grisegena*	Confirmed Breeder	Confirmed Breeder
CRANES			
Sandhill Crane	*Grus canadensis*	Migrant	Confirmed Breeder
GULLS			
Bonaparte's Gull	*Chroicocephalus philadelphia*	Confirmed Breeder	Confirmed Breeder
Mew Gull	*Larus canus*	Confirmed Breeder	Confirmed Breeder
Herring Gull	*Larus argentatus*	Possible Breeder	Migrant
TERNS			
Arctic Tern	*Sterna paradisaea*	Confirmed Breeder	Confirmed Breeder
JAEGERS			

SPECIES-GROUP SPECIES-SUBGROUP Common Name	Scientific Name	2013 Status	2014 Status
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 in 2013.

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										
Unidentified gull						24	1			2						1				

	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**
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. Numbers of Waterbirds Observed on Streams and Water Bodies during Spring and Fall Migration Surveys, 2014.

Survey Area/ Feature Location	Spring Migration					Fall Migration									
	April		May			August		September					October		
	23	29	5–6[1]	11–12	17–18	24–26	30–Sep 1	5–7	11–13	17–19	23–25	29–Oct 1	5–6	11–12	17–18
Dam/ Camp Area															
Water Body															
Unnamed water bodies	0	0	16	3	53	14	18	11	6	9	0	8	0	18	23
Dam/Camp Area Total	0	0	16	3	53	14	18	11	6	9	0	8	0	18	23
Watana Reservoir															
Stream															
Susitna River	0	85	24	–	–	–	–	–	–	–	–	–	–	–	4
Water Body															
Clarence Lake	0	0	14	63	81	121	159	165	182	264	114	105	15	58	10
Fog Lakes[2]	0	9	64	69	196	284	286	334	144	253	43	143	17	2	6
Molar Lake	0	0	14	28	80	79	62	46	28	76	25	27	3	0	0
Pistol Lake	0	0	80	131	149	5	12	8	42	16	12	8	6	0	0
Sally Lake	0	7	0	13	5	1	0	2	0	3	0	2	0	19	0
Watana Lake	0	0	2	4	7	34	27	31	19	18	19	32	0	0	0
Unnamed water bodies	0	11	141	434	427	354	238	378	243	143	124	103	11	4	1
Water Body Subtotal	0	27	315	742	945	878	784	964	658	776	337	420	52	83	17
Watana Reservoir Total	0	112	339	742	945	878	784	964	658	776	337	420	52	83	21
Denali West Corridor															
Stream															
Brushkana Creek	0	0	10	3	3	0	0	13	26	98	0	0	0	0	0
Deadman Creek	0	0	18	57	93	5	4	8	0	0	17	21	0	0	0
Nenana River	0	2	67	2	–	–	–	–	–	–	6	–	–	–	2
Seattle Creek	0	0	–	–	–	–	2	–	–	–	–	–	–	–	–
Stream Subtotal	0	2	95	62	96	5	6	21	26	98	23	21	0	0	2
Water Body															
Big Lake	0	0	2	17	0	41	31	21	5	35	7	35	2	7	7
Deadman Lake	0	4	14	4	6	40	1	53	83	61	70	76	27	2	19
NE Drashner Lake	0	71	76	79	9	0	27	2	9	19	0	0	0	0	0
Tsusena Lake	0	0	0	0	0	0	3	1	0	0	0	2	0	30	23
Unnamed water bodies	0	7	310	775	763	966	877	835	875	706	261	122	0	7	0
Water Body Subtotal	0	82	402	875	778	1,047	939	912	972	821	338	235	29	46	49
Denali West Corridor Total	0	84	497	937	874	1,052	945	933	998	919	361	256	29	46	51
Denali East															
Stream															
Brushkana Creek	0	0	–	8	–	–	–	–	–	–	–	–	–	–	–
Water Body															

Survey Area/ *Feature* Location	Spring Migration					Fall Migration									
	April		May			August		September					October		
	23	29	5–6[1]	11–12	17–18	24–26	30–Sep 1	5–7	11–13	17–19	23–25	29–Oct 1	5–6	11–12	17–18
Brushkana Lake	0	0	0	16	93	48	109	35	10	50	18	2	0	0	1
Denali East (continued)															
Water Body (continued)															
Unnamed water bodies	0	0	11	67	29	98	97	83	74	40	25	32	0	0	0
Water Body Subtotal	0	0	11	83	122	146	206	118	84	90	43	34	0	0	1
Denali East Corridor Total	0	0	11	91	122	146	206	118	84	90	43	34	0	0	1
Chulitna Corridor[3]															
Water body															
High Lake	0	0	0	0	0	7	3	0	0	0	20	1	0	0	0
Miami Lake	0	0	0	0	2	0	1	1	8	1	3	3	0	3	0
Swimming Bear Lake	0	0	0	0	0	7	23	13	9	0	0	0	0	0	0
Unnamed water bodies	0	0	0	27	49	9	7	29	21	15	6	24	25	5	2
Water Body Subtotal	0	0	0	27	51	23	34	43	38	16	29	28	25	8	2
Chulitna Corridor Total	0	0	0	27	51	23	34	43	38	16	29	28	25	8	2
Gold Creek Corridor															
Stream															
Stephan-Murder Connection	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Susitna River	1	100	39	–	–	–	–	–	–	–	–	–	–	–	–
Stream Subtotal	1	100	39	0	0	0	0	0	0	2	0	0	0	0	0
Water body															
Fog Lakes[2]	0	0	0	2	17	31	15	22	26	36	41	12	63	18	11
Murder Lake	7	21	61	70	0	129	42	67	98	121	47	156	185	147	99
Stephan Lake	4	41	34	198	214	174	207	184	147	240	322	411	320	458	292
Unnamed water bodies	0	1	58	58	146	193	185	214	188	126	163	96	200	61	19
Water Body Subtotal	11	63	153	328	377	527	449	487	459	523	573	675	768	684	421
Gold Creek Corridor Total	12	163	192	328	377	527	449	487	459	525	573	675	768	684	421
Total on Streams, All Survey Areas	1	187	158	70	96	5	6	21	26	100	23	21	0	0	6
Total on Water Bodies, All Survey Areas	11	172	897	2,058	2,326	2,635	2,430	2,535	2,217	2,235	1,320	1,400	874	839	513
Total, All Survey Areas	12	359	1,055	2,128	2,422	2,640	2,436	2,556	2,243	2,335	1,343	1,421	874	839	519

1 The part of Watana Reservoir east of Clarence Lake was not surveyed because of inclement weather.

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

3 Most of the 2013 Chulitna Corridor was omitted in 2014; only lakes that were part of the 1980s APA study were surveyed in the area in 2014.

