Bridge River Water Use Plan

Lower Bridge River (LBR) Riparian Vegetation and Wildlife Monitoring.

Implementation Year 2016

Reference: BRGMON-11

Riverine Bird Response to Habitat Restoration on the Lower Bridge River 2016 Report.

Study Period: May 2016 – September 2016

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BRGMON-11 - RIVERINE BIRD RESPONSE TO **HABITAT RESTORATION ON THE LOWER BRIDGE RIVER: 2016 Report**

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Bridge River Water Use Planning (WUP) Monitoring Program

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EXECUTIVE SUMMARY

The completion of the Terzaghi Dam in 1960 diverted water from the Bridge River to powerhouses located on the Seton Reservoir, leaving over 3 km of dry river bed below the dam. Feeder streams downstream of the dam contributed some water to the Bridge River, but flows downstream of the dam were much reduced compared to historic volumes and undoubtedly had a negative impact on populations of riverine birds. In August 2000, BC Hydro initiated an average annual release of 3 m^3/s, converting the section of formerly dry river bed into potentially usable habitat and increasing the flow of water in the system. In May 2011, the average annual release was increased to 6 m^3/s. In 2016, unforeseen circumstances resulted in a departure from the previous flow regimes, with peak flows reaching 97 m^3/s in early June, more than a six-fold increase from the previous peak flows (15 m^3/s). These flows were quickly ramped down again in July and by the end of August were approaching base flows between 1 – 2 m^3/s. It is unclear how long these exceptionally high peak flows will continue in future years.

Several species of riverine birds used this 14.9 km section during the pre-incubation and brood-raising periods. The most common species observed were Common Mergansers (*Mergus merganser*), Spotted Sandpipers (*Actitus maculatus*), Harlequin Ducks (*Histrionicus histrionicus*), American Dippers (*Cinclus mexicanus*) and Belted Kingfishers (*Ceryle alcyon*).

In 1999 and 2000, pre-release riverine bird surveys were performed on approximately 11.6 km of river (Reach 3) below the Terzaghi Dam, from the Yalakom River confluence to the dry section below the dam, during the pair and brood-raising period. In 2004, surveys were conducted on the 5.5 km section (including the upper section of Reach 3 from Aniah Creek upstream and all of Reach 4) below the dam. In 2005, 2006 and 2008 we conducted full-length surveys on the 14.9 km section (Reaches 3 and 4) from the Terzaghi Dam to the Yalakom River confluence under the average 3 m^3/s flow regime. We repeated these surveys in 2011, 2012, 2013 and 2014 for the average 6 m^3/s flow regime. In 2016, we completed the first set of surveys at the unusually high flow levels of 2016.

Surveys were conducted to test the hypothesis that the population increase of riverine birds in the Lower Bridge River corridor is directly related to the instream flow release from Terzaghi Dam. Walton and Heinrich (2015) produced a synthesis report summarizing results for the pre-release, 3 m^3/s and 6 m^3/s flow regimes. Prior to 2016, only Harlequin Duck numbers showed a tendency to increase at both flow rates, with more birds observed on average during the 6 m^3/s flow. Spotted Sandpiper numbers increased at the 3 m^3/s flow rate but fell to pre-release levels at the 6 m^3/s flow. Dipper numbers remained unchanged from pre-release levels or slightly declined. Common Merganser response was more complicated, with their numbers being highest during the pair period at the 3 m^3/s flow rate but not during the brood period. Belted Kingfisher numbers have generally declined at the higher flows.

Since 2000, the controlled release has had positive effects on riverine bird breeding habitat in the previously dry section (Reach 4) most severely affected by dam construction, with all five major riverine bird species using this section. Other responses by riverine birds have been more subtle, with dippers, mergansers, sandpipers and Harlequin Ducks showing a tendency to shift their distributions upstream at the 6 m^3/s flow, while Belted Kingfishers appeared to use the downstream half of the section more often since the controlled release.

In 2016, numbers of riverine birds were generally lower for all species and, for the first time, no other waterfowl species were observed stopping during migration in early May surveys. Water levels increased rapidly when birds were incubating on nests but it is unclear if any Harlequin Duck or sandpiper nests were flooded. Despite the exceptional water levels and high flow variability, Harlequin Ducks, dippers and mergansers (only one young) all successfully raised broods. Harlequin Ducks may have nested on the Yalakom River and then used the Lower Bridge River to raise their broods. Some American Dippers likely nested in tributary streams and were therefore unaffected by the variance flows in 2016. If flows are to continue at these exceptional levels, we recommend more surveys be conducted annually in the next four years to monitor the response of riverine birds. We also recommend that the largest flow increases should end by early May to avoid flooding nests of ground-nesting species.

BRGMON-11: STATUS of OBJECTIVES, MANAGEMENT QUESTIONS and HYPOTHESES after Year 2016

Study Objectives	Management Questions	Management Hypotheses	Year 2016 (2016-17) Status
1. The objective of this monitoring program is to document the impacts of alternate flow regimes from Terzaghi Dam on the diversity and productivity of riparian vegetation and the population and usage response of Riverine birds in the Lower Bridge River.	2. How will the changes in instream flow conditions influence the capability of the Lower Bridge River corridor to support wildlife (riverine bird) populations?	H_1: The population increase of riverine birds in the Lower Bridge River corridor is directly related to the instream flow release from Terzaghi Dam	We have data from pre-release (2 yrs), 3 m^3/s flow (3 yrs) and 6 m^3/s flow (4 yrs) regimes, and 1 year of data at 2016 levels. Our results show that riverine bird numbers are related to the instream flow release from Terzaghi Dam but that the five resident species responded differently, with some species apparently increasing in numbers and other staying the same or possibly declining at higher flow rates. All species showed general declines in 2016, but more monitoring years are required before the impact of modified flows can be assessed.

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1.0 INTRODUCTION

Hydroelectric development on the Bridge River system began in 1927 with work on the first diversion through Mission Mountain. The river first became regulated when the Mission Dam was completed in 1948, followed by completion of the La Joie Dam upstream in the early 1950s, and culminated with an enlargement of the Mission Dam to what became the Terzaghi Dam, completed in 1960. Prior to damming, the Bridge River hydrograph, measured at the site of the Terzaghi Dam, had annual maximum flows of over 300 m^3/s during spring freshet, sometimes reaching ~900 m^3/s (Hall et al. 2009). Following the completion of the Terzaghi Dam, all upstream water was diverted from the Lower Bridge River to powerhouses located on the Seton Reservoir, leaving over 3 km of dry river bed below the dam. Groundwater and feeder streams downstream of the dam contributed some water to the Lower Bridge River. Marking the end of Reach 3, a major unregulated tributary, the Yalakom River, provided significant year round flows to the two lower reaches of the Lower Bridge River, but flows were much reduced compared to historic volumes and undoubtedly had a negative impact on riverine bird populations.

In August 2000, BC Hydro initiated a permanent flow release at Terzaghi Dam designed to create a peak in summer and an enhanced winter flow (Bradford et al. 2011). Initially, a regime was adopted where flows ranged from a base flow in winter of ~2.0 m^3/s, to a maximal flow of 5.0 m^3/s during the summer freshet, resulting in an average annual release of 3 m^3/s (Wright 2004). This regime was later modified in early May 2011 to produce an average annual discharge rate of 6 m^3/s, where maximal flows reached ~15 m^3/s during freshet, and dropped to ~ 1.5 m^3/s during winter. This second 6 m^3/s regime continued until the spring of 2016, when unforeseen circumstances elsewhere in the Bridge system required a considerable variance to the 6 m^3/s regime. The 2016 variance flow increased peak flows during freshet, reaching 97 m^3/s in early June, more than a 6-fold increase over the peak flow levels under the 6 m^3/s regime. During the winter of flows remain unchanged (~1.5 m^3/s), and an average annual flow rate of 21.9 m^3/s was realized.

Prior to the reintroduction of flows through the Terzaghi Dam, it was recognized that passing water down the Lower Bridge River could have considerable consequences on riverine birds. Initial monitoring of riverine birds focused on Harlequin Ducks (*Histrionicus histrionicus*). Prior to the first flows in July 2000, two pre-release surveys were conducted to establish a baseline reference point for Harlequin Duck numbers (Wright 1998; Wright and Walton 2001a, b). During the two pre-release surveys, very few Harlequin Ducks were observed in Reach 3 and Reach 4 (Walton and Heinrich 2015). Other riverine bird species were also recorded during surveys, including: American Dipper (*Cinclus mexicanus*), Common Merganser (*Mergus merganser*), Spotted Sandpiper (*Actitus maculatus*) and Belted Kingfisher (*Ceryle alcyon*). Following these baseline surveys, monitoring occurred in Reaches 3 and 4 in most years to assess how these riverine birds responded to flow regimes (Walton and Heinrich 2015).

In 2004 a truncated survey to assess riverine bird use of the previously dewatered section was performed (Walton and Heinrich 2004) and longer surveys replicating the surveys of

1999 and 2000 were conducted in 2005, 2006, 2008, and from 2011-2016 (Walton and Heinrich 2005, 2006; Heinrich 2008; Walton and Heinrich 2011, 2012, 2013, 2014). Surveys were done during the breeding season, in the pair and brood-rearing stages. Concurrent with the above monitoring studies, the Bridge-Seton Consultative Committee engaged in a Water Use Planning process for Bridge River Power Development. Multiple competing values were considered during the Water Use Planning process, but it was recognized that outcomes for particular values could not necessarily be predicted or achieved. In the case of Lower Bridge River, the committee recommended that adaptive management flows be conducted and monitored to enhance the aquatic and riparian ecosystem in the Lower Bridge River. As part of the Water License Requirements associated with the adoption of the 2011 Water Use Plan, BC Hydro commissioned the BRGMON-11 project to monitor the impact of river regulation on riparian vegetation and riverine birds in the Lower Bridge River.

BRGMON-11 Terms of Reference were drafted in 2012 and outlined two Management Questions (MQ):

MQ-1. What is the influence of instream flow regime on the spatial extent, species diversity, and relative productivity of the riparian community of the Lower Bridge River?

MQ-2. How will the changes in riparian community and instream flow conditions influence the capability of the Lower Bridge River corridor to support wildlife (riverine bird) populations?

These two MQ's were each addressed by studies conducted by separate teams. In 2012 addressing MQ-2 became the focus of the riverine bird monitoring program, now adopted by BRGMON-11.

In 2015, following three years of monitoring under BRGMON-11, we produced a synthesis report utilizing all available monitoring data dating back to baseline conditions summarizing the response of riverine birds to the various flow regimes in the 14.9 km section (Reaches 3 and 4) below the Terzaghi Dam (Walton and Heinrich 2015). We tested the management hypothesis that the population increase of riverine birds in the Lower Bridge River corridor is directly related to the instream flow release from Terzaghi Dam. More specifically, we documented how riverine birds in the breeding season responded to the increased flow by focusing on two sections of the river: the 3.3 km of new habitat (Reach 4) created from the previously dry section immediately below the dam, and the 14.9 km section (Reaches 3 and 4) from the dam to the Yalakom River confluence. We considered whether species had shifted their distributions upstream or downstream with changing flow conditions. Results indicated that the five resident riverine bird species responded differently to the three flow regimes, and that one flow rate will not equally benefit all species. Therefore, the recommendation was made to use Harlequin Ducks as the main indicator species for riverine bird management. Both flow regimes appeared to increase usage of Reaches 3 and 4 by Harlequin Duck, and increased

flows appeared to be associated with increased productivity of this species (Walton and Heinrich 2015).

In 2016, an exceptional change to the flow regime (hereinafter variance flows) created new conditions for riverine birds by increasing freshet flows above the previous 6 m3/s regime, but still well below historic levels prior to the regulation of the river (Hall et al. 2009). To monitor the effects of the variance flow, we conducted five riverine bird surveys in 2016: two surveys during the Harlequin Duck pairing period and three surveys during their brood-rearing stage. Although all five species of riverine birds were monitored, timing was based on the harlequin Duck breeding season.

This report compares the 2016 survey results with past seasons to assess the influence of the 2016 variance flows, and to further test the hypothesis that the population increase of riverine birds in the Lower Bridge River corridor is directly related to the instream flow release from Terzaghi Dam.

2.0 STUDY AREA

The study area is located on the east side of the Coast Mountains in southwestern BC. In this region, moisture is delivered by Pacific frontal systems, which create sizable snowpack in winter, especially near the headwaters of the Bridge River. The Bridge River is approximately 120 km long and flows into the Fraser River, just upstream of Lillooet, BC. It is regulated by two dams: the LaJoie Dam and, approximately 60 km downstream, the Terzaghi Dam, which impounds the Carpenter Lake reservoir. The two dams partition the Bridge River into three main sections: The Upper Bridge River (above LaJoie Dam), the Middle Bridge River (between the dams), and the Lower Bridge River.

The Lower Bridge River has a relatively steep gradient (0.7-3 %) and passes through a long canyon for approximately 41 km until it joins the Fraser River (Bradford et al. 2011). The unregulated Yalakom River flows into the Lower Bridge River 15 km below Terzaghi Dam, adding an average of 4.4 m^3/s of water (Bradford et al. 2011).

Positioned in the rain shadow of the Coast Mountains, the Lower Bridge River occurs in the IDFxc (Interior Douglas-fir very dry cold zone) biogeoclimatic zone (Meidinger and Pojar 1991).

Surveys were conducted from the confluence of the Yalakom River to the base of the Terzaghi Dam, a distance of 14.9 km along the Bridge River (Figure 1). Prior to the controlled release in August 2000, the 3.3 km section below the dam was essentially dry river bed (Reach 4: Bradford et al. 2011). For the next 11.6 km downstream to the Yalakom River confluence (Reach 3: Bradford et al. 2011) the Bridge River was fed by ground water and minor tributaries, averaging a mean annual discharge of 0.7 m^3/s (Bradford et al. 2011). The 2.2 km section from Reach 4 to Aniah Creek (Figure 1) had especially low water levels. Water from the flow release created pools, riffles and islands, and it flooded much of the river bank vegetation, especially clusters of Sitka alder (*Alnus viridis*), making hiking along the river bank difficult in places. Riffle area increased in Reach 3 by over 25 % at the 3 m^3/s and 6 m^3/s flow regimes and added over 25,000 m^2 of riffle area to the previously dewatered section (Jeff Sneep, *unpubl. data*). More area was flooded at the peak of the large flow increase in 2016.

Water conditions pre- and post-release were assessed at a measuring station at the upstream extent of the water prior to the August 2000 release (Figure 1). To be more specific, the recorded water depth is the water level above the transducer orifice mounted on the bank, which may or may not represent the deepest point near the station; for this report, we assume station data approximated water depth at that point in the river and focus more on the relative versus absolute values among flow regimes.

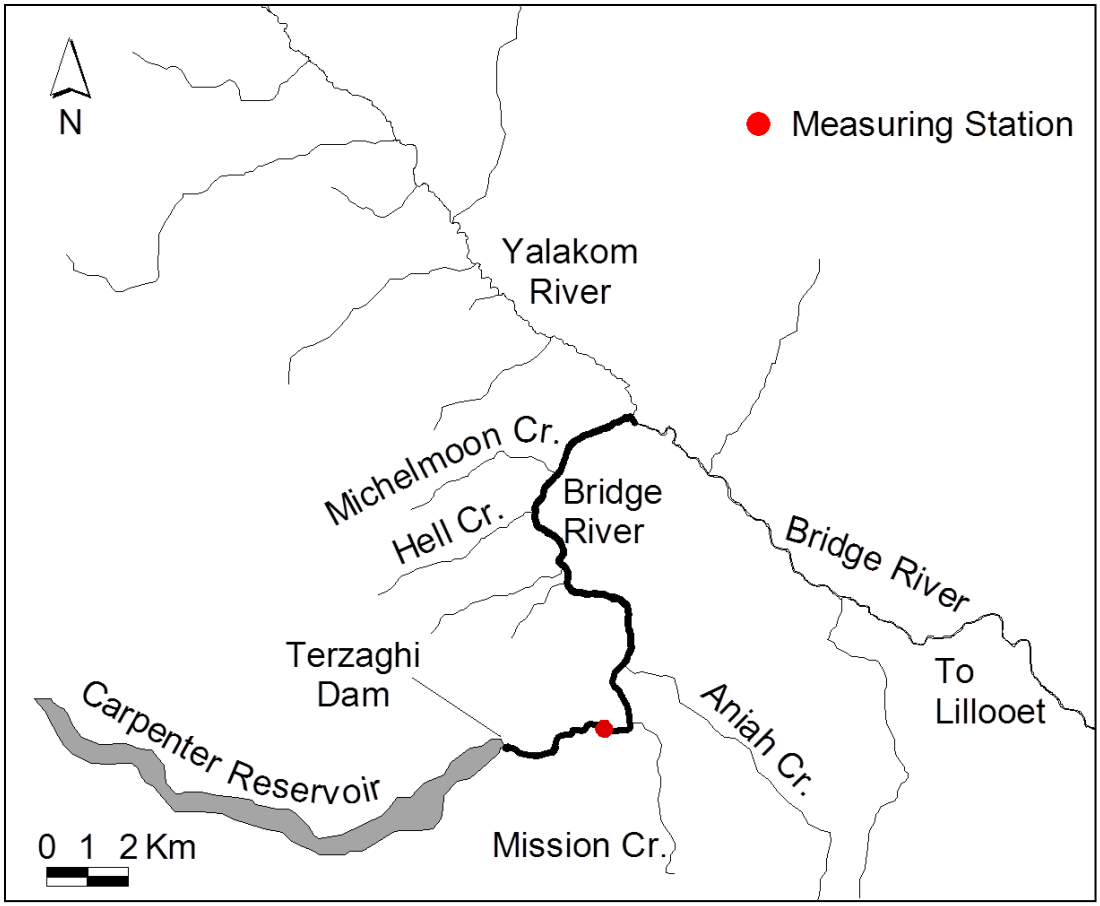

Figure 1 Map of the Survey Area. The bold line indicates the 14.9 km survey area from the Yalakom River confluence to the Terzaghi Dam. Faint lines indicate major creeks. The red dot denotes the location of the water measuring station and the approximate downstream extent of the previously dewatered section (Reach 4).

Flows at the water measuring station (Figure 1) generally increased in May and peaked in June, but were highly variable, prior to the 3 m^2/sec regime adopted in August, 2000 (Figure 2), especially in 1999, a year of higher than normal flows, and in 1997, when the Terzaghi Dam released water over the spillway (Jeff Sneep, *unpubl. data*) creating an abrupt pulse of water in late summer (Figure 2). Pre-release water levels generally increased in May and peaked in June. After minimum flow regimes were adopted, water depths emulated this general seasonal pattern but variation between and within years was minimal (VIA-SAT Data Systems Inc, *unpubl. data*). At peak flow, water depths at the station increased from approximately 0.3 m before the release to 0.9 m under the 3 m^3/s release regime. Doubling the average release rate to 6 m^3/s led to depths of approximately 1.3 m in June, a 150% increase over the 3 m^3/s the flow regime and a 430% increase over pre-release depths.

Unfortunately, data were not available for 2016 since the station was knocked out several times by high water (Dorian Turner, BC Hydro, *pers. comm.*). At peak flow in 2016 water depth was estimated to be approximately 2.4 m at the station (Dorian Turner, BC Hydro, *pers. comm.*), over a meter deeper than depths recorded for the 6 m^3/s flow.

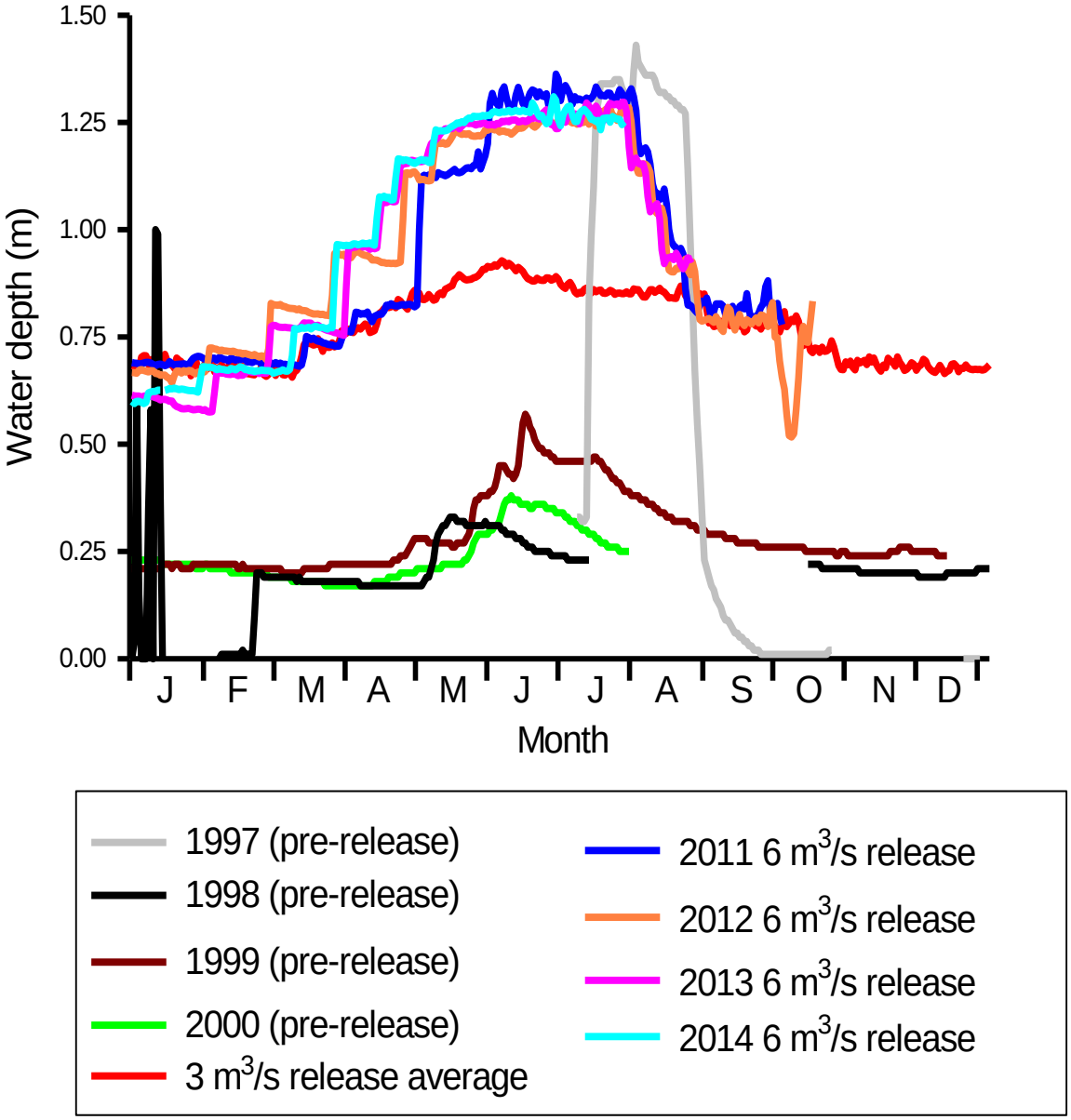

Figure 2 Pre- and post-release water depths at the upstream water measuring station by Mission Creek. The 3 m3/s post-release average is from 2008-2010. Refer to Figure 1 for location of this station.