Table 5.1-6. Numbers and Occurrence of Waterbirds during Migration and Breeding Surveys, 2014.

	Spring Migration					Breeding		Fall Migration									
	April		May			May	June	August		September					October		
Species	23	29	5–6	11–12	17–18	24–28	2–6	24–26	30–Sep 1	5–7	11–13	17–19	23–25	29–Oct 1	5–6	11–12	17–18
Greater White-fronted Goose	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Snow Goose	0	0	0	1	0	8	0	0	0	0	0	0	0	0	0	0	0
Canada Goose	0	0	4	7	0	6	4	0	0	0	0	0	0	1	0	0	0
Trumpeter Swan[1]	11	20	57	59	51	68	62	114	120	134	137	124	151	167	121	106	11
Gadwall	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Eurasian Wigeon	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
American Wigeon	0	5	214	357	209	258	213	399	377	374	330	540	91	99	66	22	2
Mallard	0	156	151	167	119	246	223	248	217	170	201	138	175	350	200	230	227
Blue-winged Teal	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Northern Shoveler	0	0	39	133	169	207	226	0	20	70	5	48	2	0	0	0	0
Northern Pintail	0	105	178	328	245	327	212	230	123	110	68	89	15	16	0	2	0
Green-winged Teal	0	25	185	450	188	162	178	214	242	188	176	164	16	13	25	0	2
Unidentified dabbler	0	0	0	0	0	0	0	5	1	4	0	0	0	0	0	0	0
Canvasback	0	0	2	6	3	8	0	0	0	0	0	0	0	0	0	0	0
Ring-necked Duck	0	0	43	80	190	261	126	70	22	96	85	59	53	47	6	29	10
Unidentified scaup	0	0	4	192	599	1,298	1,050	835	840	915	853	656	538	345	251	230	135
Harlequin Duck	0	0	10	0	27	0	2	11	0	9	7	3	4	5	0	0	0
Surf Scoter	0	0	1	56	137	153	99	76	53	15	19	61	4	0	5	0	0
White-winged Scoter	0	0	0	0	46	392	80	3	0	29	0	0	14	0	4	36	12
Black Scoter	0	0	0	0	23	4	15	23	14	9	5	30	8	12	12	0	0
Unidentified scoter	0	0	0	0	0	0	0	0	0	14	0	5	0	0	0	0	0
Long-tailed Duck	0	6	0	3	74	134	76	32	108	46	24	19	11	11	0	1	0
Bufflehead	0	7	31	100	114	109	94	41	48	58	30	52	44	94	32	32	31
Common Goldeneye	0	0	0	1	2	3	2	0	0	0	0	0	0	0	0	6	2
Barrow's Goldeneye	0	4	47	80	70	161	109	0	0	0	0	0	0	0	0	4	8
Unidentified goldeneye	0	22	7	26	19	13	14	138	147	162	194	280	135	224	92	136	67
Common Merganser	1	4	0	0	9	8	6	9	0	6	27	0	18	0	0	0	0
Red-breasted Merganser	0	1	0	12	14	29	18	78	17	40	30	2	41	32	0	3	11
Unidentified merganser	0	0	0	0	0	0	0	0	0	0	0	26	0	0	60	0	0
Unidentified duck	0	0	0	0	0	0	0	14	0	2	1	0	3	0	0	0	0
Red-throated Loon	0	0	0	3	12	6	7	7	1	4	0	0	0	0	0	0	0
Pacific Loon	0	0	0	0	5	18	13	12	8	12	2	2	0	0	0	0	0
Common Loon	0	0	0	4	15	27	18	24	24	24	15	16	9	3	0	1	0
Horned Grebe	0	0	25	10	22	8	5	20	7	30	6	0	9	1	0	0	1
Red-necked Grebe	0	0	0	2	16	16	5	0	5	18	13	15	0	1	0	0	0
Unidentified grebe	0	0	0	1	0	0	0	1	14	0	0	5	0	0	0	0	0
Unidentified diver	0	0	0	0	0	0	0	34	25	14	15	0	2	0	0	1	0
Sandhill Crane	0	0	0	0	0	0	0	2	3	3	0	0	0	0	0	0	0
Bonaparte's Gull	0	0	6	9	7	4	2	0	0	0	0	0	0	0	0	0	0

	Spring Migration					Breeding		Fall Migration									
	April		May			May	June	August		September					October		
Species	23	29	5–6	11–12	17–18	24–28	2–6	24–26	30–Sep 1	5–7	11–13	17–19	23–25	29–Oct 1	5–6	11–12	17–18
Mew Gull	0	4	45	33	33	43	39	0	0	0	0	0	0	0	0	0	0
Herring Gull	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Unidentified gull—large	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Unidentified gull	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arctic Tern	0	0	0	2	2	6	12	0	0	0	0	0	0	0	0	0	0

1 Some swans may have been Tundra Swans because groups were observed during spring and fall on the ground-based migration study in 2013. Comparable ground studies were not conducted in 2014.

Table 5.1-7. Numbers of Waterbirds by Species-group Observed on Streams and Water Bodies during Spring and Fall Migration Surveys, 2014.