Annual variability in the measured water depths observed at the Mission Creek station (Figure 2) was largely driven by flow release at the Terzaghi Dam, which emulated the timing of the natural spring freshet with some important differences across years (Figure 3). At the 3 m^3/s regime, flow gradually increased for the spring and summer "freshet" beginning in mid-March until it peaked by mid-June, gradually declining to winter levels by late October. Flows at 6 m^3/s followed the same general pattern, increasing in mid-March to a sustained peak in early June, then declining in early August to winter levels.

In 2016 this pattern changed dramatically, peaking at 97 m^3/s in 2016 compared to peak flows of 5 and 15 m^3/s in earlier regimes. Although the 2016 flow increase began at approximately the same time (mid-March), the 2016 hydrograph had a much different shape, increasing and decreasing flow more abruptly, and peaking for a briefer period (~ 3 weeks) instead of smoothly building to a plateau. By late July, flows in 2016 were similar to 6 m^3/s levels. As Figure 3 indicates, the major ramp in flow levels to peak coincided with Harlequin nesting activities; flows dropped precipitously during the brood-rearing period.

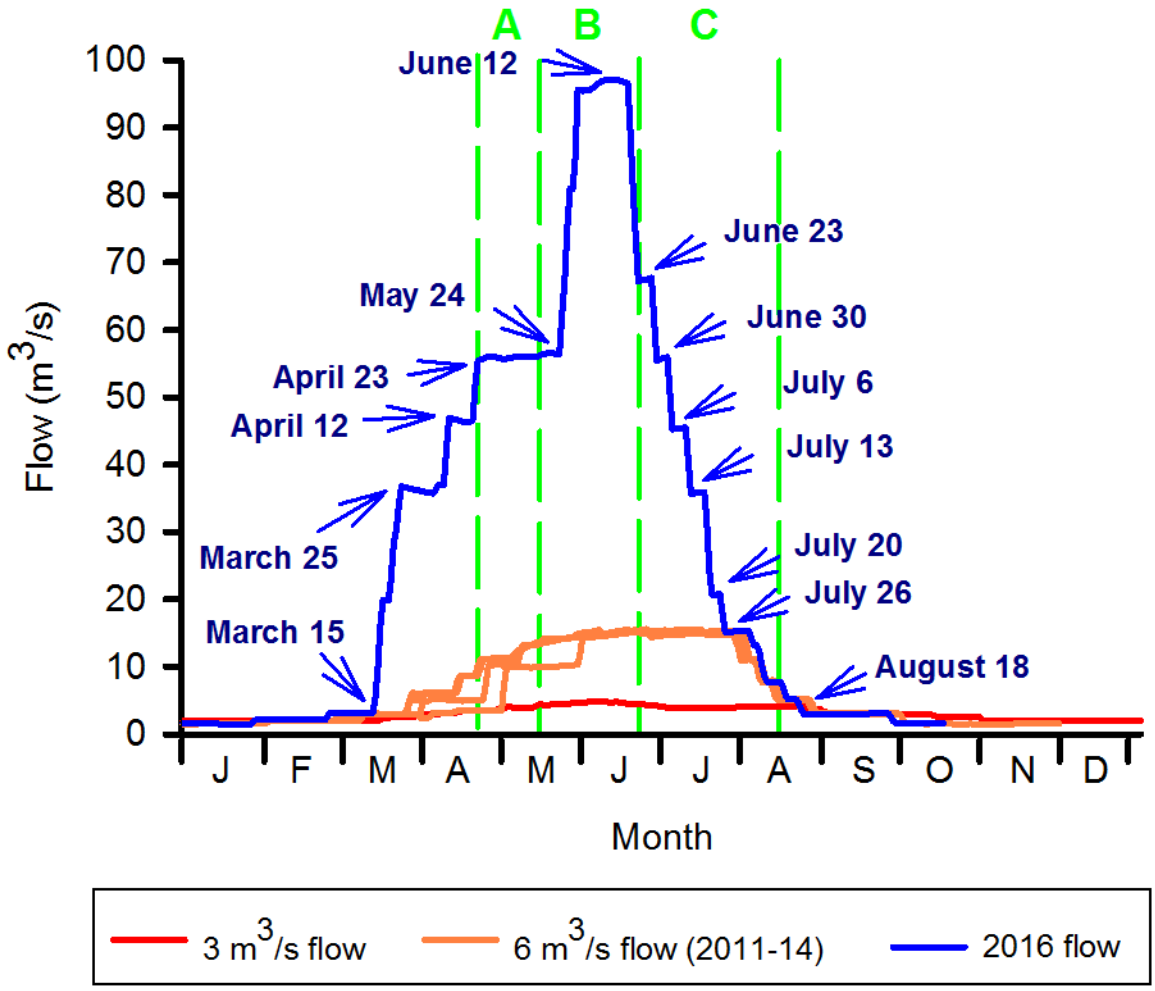

Figure 3 Flow release from the Terzaghi Dam. The red line is the average 3 m^3/s flow from 2000 to 2004. The 6 m^3/s flow regime began on May 3, 2011 and individual years from 2011-14 are represented by orange lines. Dashed green lines indicate approximate timing for breeding stages of the Harlequin Duck: A = arrival, nest-building and egg-laying; B = incubation; C = brood-rearing.

3.0 METHODS

Survey Timing

We performed five surveys in total in 2016: two breeding pair surveys and three brood surveys. Surveys began between 8:00 – 9:30 a.m. and finished by 4:00 p.m. Pair surveys were conducted on May 5 and May 19, and brood surveys were done on June 27, July 15 and 28. The seasonal timing of surveys coincided with breeding phenology of Harlequin Ducks (Figure 4) and typically allowed detections of newly hatched broods; however, all riverine species were monitored. Documentation of all mammals, birds, and herptiles observed during the surveys are appended to this report (see Appendix 2).

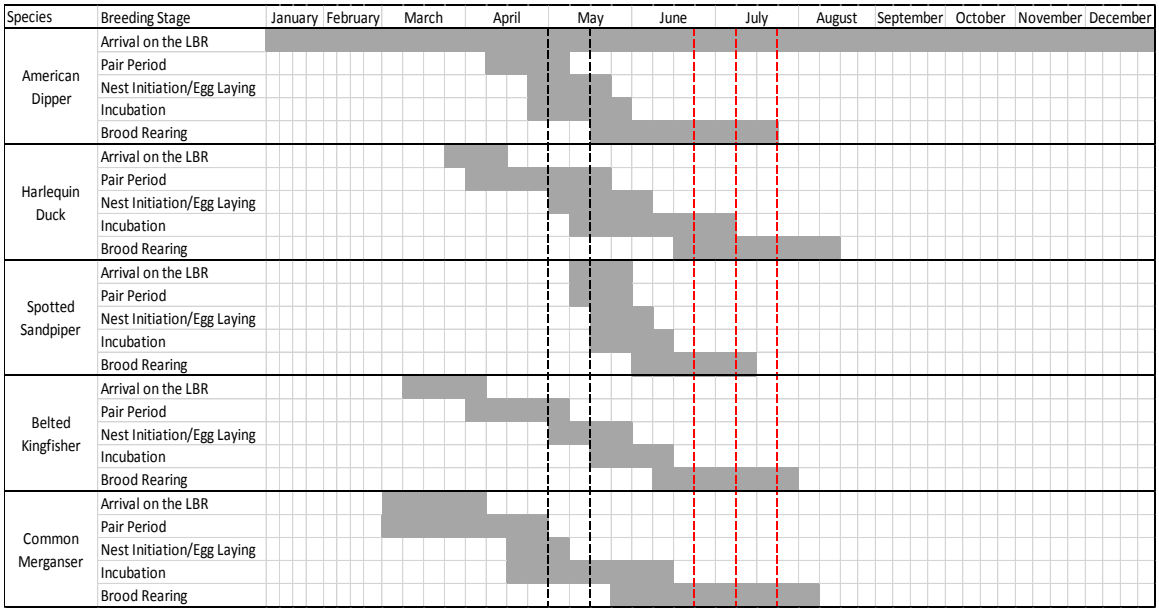

Figure 4 General breeding phenology (based on literature and local knowledge) for the five focal species of riverine birds. The black dashed lines represent the pair surveys and the red dashed lines represent the brood surveys. (Sources: Pearce et al 2015, Reed et al 2013, Wilson and Kingery 2011, Kelly et al 2009, Robertson and Goudie 1999)

Spotted Sandpipers are the last species to arrive on the river and are not usually seen until the final pair survey (Figure 4), therefore only brood survey numbers were used in our analysis.

Survey Methods

Surveys in 2016 were conducted by two teams of two observers hiking in an upstream direction along the western river bank to maximize bird detections. Teams carried binoculars to assist with identification. Survey techniques followed those proposed by the Resources Inventory Committee (RIC 1998). For the first four surveys, the first team began at the Yalakom River confluence and the second team began approximately 1.2 km downstream of Aniah Creek (Figure 1). Teams alternated routes among these surveys to guard against observer bias. In the final survey this approach was changed to maintain better radio contact, and teams "leap-frogged" each other, alternating 1-2 km sections at a

time. In previous years visual coverage was complete except for portions of back-channels on the opposite side of four small islands (approximately 250 m), but visual coverage likely decreased with more extensive flooding in 2016. Back-channels and newly flooded willow/alder riparian vegetation provided extra hiding cover potentially obscuring some birds from observers. Initial bird locations were fixed by handheld GPS (Garmin Colorado 300 and Garmin GPSMap64s, accuracies ranged from ± 4m to ± 35m) and later mapped to correspond with Digital Terrain Inventory Mapping (TRIM) features. Since handheld GPS accuracies ranged widely due to the steep canyon type terrain, TRIM features were used to ensure that field locations were mapped within a reasonable range of known features (ex. Known tributaries). Final bird locations are presented in Appendix 1.