Survey Area/	Spring					Fall									
	April		May			August		September					October		
Species-Group	23	29	5–6[1]	11–12	17–18	24–26	30–1	5–7	11–13	17–19	23–25	29–1	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
Swans	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Ducks	0	0	16	3	43	13	18	7	6	9	0	8	0	18	23
Loons	0	0	0	0	4	1	0	2	0	0	0	0	0	0	0
Grebes	0	0	0	0	6	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
Gulls/Terns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	0	16	3	53	14	18	11	6	9	0	8	0	18	23
Watana Reservoir															
Geese	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Swans	0	2	9	14	3	19	21	27	25	24	20	17	7	2	4
Ducks	0	110	317	708	915	827	741	905	622	732	309	403	45	81	17
Loons	0	0	0	1	9	9	13	9	3	6	3	0	0	0	0
Grebes	0	0	1	5	14	21	9	23	8	13	5	0	0	0	0
Cranes	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Gulls/Terns	0	0	12	14	4	0	0	0	0	1	0	0	0	0	0
Subtotal	0	112	339	742	945	878	784	964	658	776	337	420	52	83	21
Denali West															
Geese	0	0	4	12	0	0	0	0	0	0	0	0	0	0	0
Swans	0	13	36	33	33	78	70	77	83	73	72	36	2	2	0
Ducks	0	68	421	863	809	968	869	836	905	840	289	220	27	44	51
Loons	0	0	0	1	8	6	5	7	5	4	0	0	0	0	0
Grebes	0	0	24	2	3	0	1	13	5	2	0	0	0	0	0
Cranes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gulls/Terns	0	3	12	26	21	0	0	0	0	0	0	0	0	0	0
Subtotal	0	84	497	937	874	1,052	945	933	998	919	361	256	29	46	51
Denali East															
Geese	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Swans	0	0	2	4	2	8	12	6	7	2	4	2	0	0	0
Ducks	0	0	9	86	113	138	187	104	77	88	39	32	0	0	1
Loons	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grebes	0	0	0	0	3	0	7	8	0	0	0	0	0	0	0
Cranes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gulls/Terns	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0
Subtotal	0	0	11	91	122	146	206	118	84	90	43	34	0	0	1
Chulitna Corridor[2]															
Geese	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Swans	0	0	0	0	2	0	2	7	7	2	6	0	0	0	0
Ducks	0	0	0	27	45	16	26	27	24	8	17	25	25	7	2
Loons	0	0	0	0	2	7	6	9	6	6	6	3	0	1	0
Grebes	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0
Cranes	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
Subtotal	0	0	0	27	51	23	34	43	38	16	29	28	25	8	2
Gold Creek Corridor															
Geese	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Swans	11	5	10	8	11	9	15	15	15	23	49	112	112	102	7
Ducks	1	157	149	304	334	498	413	452	436	495	520	560	656	582	413
Loons	0	0	0	5	9	20	9	13	3	2	0	0	0	0	0
Grebes	0	0	0	6	10	0	9	4	5	5	4	2	0	0	1
Cranes	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0
Gulls/Terns	0	1	33	5	13	0	0	0	0	0	0	0	0	0	0
Subtotal	12	163	192	328	377	527	449	487	459	525	573	675	768	684	421
All Survey Areas															
Geese	0	0	4	12	0	0	0	0	0	0	0	1	0	0	0
Swans	11	20	57	59	51	114	120	134	137	124	151	167	121	106	11
Ducks	1	335	912	1,991	2,259	2,460	2,254	2,331	2,070	2,172	1,174	1,248	753	732	507
Loons	0	0	0	7	32	43	33	40	17	18	9	3	0	1	0
Grebes	0	0	25	13	38	21	26	48	19	20	9	2	0	0	1
Cranes	0	0	0	0	0	2	3	3	0	0	0	0	0	0	0
Gulls/Terns	0	4	57	46	42	0	0	0	0	1	0	0	0	0	0
Total Number	12	359	1,055	2,128	2,422	2,640	2,436	2,556	2,243	2,335	1,343	1,421	874	839	519

1 The part of Watana Reservoir east of Clarence Lake was not surveyed because of inclement weather.

2 Most of the 2013 Chulitna Corridor was omitted in 2014; only lakes that were part of the 1980s APA study were surveyed in the area in 2014.

Table 5.1-8. Seasonal Population Statistics for Water Bodies Surveyed during Spring Migration Surveys, 1980–1981 and 2013–2014 .

		Spring 1981[1]			Spring 2013			Spring 2014		
Water Bodies[2]	Size (mi^2)	Mean no. birds	Mean density ($no./mi^2$)	Mean no. species	Mean no. birds	Mean density ($no./mi^2$)	Mean no. species	Mean no. birds	Mean density ($no./mi^2$)	Mean no. Species
WB 107 (Murder Lake)	0.06	51.3	876.0	5.0	63.7	1,087.1	5.8	28.6	488.4	4.2
WB 106 (Stephan Lake)	1.38	99.7	72.2	7.3	47.8	34.6	6.5	96.0	69.5	8.2
WB 145 (Clarence Lake)	0.58	54.7	93.6	7.0	33.0	56.5	3.3	32.0	54.8	4.4
WB 059 (in Fog Lake group)	0.58	21.3	36.4	4.7	21.8	37.3	1.7	30.6	52.3	4.4
WB 067 (Pistol Lake)	0.34	85.0	250.5	6.0	19.7	58.0	2.8	71.8	211.6	7.0
WB 105[3] (near Stephan Lake)	0.21				5.2	24.3	2.2	7.4	34.9	3.0
WB 130[3] (Deadman Lake)	0.62				2.5	4.0	1.0	4.6	7.4	1.8
WB 060[3] (in Fog Lake group)	0.43				8.3	19.5	1.5	31.2	72.9	3.2
WB 069[3] (west of Pistol Lake)	0.05				0.0	0.0	0.0	38.0	784.4	3.8
WB 148 (Watana Lake)	0.48	21.3	44.6	3.0	0.8	1.7	0.3	2.4	5.0	0.8

Notes:

1. Data from APA Susitna Hydroelectric Project study (Kessel et al. 1982).
2. Water body designations follow Kessel et al. (1982).
3. Population statistics not available for 1980–1981 surveys.

Table 5.1-9. Seasonal Population Statistics for Water Bodies Surveyed during Fall Migration Surveys, 1980–1981 and 2013–2014 .