When we spotted a bird, we attempted to keep it in sight until we either saw it move downstream, we passed it as we moved upstream, or the bird flew out of sight upstream. If the bird flew out of sight upstream we used 2 approaches to avoid double counting. For American Dippers and Spotted Sandpipers with relatively short territories, we would not record a new sighting for a species if we saw a single bird within 100 m upstream of the last location; in other words, we would have to see 2 birds simultaneously to record 2 birds present within a 100 m section. For more mobile species like ducks, we would note the age and sex of birds that flew upstream and not count these birds again if we encountered them further upriver. We found birds generally landed within 1-2 km of their last location and, because they were restricted to the river, it was rare not to see the same group again. In practice, most birds flew downstream after being disturbed a couple of times rather than flying upstream beyond the Terzaghi Dam.

Analysis

For analysis purposes, we compared riverine bird numbers as a function of flow regime for three sections of the lower Bridge River: 1) the 14.9 km section from the Yalakom River confluence to Terzaghi Dam (Reaches 3 and 4 combined); 2) the 3.3 km previously dewatered section below the Terzaghi Dam (Reach 4); and 3) comparative riverine bird densities upstream (5.5 km) and downstream (9.4 km) of Aniah Creek (see Figure 1). We included this last comparison because, prior to the release, Aniah Creek provided a natural break between the low or dewatered sections upstream and the more substantial river extending downstream to the Yalakom River confluence. In 1999 and 2000, surveys only continued 2.2 km upstream of Aniah Creek and this distance was used for calculating upstream bird densities for the pre-release period.

Although complete surveys of Reaches 3 and 4 were done from 2005-2016, this section was not surveyed in its entirety in all years. In the pre-release period in 1999 and 2000, pair and brood surveys only covered the 11.6 km of Reach 3 (Wright and Walton 2001a, b). For analyses of Reaches 3 and 4 combined, data from these surveys were compared directly to the survey results from 2005 to 2014, including the extra 3.3 km (Reach 4) of previously dry river bed below Terzaghi Dam. We included the previously dewatered section in 1999 and 2000 in the comparison because we assumed that no riverine birds used this section prior to the release in August 2000 and numbers could safely be

interpreted as zeros. Surveys of the dewatered section on July 27 and August 3, 1999 supported this assumption (Ken Wright, *unpubl. data*), although 2-3 Spotted Sandpipers may have been using this area. In 2004 truncated surveys were conducted from Aniah Creek to the Terzaghi Dam, primarily to assess riverine bird use of the previously dewatered section. Walton and Heinrich (2015) list dates and distances for all previous surveys.

This study was restricted to Reaches 3 and 4 of the Lower Bridge River and we did not extend surveys up the Yalakom River due to financial constraints for performing multi-day surveys, and because the Yalakom River is unregulated and it is not directly influenced by flow release decisions made at the Terzaghi Dam. While smaller tributaries are also present, the Yalakom River is the largest tributary that enters the survey route along the lower Bridge River (Figure 1), contributing an annual average discharge of 4.4 m^3/s (Bradford et al. 2011). For territorial riverine birds like Belted Kingfisher, Spotted Sandpiper and American Dipper, the surveyed population can be considered "closed," although Dippers, especially, may nest short distances away from the river up streams in canyons and the occasional bird may have been missed during one of our surveys. This is not necessarily true for Harlequin Duck and Common Merganser, however, which are highly mobile during the brood-rearing phase, and can potentially enter or leave the study area (e.g., up the Yalakom River, or further down the Lower Bridge River). The "openness" of the system should be considered when interpreting survey results for these species. In 1999 and 2000, when 17 km of the Yalakom River was routinely surveyed, Harlequin Ducks tended to nest on the Yalakom River and rear their broods on the lower Bridge River. One banded female routinely flew more than 12 km during incubation breaks from her nest on the Yalakom River to the Bridge River to feed (Wright and Walton 2001a). Thus, although the Yalakom River was most likely used by more mobile species during our surveys, we believe the numbers of birds we detected on the Bridge River represented the population using the river, especially during the brood-rearing period. This is supported by the consistent number of broods we observed in most years between the first and third brood surveys.

4.0 RESULTS

Numbers of major riverine species observed during the five surveys in 2016 are presented in Table 1. Detailed data and location coordinates for each observation are documented in Appendix 1. In 2016, no other waterfowl species were observed during any of the five surveys. Only three resident Bald Eagles (*Haliaeetus leucocephalus*) were documented, and one Great Blue Heron (*Ardea herodias*) was seen during the final brood survey.

Numerically, Spotted Sandpiper was the most abundant species, followed by, Harlequin Duck, American Dipper, Common Merganser and Belted Kingfisher. During the May 5th survey, one pair of Harlequin Ducks and four pairs of Common Mergansers were observed; on the May 19th survey this changed to two pairs of Harlequin Ducks and one pair of Common Mergansers.

Table 1. Number of individuals of major riverine bird species observed on the 14.9 km survey route from the Yalakom River confluence to Terzaghi Dam in 2016.

Survey Type	American Dipper	Harlequin Duck	Spotted Sandpiper	Belted Kingfisher	Common Merganser	**Total**
Pair						
May 05	2	3	0	0	9	*14*
May 19	2	5	11	4	8	*30*
Brood						
June 27	11 (3)	3 (2)	6 (0)	1 (0)	0 (0)	*21 (5)*
July 15	13 (3)	8 (6)	13 (0)	4 (0)	5 (1)	*42 (10)*
July 28	2 (0)	12 (9)	5 (0)	9 (0)	1 (1)	*29 (10)*
Total	*30 (6)*	*31 (17)*	*35 (0)*	*18 (0)*	*23 (2)*	*136 (25)*

Values are totals of adults and juveniles combined. Numbers in parentheses indicate the number of juveniles observed.

Harlequin Duck Response

Adult Harlequin Duck numbers during pair surveys were variable across years (Figure 5a). Despite this variability, adult Harlequin Duck numbers generally increased since the release in 2000, with a tendency for more Harlequin Ducks to be seen at the 6 m^3/s flow regime than at the 3 m^3/s flow (Figure 5a). In 2016, Harlequin Duck numbers were the lowest recorded since the 3 m^3/s flow regime years but the drop was not dramatic, especially given the variation observed within years during pair surveys (Figure 5a).

During the brood-raising period, the number of Harlequin Ducks increased almost linearly from pre-release levels until 2008, when overall numbers appeared to plateau at approximately 10 birds per survey, with the exception of a dip in numbers in 2013 (Figure 5b). This translates to approximately 2-4 Harlequin Duck females raising young

on this section of river each year. This pattern continued in 2016, with three Harlequin Duck females observed with a total of 9 young at the final July survey (Table 1).

Harlequin Duck brood surveys suggest that nesting success has been variable across years, with complete brood failures occurring in 1999, 2006 and 2011; there appears to be little correlation of these productivity measures with flow regime (Figure 5b).

Harlequin Ducks were observed upstream of Mission Creek (Reach 4) in both the pair and brood periods in 2016, but use of this reach has been variable among years and possibly unrelated to the post release flow regimes (Figures 5c, d).

Harlequin Ducks appeared to use the sections upstream and downstream of Aniah Creek equally under the 3 m^3/s flow regime (Figure 5e), but they showed a tendency to be found more often upstream of Aniah Creek under the 6 m^3/s flow regime in all years except in 2014 (Figure 5e). In 2016, slightly more Harlequin Duck adults and juveniles were found downstream of Aniah Creek than upstream (Figure 5e, 5f).

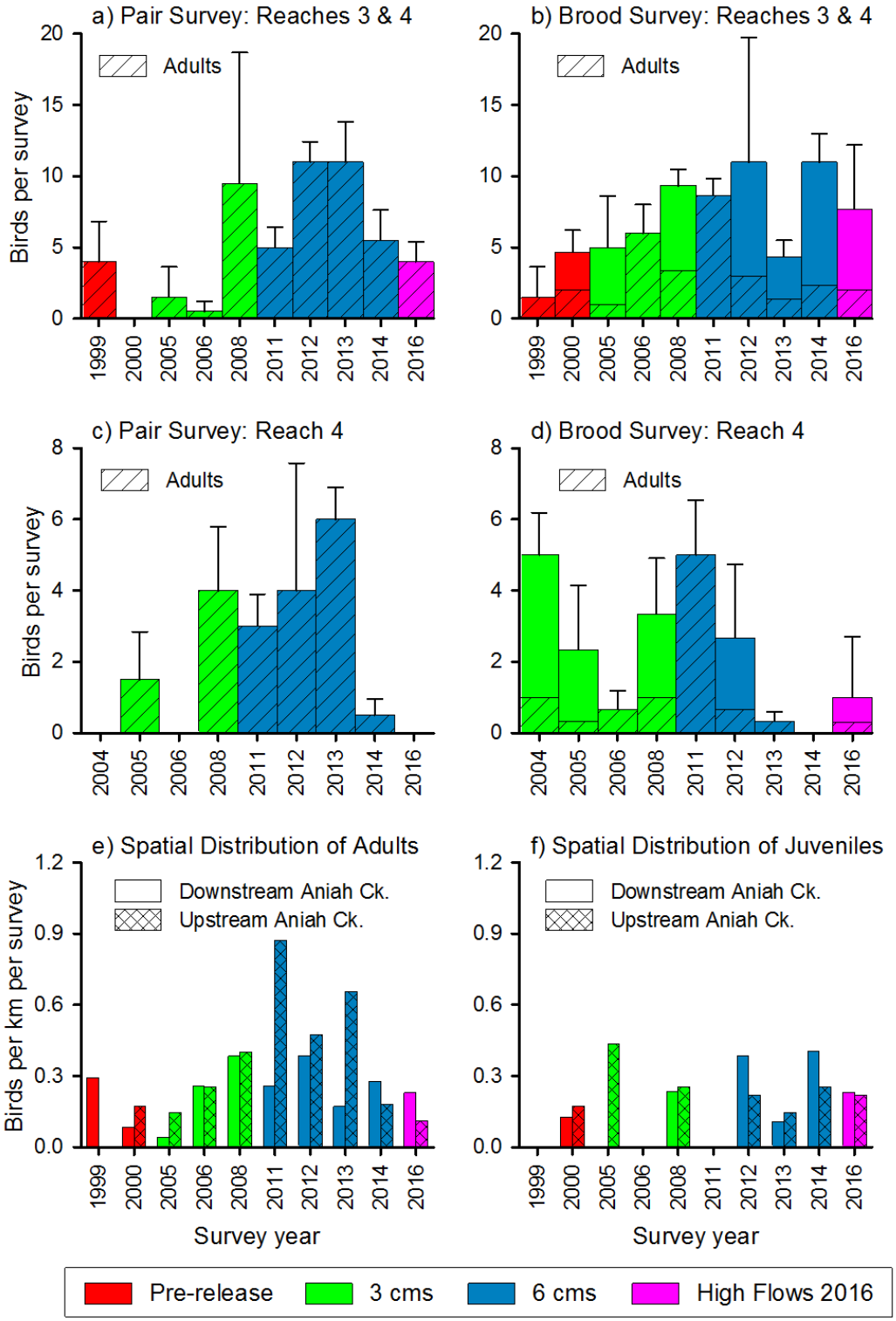

Figure 5. Average number of Harlequin Ducks per survey (± 1 SD) from the Yalakom River confluence to Terzaghi Dam (5a, b) and upstream of Mission Creek (5c, d) for pair and brood surveys. Number of adult (5e) and juvenile (5f) Harlequin Ducks observed per km per survey above and below Aniah Creek (totaled over all 5 surveys).