Water Bodies[2]	Size (mi^2)	Fall 1981[1] Mean no. birds	Fall 1981 Mean density (no./mi^2)	Fall 1981 Mean no. species	Fall 2013 Mean no. birds	Fall 2013 Mean density (no./mi^2)	Fall 2013 Mean no. species	Fall 2014 Mean no. birds	Fall 2014 Mean density (no./mi^2)	Fall 2014 Mean no. Species
WB 107 (Murder Lake)	0.06	39.0	665.9	4.3	96.3	1,644.3	4.5	110.7	1,890.2	5.0
WB 106 (Stephan Lake)	1.38	156.0	112.9	9.5	214.2	155.1	8.8	275.5	199.4	9.2
WB 145 (Clarence Lake)	0.58	103.8	177.6	7.0	111.7	191.1	5.7	119.3	204.2	5.9
WB 059 (in Fog Lake group)	0.58	72.8	124.5	6.5	123.4	211.0	6.3	71.7	122.6	4.8
WB 067[3] (Pistol Lake)	0.47	19.0	40.5	4.0	26.9	57.4	3.0	13.2	28.1	2.8
WB 105[4] (near Stephan Lake)	0.21				40.8	192.2	4.8	28.0	131.9	3.4
WB 130[4] (Deadman Lake)	0.62				46.1	74.2	2.6	43.2	69.5	3.0
WB 060[4] (in Fog Lake group)	0.43				55.8	130.3	5.6	67.1	156.7	4.6
WB 069[4] (west of Pistol Lake)	0.05				5.18	107.0	1.6	18.8	388.1	2.6
WB 148 (Watana Lake)	0.48	95.8	200.5	3.8	31.0	64.9	4.3	17.9	37.5	2.6

Notes:

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 surveys, following Kessel et al. (1982).
4. Population statistics not available for 1980–1981 surveys.

Table 5.1-10. Importance Ranks and Values of Water Bodies Surveyed for Waterbirds during Spring and Fall Migration Surveys, 1980–1981 and 2013–2014.

Water Bodies[3]	Survey Area	Importance Rank[1] (Value[2])					
		Spring 1981[4]	Fall 1980[4]	Spring 2013	Fall 2013	Spring 2014	Fall 2014
WB 107 (Murder Lake)	Gold Creek Corridor	1 (21.5)	1 (19.7)	1 (132.9)	1 (63.9)	4 (41.4)	1 (67.4)
WB 106 (Stephan Lake)	Gold Creek Corridor	3 (9.0)	2 (18.7)	2 (50.6)	2 (41.3)	2 (47.1)	2 (49.3)
WB 145 (Clarence Lake)	Watana Reservoir	4 (7.7)	3 (15.0)	3 (32.9)	4 (26.3)	5 (20.8)	3 (27.1)
WB 059 (in Fog Lake group)	Watana Reservoir	8 (3.8)	4 (12.7)	5 (19.7)	3 (29.0)	6 (20.3)	5 (18.1)
WB 067 (Pistol Lake)	Danali Corridor	2 (11.9)	9[6] (5.8)	4 (24.6)	11[6] (10.0)	3 (45.2)	14[6] (6.3)
WB 105 (near Stephan Lake)	Gold Creek Corridor	10 (3.5)	6 (10.3)	6 (12.6)	6 (17.0)	8 (10.1)	7 (11.4)
WB 130 (Deadman Lake)	Denali Corridor	6 (4.3)	7 (7.0)	8 (5.3)	10 (11.1)	10 (5.4)	9 (11.0)
WB 060 (in Fog Lake group)	Watana Reservoir	9 (3.8)	13 (1.8)	7 (11.2)	5 (18.1)	7 (19.0)	4 (18.2)
WB 069 (unnamed lake W of Pistol)	Watana Reservoir	n/a[5] n/a[5]	8 (6.8)	>11 (0.0)	14 (5.8)	1 (58.2)	6 (15.7)
WB 148 (Watana Lake)	Watana Reservoir	11 (3.0)	5 (12.0)	11 (1.8)	9 (11.5)	16 (2.6)	13 (6.8)

Notes:

1. Rank of importance value within the season. Table 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 and 2014.
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. Rank and importance value for lake not presented in Kessel et al. (1982).
6. Includes water bodies 064–066, which were grouped with Pistol Lake for fall analyses following Kessel et al. (1982).

Table 5.1-11. 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 5.1-12. 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 5.1-13. 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 5.1-14. 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 5.1-15. 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. Numbers and Densities[1] (birds/mi) of Waterbirds Observed during Breeding Surveys of Water Bodies, 2013.

	Dam/Camp Area		Watana Reservoir		Denali Corridor		Chulitna Corridor		Gold Creek Corridor		Total (Density)	
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 (in parentheses) calculated as the number of birds/lake area surveyed in each corridor.

Table 5.2-2. Numbers and Density (mi²)[1] of Waterbirds Observed during Breeding Surveys of Water Bodies, 2014.