American Dipper Response

We found no statistical difference in the number of American Dippers observed among flow regimes during the pair and brood surveys on Reaches 3 and 4. However, during pair surveys, four of the five years with lowest dipper numbers have come under the highest flows (Figure 6a), with the lowest count recorded in the study occurring during the exceptional flow year of 2016. This negative relationship with higher flows was not supported by the brood-raising period in 2016 when we recorded the second highest average number of dippers for the study (Figure 6b).

Juvenile production in 2016 remained relatively constant with previous years (Figure 6b). Dippers are the only one of the five resident riverine bird species studied with at least 1 juvenile observed in all survey years.

Dippers used Reach 4 in both the pair and brood periods (Figures 6c, d). Juvenile dippers were observed in this reach in all survey years except 2008 (Figure 6d). More dippers were seen in Reach 4 during brood surveys in 2016 than in any previous year (Figure 6d).While overall numbers of dippers on the river have not changed substantially, both adult and juvenile dippers appear to have shifted their distribution upstream of Aniah Creek since the controlled release was initiated, and this trend continued in 2016 (Figures 6e, f). This shift seems to be especially strong for juvenile birds (Figure 6f).

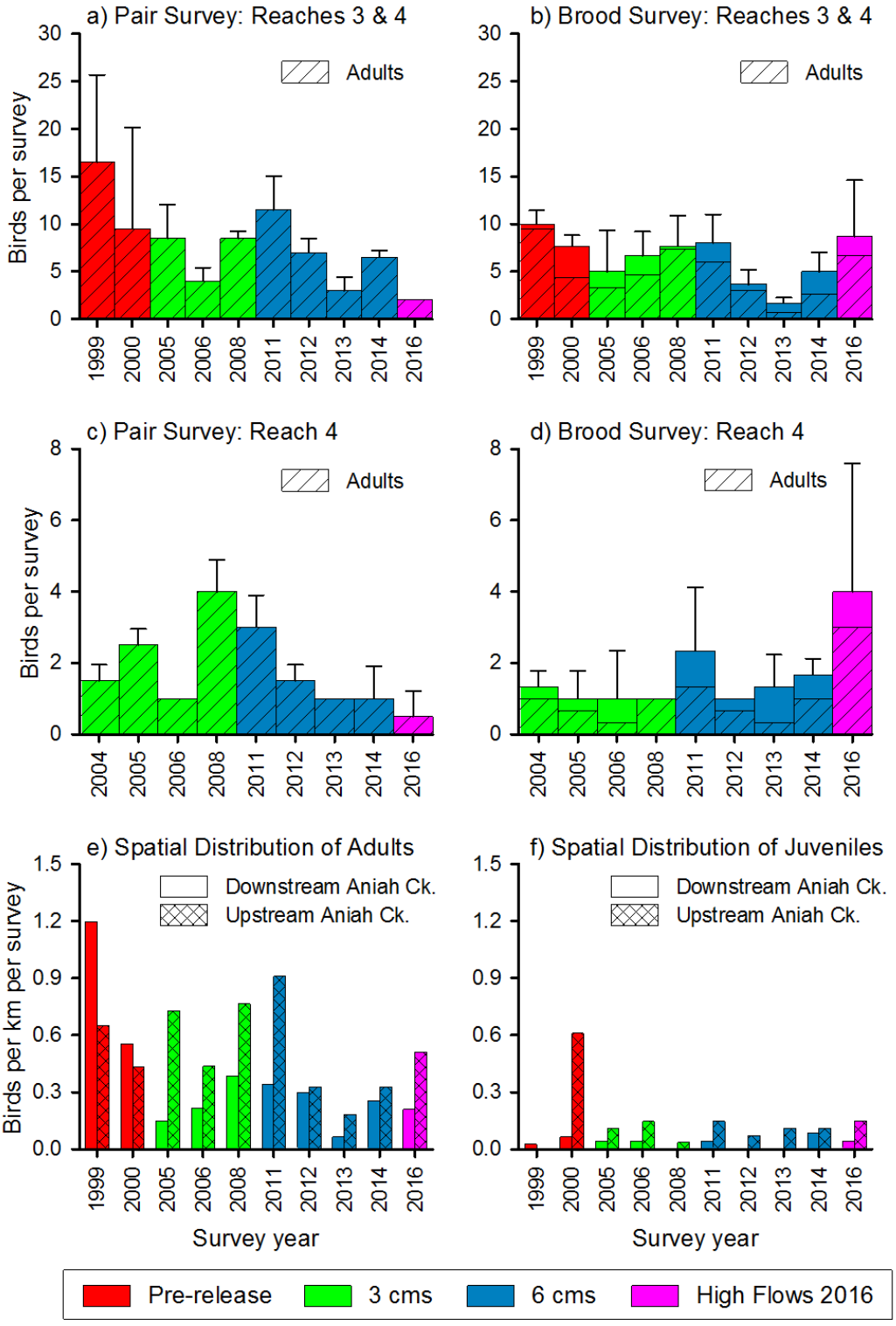

Figure 6. Average number of American Dippers per survey (± 1 SD) from the Yalakom River confluence to Terzaghi Dam (6a, b) and upstream of Mission Creek (6c, d) for pair and brood surveys. Number of adult (6e) and juvenile (6f) American Dippers observed per km per survey above and below Aniah Creek (totaled over all 5 surveys).

Common Merganser Response

Between 2000 and 2016, Common Merganser numbers appeared to remain stable or to increase slightly in the study area (Figures 7a, b), with an average of 13.9 mergansers during pair surveys, ranging from 12 birds in 2013 to 19.5 birds per survey in 2006 (Figure 7a). In 2016, we observed a historic low count of mergansers (8.5 mergansers per survey; Figure 7a).

Juvenile production was also highly variable across years (Figure 7b). No young mergansers were observed during brood surveys in 1999 and 2013, and only 1 young bird was seen during all 3 brood surveys in 2011. In 2016 we observed one young bird on each of the final two brood surveys, and overall merganser numbers were the second lowest since brood surveys began in 1999 (Figure 7b).

Common Mergansers used Reach 4 during both pair and brood surveys in 2016 (Figures 7c, d). In 2006, we recorded the highest number of young birds in the study area (Figure 7b), however, no birds were observed on Reach 4. There were no apparent differences in their overall use of Reach 4 between the two flow regimes (Figure 7).

Prior to 2000, Common Mergansers were observed more often downstream of Aniah Creek, (Figures 7e, f). This trend continued for 2 of the 3 survey years under the 3 m^3/s flow regime. Under the 6 m^3/s flow regime, and in 2016, Common Mergansers were more often encountered upstream of Aniah Creek.

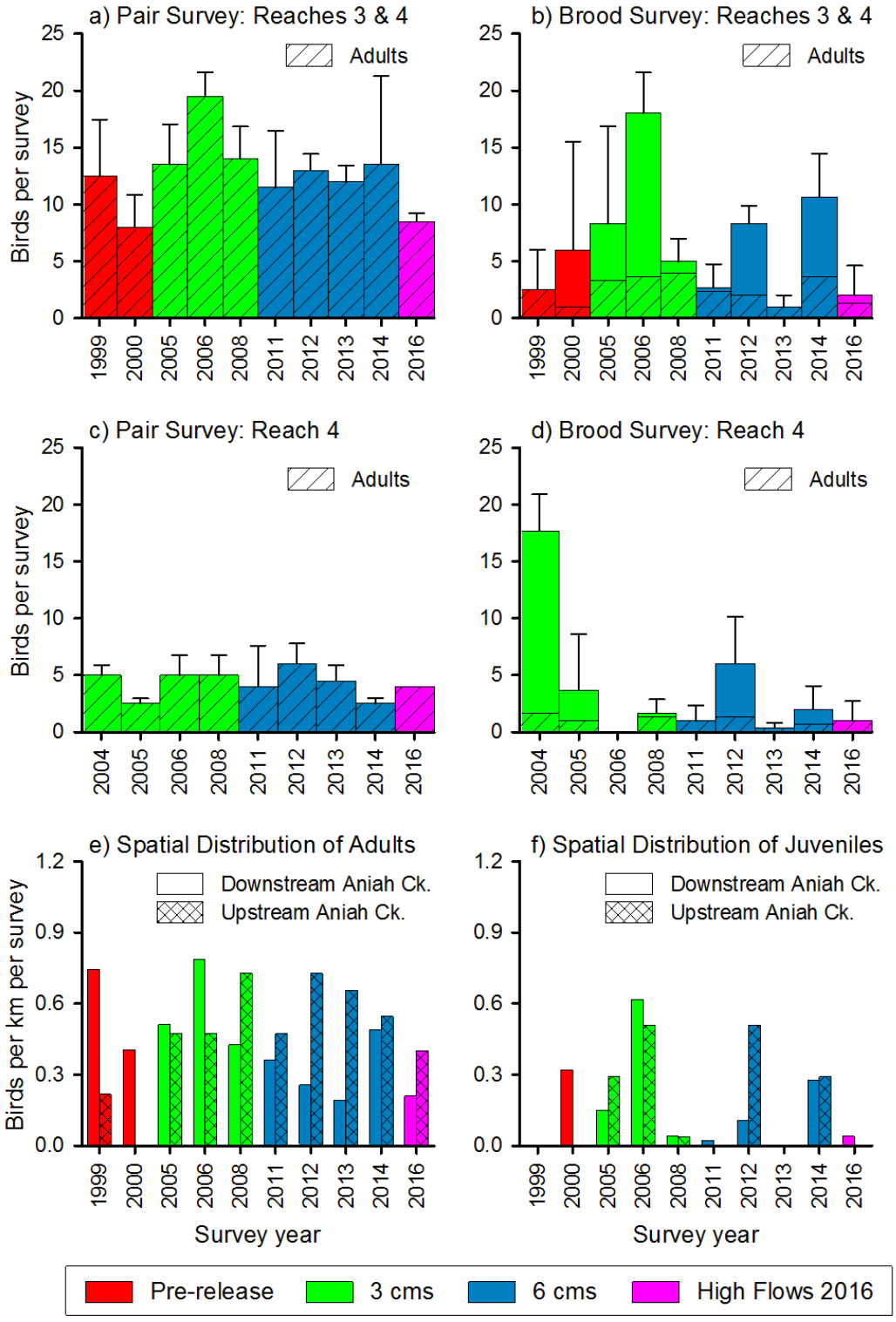

Figure 7. Average number of Common Mergansers per survey (± 1 SD) from the Yalakom River confluence to Terzaghi Dam (7a, b) and upstream of Mission Creek (7c, d) for pair and brood surveys. Number of adult (7e) and juvenile (7f) Common Mergansers observed per km per survey above and below Aniah Creek (totaled over all 5 surveys).

Spotted Sandpiper Response

Sandpipers more than doubled their numbers in 2005, and their numbers remained elevated in 2006 and 2008 (Figure 8b). During the 6 m^3/s flow, however, their numbers declined to pre-release levels (Figures 8b). In 2016 sandpiper numbers were among the lowest seen during brood surveys, similar to those observed at the 6 m^3/s flow (Figure 8b).

Spotted Sandpipers use of Reach 4 was lowest in 2016 surveys, although marginally so, compared with usage in previous years under the 3 m^3/s and 6 m^3/s flow regimes (Figure 8d).

Compared to the section from the Yalakom River to Aniah Creek, adult sandpipers were more often found in the area upstream of Aniah Creek in all post-release survey years, including 2016 (Figure 8e).

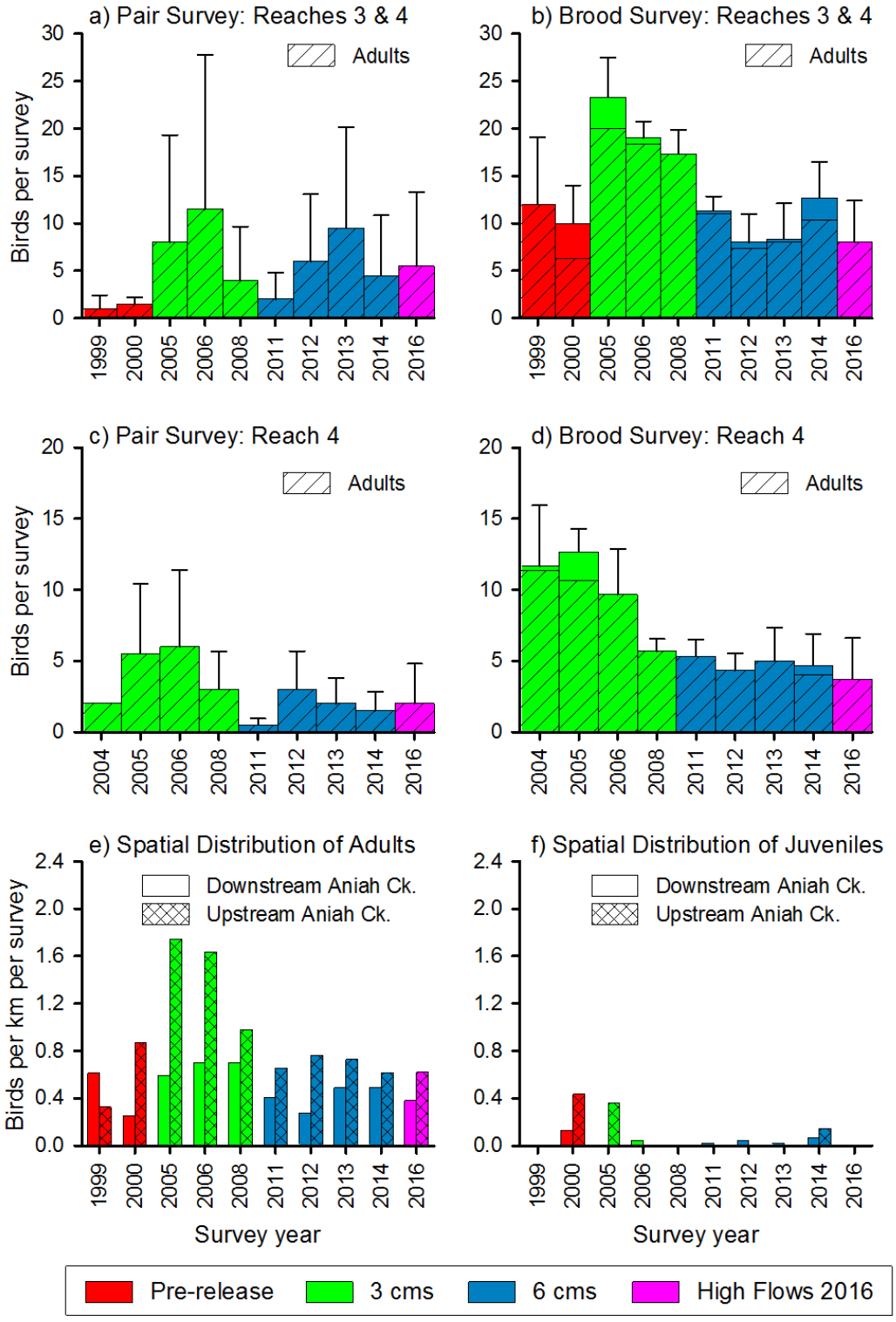

Figure 8. Average number of Spotted Sandpipers per survey (± 1 SD) from the Yalakom River confluence to Terzaghi Dam (8a, b) and upstream of Mission Creek (8c, d) for pair and brood surveys. Number of adult (8e) and juvenile (8f) Spotted Sandpipers observed per km per survey above and below Aniah Creek (totaled over all 5 surveys).

Belted Kingfishers

A long term trend in the Kingfisher population remains unclear; the tendency for decline in numbers during the study was countered by a rebound in 2016 observations (Figures 9a, 9b). A notable result was that more kingfisher were detected in the upper-most reach of the Lower Bridge River in 2016 (Figures 9c, 9d, and 9e).

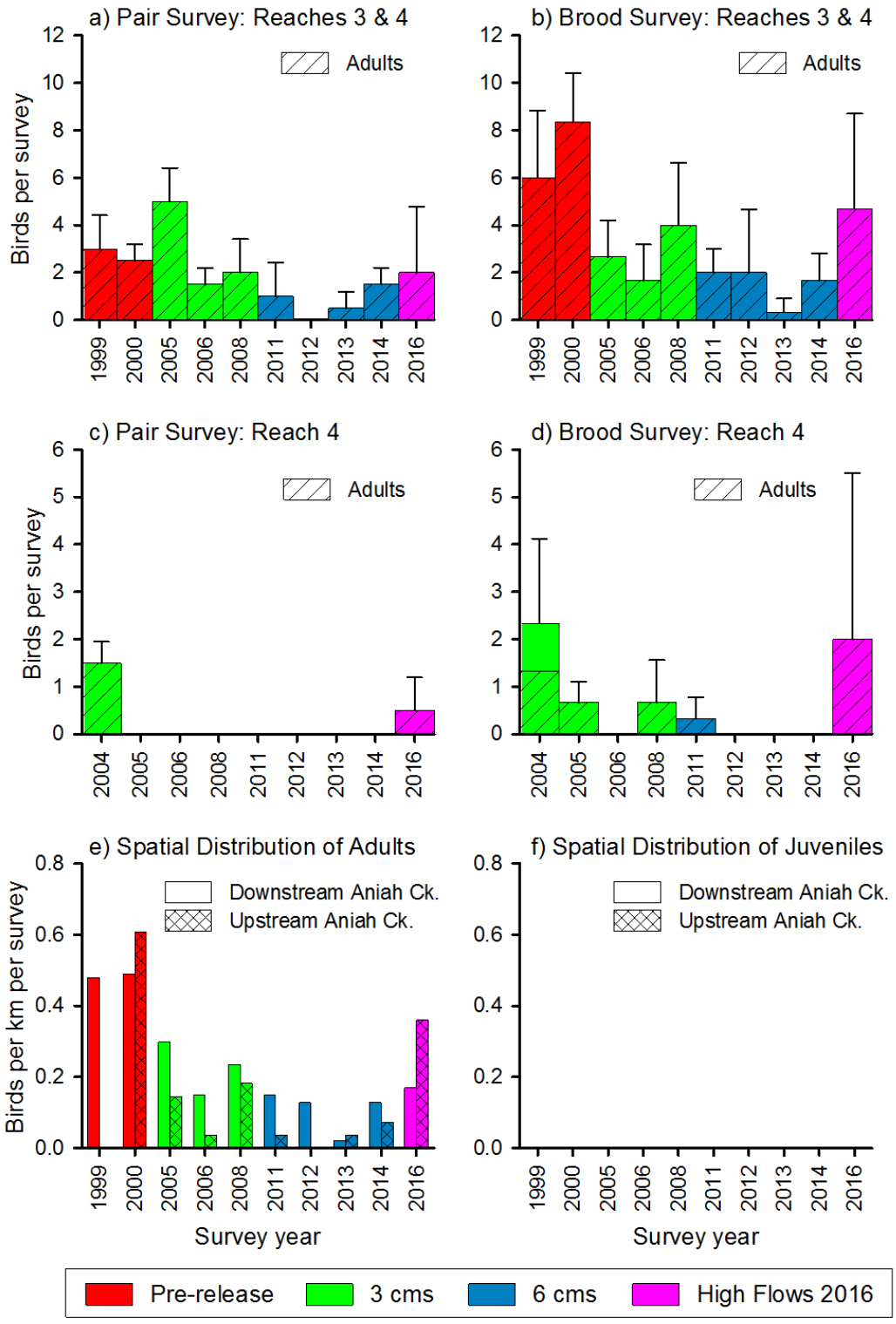

Figure 9. Average number of Belted Kingfishers per survey (± 1 SD) from the Yalakom River confluence to Terzaghi Dam (9a, b) and upstream of Mission Creek (9c, d) for pair and brood surveys. Number of adult (9e) and juvenile (9f) Belted Kingfishers observed per km per survey above and below Aniah Creek (totaled over all 5 surveys).

5.0 DISCUSSION

All five resident riverine bird species used the 14.9 km section below Terzaghi Dam to the Yalakom River confluence for at least part of their breeding stages throughout all years of the study. Spotted Sandpiper and dipper nests were occasionally detected along this section. Although Harlequin Duck nests were found on the Bridge River after the release in 2000 (Ken Wright, *pers. comm.*), previous work (Wright and Goudie 2000; Wright and Walton 2001a) suggested that some Harlequin Ducks nested on the Yalakom River and moved their young to the Bridge River for brood-rearing. Common Mergansers, a cavity-nesting species, probably nested along our survey route where trees with appropriate cavities were available, and their numbers may be limited by this availability.

The most unusual result from the 2016 surveys is that other waterfowl species were not observed during pair surveys for the first time since surveys began in 1999. Typically, goldeneye (*Bucephela spp)*, Scaups (*Athya spp*), Buffleheads (*Bucephela albeola*) and other waterfowl were seen in the May surveys, presumably stopping briefly during migration to nesting areas. High flows in 2016 increased the intensity of the river and converted some existing pools and glides to riffles. The change may have made conditions less desirable for waterfowl adapted to calmer lakes and ponds. As before, this absence may also be due to the small sample size of only one year's worth of data at 2016 flow levels. If 2016 flow levels are to return, surveys should be repeated to determine if lower numbers of riverine birds and the absence of other waterfowl species is a real trend.