	Dam/Camp Area		Watana Reservoir		Denali West Corridor		Denali East Corridor		Chulitna Corridor[2]		Gold Creek Corridor		Total (Density)	
Species	**May 24–28**	**Jun 2–28**	**May 24–28**	**Jun 2–28**	**May 24–28**	**Jun 2–28**	**May 24–28**	**Jun 2–28**	**May 24–28**	**Jun 2–28**	**May 24–28**	**Jun 2–28**	**May 24–28**	**Jun 2–28**
Snow Goose											8 (2.1)		8 (0.5)	
Canada Goose					2 (0.4)	4 (0.9)	4 (6.7)						6 (0.4)	4 (0.3)
Trumpeter Swan			10 (2.1)	11 (2.3)	43 (9.1)	38 (8.1)	5 (8.3)	5 (8.3)	2 (1.3)	4 (2.5)	8 (2.1)	4 (1)	68 (4.3)	62 (3.9)
Eurasian Wigeon						1 (0.2)								1 (0.1)
American Wigeon	6 (15)		75 (16)	73 (15.5)	152 (32.3)	95 (20.2)	4 (6.7)	6 (10)	2 (1.3)		19 (4.9)	39 (10)	258 (16.1)	213 (13.3)
Mallard	6 (15)	2 (5)	76 (16.2)	54 (11.5)	117 (24.9)	118 (25.1)	13 (21.7)	7 (11.7)	5 (3.1)	1 (0.6)	29 (7.4)	41 (10.5)	246 (15.4)	223 (13.9)
Blue-winged Teal				1 (0.2)										1 (0.1)
Northern Shoveler	22 (55)	17 (42.5)	43 (9.1)	93 (19.8	99 (21.1)	108 (23.0)	7 (11.7)	3 (5)	3 (1.9)		33 (8.5)	5 (1.3)	207 (12.9)	226 (14.1)
Northern Pintail	3 (7.5)		104 (22.1)	61 (13)	185 (39.4)	121 (25.7)	23 (38.3)	6 (10)	1 (0.6)	6 (3.8)	11 (2.8)	18 (4.6)	327 (20.4)	212 (13.3)
Green-winged Teal		3 (7.5)	71 (15.1)	65 (13.8)	61 (13)	74 (15.7)	9 (15)	7 (11.7)	2 (1.3)	6 (3.8)	19 (4.9)	23 (5.9)	162 (10.1)	178 (11.1)
Canvasback					2 (0.4)						6 (1.5)		8 (0.5)	
Ring-necked Duck	5 (12.5)	4 (10)	50 (10.6)	26 (5.5)	111 (23.6)	77 (16.4)	11 (18.3)	1 (1.7)	13 (8.1)		71 (18.2)	18 (4.6)	261 (16.3)	126 (7.9)
Unidentified scaup	31 (77.5)	11 (27.5)	488 (103.8)	430 (91.5)	436 (92.8)	366 (77.9)	82 (136.7)	75 (125)	25 (15.6)	3 (1.9)	236 (60.5)	165 (42.3)	1,298 (81.1)	1,050 (65.6)
Harlequin Duck												2 (0.5)		2 (0.1)
Surf Scoter	5 (12.5)	3 (7.5)	72 (15.3)	58 (12.3)	8 (1.7)	9 (1.9)	6 (10)		2 (1.3)		60 (15.4)	29 (7.4)	153 (9.6)	99 (6.2)
White-winged Scoter	58 (145) (58)		95 (20.2)	64 (13.6)	55 (11.7)	4 (0.9)	43 (71.7)	6 (10)	40 (25)		101 (25.9)	6 (1.5)	392 (24.5)	80 (5.0)
Black Scoter			2 (0.4)	3 (0.6)		1 (0.2)					2 (0.5)	11 (2.8)	4 (0.3)	15 (0.9)
Long-tailed Duck	2 (5)		21 (4.5)	29 (6.2)	25 (5.3)	18 (3.8)	44 (73.3)	24 (40)	34 (21.3)		8 (2.1)	5 (1.3)	134 (8.4)	76 (4.8)
Bufflehead	2 (5)		31 (6.6)	24 (5.1)	43 (9.1)	25 (5.3)	12 (20)	24 (40)	2 (1.3)		19 (4.9)	21 (5.4)	109 (6.8)	94 (5.9)
Common Goldeneye								1 (1.7)			3 (0.8)	1 (0.3)	3 (0.2)	2 (0.1)
Barrow's Goldeneye	4 (10)		74 (15.7)	19 (4.0)	31 (6.6)	50 (10.6)	2 (3.3)	4 (6.7)	1 (0.6)	9 (5.6)	49 (12.6)	27 (6.9)	161 (10.1)	109 (6.8)
Unidentified goldeneye		2 (5)	2 (0.4)	4 (0.9)	8 (1.7)	2 (0.4)				1 (0.6)	3 (0.8)	5 (1.3)	13 (0.8)	14 (0.9)
Common Merganser					5 (1.1)	6 (1.3)					3 (0.8)		8 (0.5)	6 (0.4)
Red-breasted Merganser		2 (5)	7 (1.5)	2 (0.4)	9 (1.9)	9 (1.9)					13 (3.3)	5 (1.3)	29 (1.8)	18 (1.1)
Red-throated Loon			1 (0.2)	2 (0.4)	1 (0.2)	4 (0.9)	1 (1.7)				3 (0.8)	1 (0.3)	6 (0.4)	7 (0.4)
Pacific Loon	4 (10)	6 (15)	2 (0.4)	2 (0.4)		2 (0.4)	2 (3.3)		5 (3.1)		5 (1.3)	3 (0.8)	18 (1.1)	13 (0.8)
Common Loon	1 (2.5)		4 (0.9)	5 (1.1)	4 (0.9)	4 (0.9)	1 (1.7)	1 (1.7)	11 (6.9)	6 (3.8)	6 (1.5)	2 (0.5)	27 (1.7)	18 (1.1)
Horned Grebe	2 (5)		5 (1.1)	3 (0.6)	1 (0.2)	2 (0.4)							8 (0.5)	5 (0.3)
Red-necked Grebe			4 (0.9)			1 (0.2)	3 (5.0)				9 (2.3)	4 (1.0)	16 (1.0)	5 (0.3)
Bonaparte's Gull						2 (0.4)					4 (1.0)		4 (0.3)	2 (0.1)
Mew Gull	3 (7.5)	3 (7.5)	6 (1.3)	3 (0.6)	19 (4.0)	23 (4.9)	7 (11.7)	1 (1.7)	5 (3.1)	4 (2.5)	3 (0.8)	5 (1.3)	43 (2.7)	39 (2.4)
Arctic Tern					4 (0.9)	10 (2.1)				2 (1.3)	2 (0.5)		6 (0.4)	12 (0.8)
Area (mi²) of Lakes Surveyed	0.4	0.4	4.7	4.7	4.7	4.7	0.6	0.6	1.6	1.6	3.9	3.9	16.0	16.0
Total Density	154 (415.1)	53 (142.9)	1,243 (261.8)	1,032 (217.4)	1,421 (303.4)	1,174 (250.6)	279 (431.2)	171 (264.3)	153 (95.4)	42 (26.2)	733 (187.3)	440 (112.4)	3,983 (249.4)	2,912 (182.4)

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

2. Most of the 2013 Chulitna Corridor was omitted in 2014; only lakes that were part of the 1980s APA study were surveyed in the area in 2014.

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	4	0	9	1	9	0.5	4
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						214	11.3	100
June 15								
Trumpeter Swan[7]	0	5	5	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]	0	1	5	7	3.3	23	1.2	6
Common Loon[7]	0	0	1	1	1	1	0.1	0
Horned Grebe[7]	0	2	0	4	5.4	22	1.1	6
Total						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 and Densities of Waterbirds Observed during Breeding-population Transect Surveys, 2014.

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/ mi^2)	Composition (% of total)
June 2								
Canada Goose[7]	1	0	0	1	1	1	0.1	0
Trumpeter Swan[7]	1	1	0	4	1	4	0.2	1
American Wigeon	3	1	0	8	3.65	29	1.5	6
Mallard	8	4	0	24	3.57	86	4.5	18
Northern Shoveler	1	0	0	2	3.35	7	0.3	1
Northern Pintail	8	0	0	16	2.51	40	2.1	8
Green-winged Teal	3	6	0	18	8.88	160	8.3	34
Unidentified dabbling duck	0	1	0	2	1	2	0.1	0
Unidentified scaup[7]	15	18	0	51	1.82	93	4.8	20
Surf Scoter	0	10	0	20	1.08	22	1.1	5
Black Scoter	0	2	0	4	1.08	4	0.2	1
Unidentified scoter	0	2	0	4	1.08	4	0.2	1
Long-tailed Duck	0	2	0	4	1.99	8	0.4	2
Red-throated Loon[7]	1	1	0	3	3.3	10	0.5	2
Red-necked Grebe[7]	1	0	0	1	5.4	5	0.3	1
Total						475	24.6	100
June 15								
Trumpeter Swan[7]	1	4	0	9	1	9	0.5	3
American Wigeon	3	0	0	6	3.65	22	1.1	6
Mallard	3	2	0	10	3.57	36	1.9	10
Northern Pintail	1	0	0	2	2.51	5	0.3	1
Green-winged Teal	6	0	0	12	8.88	107	5.5	30
Unidentified scaup[7]	12	18	14	62	1.82	113	5.9	32
Surf Scoter	3	2	0	10	1.08	11	0.6	3
Black Scoter	2	4	0	12	1.08	13	0.7	4
Long-tailed Duck	0	2	0	4	1.99	8	0.4	2
Bufflehead	2	2	0	8	1.86	15	.8	4
Unidentified duck	2	0	0	2	1	2	0.1	1
Red-throated Loon[7]	1	0	0	1	3.3	3	0.2	1
Common Loon[7]	0	1	0	2	1	2	0.1	1
Red-necked Grebe[7]	2	0	0	2	5.4	11	0.6	3
Total						357	18.7	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). No correction factor applied to unidentified ducks (VCF = 1).
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 (mi^2) sample area.
7. Males and single birds not doubled in calculating indicated total number of birds.

Table 5.2-5. 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 5.2-6. Numbers of Harlequin Ducks Observed during Pre-nesting Surveys, 2013.

Survey Area	June 1–5[1]				June 14–17[1]			
Stream[2]	Single Male	Single Female	Pairs	Total Birds[3]	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 5.2-7. Numbers and Linear Densities (birds/mi) of Harlequin Ducks Observed during Pre-nesting Surveys, 2014.

	May 24–28					June 2–6			
Survey Area Stream[1]	Length of stream (mi)	Single Male	Single Female	Pairs	Total Birds[2]	Single Male	Single Female	Pairs	Total Birds[2]
Dam/Camp Area									
Deadman Creek	4.08	0	0	1 (0.25)	2 (0.49)	0	0	1 (0.25)	2 (0.49)
Susitna River	1.15	0	0	0	0	0	0	0	0
Tsusena Creek	3.24	0	0	0	0	0	0	0	0
Dam/Camp Area Total	8.47	0	0	1 (0.12)	2 (0.24)	0	0	1 (0.12)	2 (0.24)
Watana Reservoir									
Black River	10.71	1 (0.09)	1 (0.09)	9 (0.84)	20 (1.87)	3 (0.28)	0	5 (0.47)	13 (1.21)
Fog Creek	6.71	5 (0.75)	0	4 (0.60)	13 (1.94)	0	0	0	0
Gilbert Creek	10.40	2 (0.19)	0	4 (0.38)	10 (0.96)	10 (0.96)	0	5 (0.48)	20 (1.92)
Goose Creek	15.02	1 (0.07)	1 (0.07)	8 (0.53)	18 (1.20)	3 (0.20)	0	5 (0.33)	13 (0.87)
Jay Creek	18.12	0	0	1 (0.06)	2 (0.11)	0	0	0	0
Kosina Creek	18.79	2 (0.11)	0	6 (0.32)	14 (0.75)	12 (0.64)	0	3 (0.16)	18 (0.96)
Oshetna River	20.09	4 (0.20)	0	11 (0.55)	26 (1.29)	0	0	0	0
R12	7.12	0	0	2 (0.28)	4 (0.56)	0	0	0	0
R19	6.73	1 (0.15)	0	2 (0.30)	5 (0.74)	1 (0.15)	0	2 (0.30)	5 (0.74)
R21	9.98	2 (0.20)	0	5 (0.50)	12 (1.20)	8 (0.80)	0	2 (0.20)	12 (1.20)
Susitna River	51.78	5 (0.10)	1 (0.02)	7 (0.14)	20 (0.39)	17 (0.33)	0	5 (0.10)	27 (0.52)
Tsisi Creek	10.36	1 (0.10)	0	10 (0.97)	21 (2.03)	6 (0.58)	0	4 (0.39)	14 (1.35)
Watana Creek	28.83	3 (0.10)	0	19 (0.66)	41 (1.42)	9 (0.31)	0	4 (0.14)	17 (0.59)
Watana Reservoir Total	214.62	27 (0.13)	3 (0.01)	88 (0.41)	206	69 (0.32)	0	35 (0.16)	139 (0.65)
Denali West Corridor									
Brushkana Creek	12.46	0	0	16 (1.28)	32 (2.57)	1 (0.08)	0	7 (0.56)	15 (1.20)
Clark Creek	8.06	1 (0.12)	0	2 (0.25)	5 (0.62)	0	0	0	0
Deadman Creek	39.67	1 (0.03)	2 (0.05)	32 (0.81)	67 (1.69)	7 (0.18)	0	25 (0.63)	57 (1.44)
Jack River	18.13	2 (0.11)	0	7 (0.39)	16 (0.88)	2 (0.11)	1 (0.06)	2 (0.11)	7 (0.39)
Nenana River	18.41	0	0	0	0	0	1 (0.05)	1 (0.05)	3 (0.16)