Only Harlequin Ducks showed a tendency to increase with higher flows under the 6 m^3/s regime, prior to 2016. In 2016, however, Harlequin Duck numbers appeared to decline slightly, although brood production was normal relative to previous years (Walton and Heinrich 2015). Anecdotally, we observed several females with brood patches in brood-failure years, and we believe the higher numbers of adults observed in these years were likely caused by females from tributaries or other river systems moving to the Bridge River after the loss of their nests or young. In 2016, despite the large increase in flow during the incubation period and the sharp decline in flow during the brood-rearing stage (Figure 2), Harlequin Ducks demonstrated that they can successfully rear young across a wide range of flow conditions on this section of river.

American Dipper numbers generally remained unchanged from pre-release levels or slightly declined prior to 2016, but their response to the 2016 flows is unclear, with lower than average dipper numbers observed during pair surveys being balanced by relatively higher numbers during brood surveys. We usually spotted dippers on midstream boulders or along the shoreline. Higher water levels and an inundated shoreline could make observing dippers more difficult in sections with flooded trees but it is not clear why dipper counts would differ so much between the pair and brood surveys in 2016. One possible explanation for the lower pair survey numbers is that dippers may have been more active on tributaries while water levels were increasing in early May. This contradiction may simply be a factor of a small sample size, with only 1 year of surveys under the high flow conditions of 2016.

Before 2016 the Common Merganser response was complicated, with numbers being highest during the pair period at the 3 m^3/s flow rate but not during the brood period. In 2016, fewer mergansers were recorded than in previous years, and only 1 hatch-year bird was consistently observed during the brood-raising period. With only one set of surveys completed during the exceptional flows of 2016, it is difficult to say if lower merganser numbers along Reaches 3 and 4 reflect a real decline or if it is simply an artifact of small sample size.

Spotted Sandpiper abundance appeared to increase during the period when the 3 m^3/s flow regime was implemented, by more than doubling their pre-release numbers; since the initiation of the 6 m^3/s flow, however, their numbers have declined to pre-release levels, and higher flows in 2016 continued this trend. No juvenile sandpipers were observed in 2016 but, because of the difficulty in detecting camouflaged young sandpipers, this is not proof of extensive nest-failure. Thus, while it is possible that ground nests were flooded in Reaches 3 and 4 in 2016, our surveys are unable to detect this issue.

Belted Kingfishers, of the 5 main riverine species studied, are the most difficult to observe during surveys. Most often they are seen briefly while flying from a tree perch along the river. As a result of this, juveniles are difficult to identify and their numbers should be treated cautiously. Unlike most years previously, adult Belted Kingfishers were more often observed upstream of Aniah Creek in 2016 (Figure 9e) and only in 2004 and 2016 were kingfishers observed using Reach 4 upstream of Mission Creek during pair surveys (Figure 9c). Kingfishers were seen more often in Reach 4 during brood surveys but they were still found at low numbers and were seen only once at the 6 m^3/s flow (Figure 9d). Overall, however, Belted Kingfisher numbers appear to have declined since initiation of the controlled release in 2000, especially during brood surveys (Figures 9a, b). In 2016, more kingfishers were observed during the brood surveys than in the pair surveys. While evidence of an increase was also present prior to the final 2016 brood survey on July 27, new methodology for the final survey may have inflated kingfisher numbers through double-counting. Trends in kingfisher response to flow regimes should be interpreted cautiously given the low overall number of kingfishers detected on the river and the difficulty with juvenile detectability.

In 2016, all riverine species except Harlequin Ducks were found at higher densities upstream than downstream of Aniah Creek, generally following a trend established at the 3 and 6 m^3/s flows (Walton and Heinrich 2015). Prior to 2016, some of the shift upstream may simply have been explained by the increased availability of habitat contributed by the re-watered 3.3 km below the dam. Shifting distribution may also reflect changes in habitat structure caused by the increased flow or by changes in the availability of aquatic invertebrates and fish prey. Bradford et al. (2011) found juvenile salmonid abundance did not change at the 3 m^3/s discharge in Reach 3, compared to pre-release abundance, and similar results were found at the 6 m^3/s discharge (Jeff Sneep, *pers. comm.*), although total salmonid abundance did increase overall with the creation of new habitat in Reach 4. Mergansers are highly mobile and likely tracked this additional food resource upstream.

Harlequin Ducks and dippers prey largely upon aquatic macroinvertebrates during the breeding season (Robertson and Goudie 1999, Kingery 1996). Prior to 2016, the response by the aquatic invertebrate community to increased flows was variable in Reach 3, with most of the differences coming between pre-release levels and the two discharge rates; in other words, the 3 m^3/s and 6 m^3/s flows had similar effects (Jeff Sneep, *pers. comm.*). Sampling with fall baskets suggested a tendency for the total abundance of benthic invertebrates to decline on Reach 3 at higher flow levels, although this was compensated to some degree by their colonization of Reach 4 (Jeff Sneep, *pers. comm.*). Harlequin Duck densities are typically related to higher densities of aquatic invertebrates (LeBourdais et al. 2009) although this relationship can be weak (e.g., Esler 2007) or non-existent (Cassirer and Groves 1994). In 2016, concern was expressed about the effect of the timing of flow changes on aquatic invertebrate abundance. The last large increase in flow began during the incubation period, peaked for approximately 3 weeks, and then declined precipitously in mid-June as young birds appeared on the river (Figure 3). Since aquatic invertebrate abundance is negatively affected by high variability in flow (LeBourdais et al. 2009) and the unusually high water levels in 2016 were expected to scour previously unflooded shoreline, increasing sedimentation, it was unclear if aquatic invertebrates would be available for young riverine birds. To study this, we sampled aquatic invertebrates at the beginning of the brood period in Reaches 3 and 4. From the results (Walton and Heinrich, *2018*), analysis suggests that invertebrate density was similar to that studied by LeBourdais et al. (2009) during the 3 m^3/s flow. Reassuringly, three Harlequin Duck females raised a total of nine young in 2016 on Reaches 3 and 4 (Figure 4 b, d), suggesting that invertebrate availability was not an important limitation.

Harlequin Ducks and Spotted Sandpipers nest on the ground and are the most likely species to be affected by the timing of the freshet, depending on where they choose to nest, relative to the high water mark, and depending on the timing of nesting, relative to the hydrograph. In 2016, flows almost doubled from mid-May to a peak in mid-June, overlapping with nest initiation and incubation of Harlequin Duck (Figure 3). After a short 3 week peak, flow then dropped precipitously in mid-June, when hatch-year young first appear on the Bridge River. Despite this, three Harlequin Duck broods were raised successfully on Reaches 3 and 4 in 2016. Comparing absolute numbers of riverine birds among years should be done carefully though since extrinsic factors unrelated to the study can also influence breeding success. For example, in 1999 most broods failed due to severe flooding (Wright and Walton 2001a). Again in 2006 and 2011, Harlequin Ducks failed to raise broods (Walton and Heinrich 2006; Walton and Heinrich 2011) and Common Merganser young were not observed in 2013 (Walton and Heinrich 2013).Without radio-tracking, however, it is not certain that these females nested on the Lower Bridge River. In 1999 prior to minimum flow regimes in the Lower Bridge River, we observed two female Harlequin Ducks incubating on the Yalakom River, and females typically moved their broods to the Bridge River after hatching (Wright and Walton 2001a). As such, it is possible that the broods observed in 2016 were not from nests vulnerable to the variance flow releases, and that nest failures still occurred. Without conducting more detailed study of Harlequin Ducks (e.g., via telemetry), this possibility will be challenging to rule out. However, the relatively normal number of broods was

observed in 2016 provides evidence that the productivity of the local Harlequin Duck population was not dramatically affected by the variance flow regime in 2016.

One caveat for our study is that higher flows inundate the shoreline, making it more difficult to spot birds, and this may have created a bias towards underestimating bird numbers at higher flows. While we cannot discount this possibility, the use of two observers provided some protection against this bias, and bird detections, at least prior to 2016, were generally higher at increased flows compared to low water conditions in 1999 and 2000. At all flow rates, numbers of juvenile sandpipers, kingfishers and, to some extent, dippers, are likely underestimated in the brood surveys. These birds were often observed very briefly, not allowing enough time for positive age identification. Belted Kingfishers, in particular, were usually observed in flight and their juvenile (and probably adult) count will be underrepresented.

6.0 RECOMMENDATIONS

1. As part of the Water Use Planning process, more surveys are scheduled for 2018 and 2020. This schedule was designed **before** the need for variance flows had been identified. To better understand the impact of variance flows, should they continue to be implemented (e.g., until the seismic upgrade of Downton Reservoir are completed), annual riverine bird surveys are necessary in order to gain sufficient data under this new regime.

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APPENDIX 1

Appendix 1 Detailed riverine bird observations from the 2016 survey.

Coordinates are UTM Zone 10, NAD 83. Species codes: AMDI = American Dipper; BAEA = Bald Eagle; BEKI = Belted Kingfisher; COME = Common Merganser; GBHE = Great Blue Heron; HADU = Harlequin Duck; SPSA = Spotted Sandpiper.