Survey Area Stream[1]	Length of stream (mi)	May 24–28 Single Male	May 24–28 Single Female	May 24–28 Pairs	May 24–28 Total Birds[2]	June 2–6 Single Male	June 2–6 Single Female	June 2–6 Pairs	June 2–6 Total Birds[2]
Seattle Creek	10.32	1 (0.10)	0	4 (0.39)	9 (0.87)	0	0	0	0
Denali West Corridor (continued)									
Tsusena Creek	19.79	0	0	4 (0.20)	8 (0.40)	4 (0.20)	0	0	4 (0.20)
Wells Creek	3.94	0	0	1 (0.25)	2 (0.51)	0	0	1 (0.25)	2 (0.51)
Denali West Corridor Total	130.79	5 (0.04)	3 (0.02)	66 (0.50)	140	14 (0.11)	2 (0.02)	36 (0.28)	88 (0.67)
Denali East Corridor									
Brushkana Creek	11.07	0	0	3 (0.27)	6 (0.54)	0	0	1 (0.09)	2 (0.18)
Monahan Creek	7.44	1 (0.13)	0	4 (0.54)	9 (1.21)	0	1 (0.13)	1 (0.13)	3 (0.40)
Denali East Corridor Total	18.51	1 (0.05)	0	7 (0.38)	15 (0.81)	0	1 (0.05)	2 (0.11)	5 (0.27)
Gold Creek Corridor									
Cheechako Creek	9.87	0	0	0	0	0	0	0	0
Chinook Creek	6.84	0	0	0	0	0	0	0	0
Devil Creek	20.05	1 (0.05)	0	3 (0.15)	7 (0.35)	1 (0.05)	0	0	1 (0.05)
Fog Creek	16.03	2 (0.12)	0	5 (0.31)	12 (0.75)	0	0	0	0
Gold Creek	7.77	0	0	0	0	0	0	0	0
Indian River	17.41	1 (0.06)	0	6 (0.34)	13 (0.75)	6 (0.34)	0	1 (0.06)	8 (0.46)
Portage Creek	30.97	1 (0.03)	0	0	1 (0.03)	4 (0.13)	0	1 (0.03)	6 (0.19)
R9	18.04	0	1 (0.06)	0	1 (0.06)	0	0	0	0
Susitna River	44.99	11 (0.24)	0	12 (0.27)	35 (0.78)	9 (0.20)	1 (0.02)	3 (0.07)	16 (0.36)
Thoroughfare Creek	6.35	0	0	0	0	0	0	0	0
Gold Creek Corridor Total	178.32	16 (0.09)	1 (0.01)	26 (0.15)	69 (0.39)	20 (0.11)	1 (0.01)	5 (0.03)	31 (0.17)
Total All Survey Areas	550.73	49 (0.09)	6 (0.01)	188 (0.34)	431	103 (0.19	4 (0.01)	79 (0.14)	265 (0.48)

1 Susitna River and Deadman, Brushkana, Fog, and Tsusena creeks occurred in multiple survey areas.

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

Table 5.2-8. 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 5.2-9. Numbers and Linear Densities (birds or broods/mi) of Harlequin Ducks Observed during Brood-rearing Surveys, 2014.

		August 2–6				August 17–19			
Survey Area Stream[1]	Length of stream (mi)	Females	Young	Total Birds	No. Broods	Females	Young	Total Birds	No. Broods
Dam/Camp Area									
Deadman Creek	4.08	0	0	0	0	0	1 (0.25)	1 (0.25)	1 (0.25)
Tsusena Creek	3.24	0	0	0	0	0	0	0	0
Dam/Camp Area Total	7.32	0	0	0	0	0	1 (0.14)	1 (0.14	1 (0.14
Watana Reservoir									
Black River	10.71	8 (0.75)	0	8 (0.75)	0	1 (0.09)	2 (0.19)	3 (0.28)	1 (0.09)
Fog Creek	6.71	0	0	0	0	1 (0.15)	2 (0.30)	3 (0.45)	1 (0.15)
Gilbert Creek	10.40	4 (0.38)	0	4 (0.38)	0	1 (0.10)	7 (0.67)	8 (0.77)	1 (0.10)
Goose Creek	15.02	0	0	0	0	2 (0.13)	9 (0.60)	11 (0.73)	3 (0.20)
Jay Creek	18.12	0	0	0	0	0	0	0	0
Kosina Creek	18.79	5 (0.27)	7 (0.37)	12 (0.64)	2 (0.11)	2 (0.11)	10 (0.53)	12 (0.64)	2 (0.11)
Oshetna River	20.09	0	0	0	0	0	0	0	0
R12	7.12	0	0	0	0	0	0	0	0
R19	6.73	0	0	0	0	2 (0.30)	7 (1.04)	9 (1.34)	2 (0.30)
R21	9.98	4 (0.40)	18 (1.80)	22 (2.20)	4 (0.40)	4 (0.40)	12 (1.20)	16 (1.60)	3 (0.30)
Tsisi Creek	10.36	1 (0.10)	5 (0.48)	6 (0.58)	1 (0.10)	0	0	0	0
Watana Creek	28.83	1 (0.03)	2 (0.07)	3 (0.10)	1 (0.03)	2 (0.07)	5 (0.17)	7 (0.24)	2 (0.07)
Watana Reservoir Total	162.86	23 (0.14)	32 (0.20)	55 (0.34)	8 (0.05)	15 (0.09)	54 (0.33)	69 (0.42)	15 (0.09)
Denali West Corridor									
Brushkana Creek	12.46	0	0	0	0	1 (0.08)	6 (0.48)	7 (0.56)	1 (0.08)
Clark Creek	8.06	0	0	0	0	0	0	0	0
Deadman Creek	39.67	5 (0.13)	18 (0.45)	23 (0.58)	4 (0.10)	6 (0.15)	26 (0.66)	32 (0.81)	6 (0.15)
Jack River	18.13	0	0	0	0	3 (0.17)	8 (0.44)	11 (0.61)	2 (0.11)
Seattle Creek	10.32	0	0	0	0	0	0	0	0
Tsusena Creek	19.79	0	0	0	0	0	4 (0.20)	4 (0.20)	1 (0.05)
Wells Creek	3.94	0	0	0	0	0	0	0	0

Survey Area Stream[1]	Length of stream (mi)	August 2–6				August 17–19			
		Females	Young	Total Birds	No. Broods	Females	Young	Total Birds	No. Broods
Denali West Corridor Total	112.37	5 (0.04)	18 (0.16)	23 (0.20)	4 (0.04)	10 (0.09)	44 (0.39)	54 (0.48)	10 (0.09)
Denali East Corridor									
Brushkana Creek	11.07	0	0	0	0	0	0	0	0
Monahan Creek	7.44	0	0	0	0	0	0	0	0
Denali East Corridor Total	18.51	0	0	0	0	0	0	0	0
Gold Creek Corridor									
Cheechako Creek	9.87	0	0	0	0	0	0	0	0
Chinook Creek	6.84	0	0	0	0	0	0	0	0
Devil Creek	20.05	0	0	0	0	0	0	0	0
Fog Creek	16.03	0	0	0	0	0	0	0	0
Gold Creek	7.77	0	0	0	0	0	0	0	0
Indian River	17.41	0	0	0	0	4 (0.23)	12 (0.69)	16 (0.92)	3 (0.17)
Portage Creek	30.97	2 (0.06)	0	2 (0.06)	0	2 (0.06)	10 (0.32)	12 (0.39)	2 (0.06)
R9	18.04	0	0	0	0	0	0	0	0
Thoroughfare Creek	6.35	0	0	0	0	0	0	0	0
Gold Creek Corridor Total	133.33	2 (0.02)	0	2 (0.02)	0	6 (0.05)	22 (0.17)	28 (0.21)	5 (0.04)
Total All Survey Areas	434.39	30 (0.07)	50 (0.12)	80 (0.18)	12 (0.03)	31 (0.07)	121 (0.28)	152 (0.35)	31 (0.07)

1 Susitna River and Deadman, Brushkana, Fog, and Tsusena creeks occurred in multiple survey areas.

Table 5.2-10. 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 5.2-11. 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 with no visible feathers, Class 2 chicks are partially feathered, and Class 3 chicks are fully feathered.

Table 5.2-12. Numbers of Waterbird Broods Observed on Water Bodies during Brood-rearing Surveys, 2014.

	Dam/Camp Area			Watana Reservoir			Denali West Corridor			Denali East Corridor			Gold Creek Corridor		
Species	**Jul 9–12**	**Jul 19–23**	**Aug 2–6**	**Jul 9–12**	**Jul 19–23**	**Aug 2–6**	**Jul 9–12**	**Jul 19–23**	**Aug 2–6**	**Jul 9–12**	**Jul 19–23**	**Aug 2–6**	**Jul 9–12**	**Jul 9–23**	**Aug 2–6**
Trumpeter Swan	0	0	0	0	0	0	5	6	5	1	1	1	0	0	0
American Wigeon	0	0	0	0	1	0	4	16	7	1	1	2	0	0	0
Mallard	0	0	0	0	0	0	2	2	2	0	0	0	0	2	0
Northern Shoveler	0	0	0	0	0	0	0	4	3	0	0	0	0	0	0
Northern Pintail	1	0	0	0	1	0	3	18	2	2	1	0	0	0	0
Green-winged Teal	1	0	1	2	3	0	8	32	12	2	2	1	1	0	0
Unident. Dabbling duck	0	1	0	0	0	0	4	7	2	1	0	0	0	0	0
Ring-necked Duck	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Greater Scaup	0	0	0	0	0	2	0	0	2	0	0	0	0	0	1
Unident. Scaup	2	3	3	1	6	7	6	29	31	0	0	2	0	2	3
Surf Scoter	2	2	0	0	0	0	0	0	0	0	0	0	1	2	1
Black Scoter	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Long-tailed Duck	0	0	0	0	0	0	2	2	1	2	3	2	0	0	0
Barrow's Goldeneye	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Unident. goldeneye	0	0	0	7	7	3	3	4	3	0	0	0	5	6	2
Common Merganser	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Red-breasted Merganser	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Unident. Duck	0	0	3	0	1	1	2	2	4	0	0	0	0	0	0
Red-throated Loon	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Pacific Loon	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2
Common Loon	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
Horned Grebe	0	1	0	1	1	0	0	0	0	0	0	0	1	1	1
Red-necked Grebe	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1
Bonaparte's Gull	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Mew Gull	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Total Broods	**8**	**7**	**7**	**13**	**22**	**13**	**40**	**127**	**77**	**9**	**9**	**8**	**10**	**16**	**11**
Number of Species	**3**	**4**	**2**	**5**	**8**	**2**	**9**	**13**	**12**	**5**	**6**	**5**	**6**	**7**	**6**
Density (broods/mi²)	**21.6**	**18.9**	**18.9**	**26.9**	**45.5**	**26.9**	**9.9**	**31.4**	**19.1**	**45.5**	**45.5**	**40.4**	**6.6**	**10.6**	**7.3**

Table 5.2-13. Age Subclass[1] of broods of selected species of ducks observed during brood-rearing Surveys, 2014.

	July 9–12							July 19–23								August 1–6							
Species	**1A**	**1B**	**1C**	**2A**	**2B**	**2C**	**Brood Total**	**1A**	**1B**	**1C**	**2A**	**2B**	**2C**	**3**	**Brood Total**	**1A**	**1B**	**1C**	**2A**	**2B**	**2C**	**3**	**Brood Total**
American Wigeon	1	3	1	0	0	0	5	0	2	4	3	6	3	0	18	0	0	0	0	2	2	5	9
Mallard	0	0	1	1	0	0	2	0	0	0	0	1	3	0	4	0	0	0	0	1	0	1	2
Northern Shoveler	0	0	0	0	0	0	0	0	0	1	0	2	1	0	4	0	0	1	0	0	0	2	3
Northern Pintail	1	1	1	0	2	1	6	0	0	0	2	2	9	7	20	0	0	0	0	0	0	2	2
Green-winged Teal	1	6	1	1	2	3	14	3	2	3	1	9	12	7	37	1	0	1	0	1	5	6	14
Unidentified dabbler	1	2	0	1	0	1	5	1	0	5	2	0	0	0	8	0	0	1	0	0	0	0	1
Ring-necked duck	2	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greater Scaup	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	0	0	5
Unidentified scaup	8	0	0	1	0	0	9	22	14	3	0	0	1	0	40	7	10	10	9	6	2	2	46
Surf Scoter	1	2	0	0	0	0	3	1	0	2	1	0	0	0	4	0	0	0	0	0	1	0	1
Black Scoter	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Long-tailed Duck	2	2	0	0	0	0	4	1	1	1	2	0	0	0	5	0	0	0	1	0	1	1	3
Barrow's Goldeneye	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unidentified goldeneye	7	4	0	4	0	0	15	1	3	0	8	5	0	0	17	0	0	0	0	2	5	1	8
Common Merganser	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Red-breasted Merganser	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2
Mew Gull	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Total	**25**	**21**	**5**	**7**	**4**	**5**	**67**	**30**	**22**	**19**	**19**	**25**	**30**	**15**	**160**	**8**	**11**	**15**	**12**	**14**	**16**	**20**	**96**

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