Date	Survey	Species	M	F	Unknown Sex	Adult Group Size	Brood Size	Easting	Northing
05-May-16	1st Pair	HADU	1	1	0	2	0	558176	5629504
05-May-16	1st Pair	COME	1	1	0	2	0	558108	5628805
05-May-16	1st Pair	COME	1	1	0	2	0	556882	5626921
05-May-16	1st Pair	COME	1	1	0	2	0	555074	5626485
05-May-16	1st Pair	HADU	0	1	0	1	0	556723	5634310
05-May-16	1st Pair	AMDI	0	0	1	1	0	555750	5632479
05-May-16	1st Pair	COME	0	1	0	1	0	556400	5631230
05-May-16	1st Pair	AMDI	0	0	1	1	0	556403	5631226
05-May-16	1st Pair	COME	1	1	0	2	0	557406	5630432
19-May-16	2nd Pair	AMDI	0	0	1	1	0	558225	5634959
19-May-16	2nd Pair	SPSA	0	0	1	1	0	558142	5634961
19-May-16	2nd Pair	BEKI	1	0	0	1	0	557772	5634808
19-May-16	2nd Pair	SPSA	0	0	1	1	0	557660	5634733
19-May-16	2nd Pair	HADU	0	1	0	1	0	557461	5634669
19-May-16	2nd Pair	COME	2	1	0	3	0	557434	5634656
19-May-16	2nd Pair	HADU	1	1	0	2	0	557425	5634653
19-May-16	2nd Pair	BEKI	1	0	0	1	0	556446	5633720
19-May-16	2nd Pair	SPSA	0	0	1	1	0	556429	5633674
19-May-16	2nd Pair	SPSA	0	0	1	1	0	555766	5632517
19-May-16	2nd Pair	SPSA	0	0	1	1	0	556385	5631305
19-May-16	2nd Pair	COME	0	1	0	1	0	556597	5630787
19-May-16	2nd Pair	HADU	1	1	0	2	0	556953	5630470
19-May-16	2nd Pair	SPSA	0	0	1	1	0	558135	5629724
19-May-16	2nd Pair	SPSA	0	0	1	1	0	558134	5629688
19-May-16	2nd Pair	BAEA	0	0	1	1	0	558134	5629644
19-May-16	2nd Pair	COME	3	0	0	3	0	556281	5626523
19-May-16	2nd Pair	BEKI	0	0	1	1	0	556277	5626512
19-May-16	2nd Pair	SPSA	1	1	0	2	0	556234	5626406
19-May-16	2nd Pair	SPSA	1	1	0	2	0	555836	5626289
19-May-16	2nd Pair	COME	0	1	0	1	0	555034	5626474
19-May-16	2nd Pair	AMDI	0	0	1	1	0	555032	5626508
19-May-16	2nd Pair	BAEA	0	0	1	1	0	558173	5627170
19-May-16	2nd Pair	BEKI	0	0	1	1	0	557839	5626908

Date	Survey	Species	M	F	Unknown Sex	Adult Group Size	Brood Size	Easting	Northing
27-Jun-16	1st Brood	SPSA	0	0	1	1	0	558199	5629414
27-Jun-16	1st Brood	SPSA	0	0	1	1	0	558208	5628992
27-Jun-16	1st Brood	SPSA	0	0	1	1	0	557779	5628334
27-Jun-16	1st Brood	BEKI	1	0	0	1	0	557764	5628294
27-Jun-16	1st Brood	AMDI	0	0	1	1	0	558148	5627425
27-Jun-16	1st Brood	HADU	0	1	0	1	2	558137	5626949
27-Jun-16	1st Brood	AMDI	1	1	0	2	1	558094	5626938
27-Jun-16	1st Brood	AMDI	0	0	1	1	0	557177	5627103
27-Jun-16	1st Brood	AMDI	0	0	1	1	1	556695	5626864
27-Jun-16	1st Brood	SPSA	0	0	2	2	0	556091	5626359
27-Jun-16	1st Brood	SPSA	0	0	1	1	0	556481	5631509
27-Jun-16	1st Brood	AMDI	0	0	1	1	0	556587	5630713
27-Jun-16	1st Brood	AMDI	0	0	1	1	1	556634	5630586
27-Jun-16	1st Brood	AMDI	0	0	1	1	0	557360	5630434
15-Jul-16	2nd Brood	SPSA	0	0	1	1	0	557542	5634700
15-Jul-16	2nd Brood	COME	0	1	0	1	1	557424	5634656
15-Jul-16	2nd Brood	SPSA	0	0	1	1	0	557103	5634521
15-Jul-16	2nd Brood	SPSA	0	0	1	1	0	556791	5634367
15-Jul-16	2nd Brood	HADU	0	1	0	1	4	556244	5633422
15-Jul-16	2nd Brood	BEKI	0	0	1	1	0	555922	5632897
15-Jul-16	2nd Brood	SPSA	0	0	1	1	0	555754	5632621
15-Jul-16	2nd Brood	SPSA	0	0	1	1	0	555769	5632566
15-Jul-16	2nd Brood	AMDI	0	0	1	1	0	555767	5632520
15-Jul-16	2nd Brood	BEKI	1	0	0	1	0	556462	5631431
15-Jul-16	2nd Brood	AMDI	0	0	0	0	1	556620	5630612
15-Jul-16	2nd Brood	SPSA	0	0	1	1	0	555431	5626332
15-Jul-16	2nd Brood	AMDI	0	0	1	1	0	555427	5626333
15-Jul-16	2nd Brood	COME	0	3	0	3	0	555157	5626465
15-Jul-16	2nd Brood	SPSA	0	0	1	1	0	555018	5626498
15-Jul-16	2nd Brood	AMDI	1	1	0	2	2	555984	5626331
15-Jul-16	2nd Brood	SPSA	0	0	2	2	0	556154	5626375
15-Jul-16	2nd Brood	SPSA	0	0	1	1	0	556249	5626463
15-Jul-16	2nd Brood	AMDI	0	0	1	1	0	556277	5626531
15-Jul-16	2nd Brood	SPSA	0	0	1	1	0	556277	5626536
15-Jul-16	2nd Brood	AMDI	0	0	1	1	0	556614	5626823
15-Jul-16	2nd Brood	BEKI	0	0	1	1	0	558203	5629385
15-Jul-16	2nd Brood	AMDI	0	0	1	1	0	558226	5629054
15-Jul-16	2nd Brood	AMDI	0	0	1	1	0	558176	5628938
15-Jul-16	2nd Brood	HADU	0	1	0	1	2	557836	5628016
15-Jul-16	2nd Brood	BEKI	0	0	1	1	0	557947	5627882
15-Jul-16	2nd Brood	SPSA	0	0	1	1	0	557999	5627793

Date	Survey	Species	M	F	Unknown Sex	Adult Group Size	Brood Size	Easting	Northing
15-Jul-16	2nd Brood	AMDI	0	0	1	1	0	557801	5626905
15-Jul-16	2nd Brood	AMDI	0	0	1	1	0	557423	5627052
15-Jul-16	2nd Brood	SPSA	0	0	1	1	0	556979	5626919
28-Jul-16	3rd Brood	COME	0	0	0	0	1	558195	5634967
28-Jul-16	3rd Brood	HADU	0	1	0	1	3	557979	5634905
28-Jul-16	3rd Brood	SPSA	0	0	1	1	0	557922	5634875
28-Jul-16	3rd Brood	GBHE	0	0	1	1	0	557235	5634580
28-Jul-16	3rd Brood	HADU	0	1	0	1	4	557005	5634486
28-Jul-16	3rd Brood	AMDI	0	0	1	1	0	558079	5628694
28-Jul-16	3rd Brood	BEKI	0	0	2	2	0	558080	5628695
28-Jul-16	3rd Brood	BEKI	0	0	1	1	0	557213	5627099
28-Jul-16	3rd Brood	BEKI	1	1	0	2	0	556953	5626915
28-Jul-16	3rd Brood	AMDI	0	0	1	1	0	556715	5626914
28-Jul-16	3rd Brood	BEKI	0	0	2	2	0	556703	5626894
28-Jul-16	3rd Brood	SPSA	0	0	2	2	0	556239	5626432
28-Jul-16	3rd Brood	BAEA	0	0	1	1	0	556192	5626387
28-Jul-16	3rd Brood	BEKI	0	0	1	1	0	555951	5632963
28-Jul-16	3rd Brood	SPSA	0	0	1	1	0	555953	5632974
28-Jul-16	3rd Brood	SPSA	0	0	1	1	0	556684	5630540
28-Jul-16	3rd Brood	BEKI	0	0	1	1	0	557984	5626931
28-Jul-16	3rd Brood	HADU	0	1	0	1	2	557416	5627057

APPENDIX 2

Appendix 2 List of wildlife species encountered during the Riverine Bird Surveys conducted between May 5th and July 28th, 2016.

Mammals (Eder and Pattie 2001)

Common Name	Latin Name	Provincial List	COSEWIC[1]	Identified Wildlife	Bridge R. Status
Mule Deer	*Odocoileus hemionus*	Yellow	N/A	No	Resident
Red Squirrel	*Tamiasciurus hudsonicus*	Yellow	N/A	No	Resident
Yellow Pine Chipmunk	*Tamias amoenus*	Yellow	N/A	No	Resident
American Beaver	*Castor canadensis*	Yellow	N/A	No	Resident
Black Bear	*Ursus americanus*	Yellow	N/A	No	Resident

Birds (Alsop 2002, Campbell *et* al 1997a, 1997b and 1997c, and Ehrlich *et al* 1988)

Common Name	Latin Name	Provincial List	COSEWIC[1]	Identified Wildlife	Bridge R. Status
Great Blue Heron	*Ardea herodias*	Blue	SC	No	Breeding Migrant
Harlequin Duck	*Histrionicus histrionicus*	Yellow	N/A	No	Breeding Migrant
Hooded Merganser	*Lophodytes cucullatus*		N/A	N/A	Migrant
Common Merganser	*Mergus merganser*	Yellow	N/A	No	Resident
Hawks, Eagles and Ospreys (Acipitridae)					
Osprey	*Pandion haliaetus*	Yellow	NAR	No	Breeding Migrant
Bald Eagle	*Halieaeetus leucocephalus*	Yellow	NAR	No	Resident
Red-Tailed Hawk	*Buteo jamaicensis*	Yellow	NAR	No	Resident
Falcons (Falconidae)					
American Kestrel	*Falco sparverius*	Yellow	N/A	No	Breeding Migrant
Grouse, partridges and pheasants (Phasianidae)					
Ruffed Grouse	*Bonansa umbellus*	Yellow	N/A	No	Resident
Sandpipers and Phalaropes (Scolopacidae)					
Spotted Sandpiper	*Actitis macularius*	Yellow	N/A	No	Breeding Migrant
Hummingbirds (Trochilidae)					
Rufous Hummingbird	*Selasphorus rufus*	Yellow	N/A	No	Breeding Migrant
Kingfishers (Alcedinidae)					
Belted Kingfisher	*Ceryle alcyon*	Yellow	N/A	No	Resident
Woodpeckers (Picidae)					

Common Name	Latin Name	Provincial List	COSEWIC[1]	Identified Wildlife	Bridge R. Status
Northern Flicker	*Colaptes auratus*	Yellow	N/A	No	Resident
Flycatchers (Tyranidae)					
Dusky Flycatcher	*Empidonax oberholseri*	Yellow	N/A	No	Breeding Migrant
Pacific Slope Flycatcher	*Empidonax difficilis*	Yellow	N/A	No	Breeding Migrant
Vireos (Vireonidae)					
Red-eyed Vireo	*Vireo olivaceus*	Yellow	N/A	No	Breeding Migrant
Warbling Vireo	*Vireo gilvus*	Yellow	N/A	No	Breeding Migrant
Jays, Crows and Ravens (Corvidae)					
Clark's Nutcracker	*Nucifraga columbiana*	Yellow	N/A	No	Resident
Black-billed Magpie	*Pica hudsonia*	Yellow	N/A	No	Resident
American Crow	*Corvus brachyrhynchos*	Yellow	N/A	No	Resident
Common Raven	*Corvus corax*	Yellow	N/A	No	Resident
Swallows (Hirundinidae)					
Tree Swallow	*Tachycineta bicolor*	Yellow	N/A	No	Breeding Migrant
Violetgreen Swallow	*Tachycineta thalassina*	Yellow	N/A	No	Breeding Migrant
Northern Rough-winged Swallow	*Stelgidopteryx serripensis*	Yellow	N/A	No	Breeding Migrant
Chickadees (Paridae)					
Black-capped Chickadee	*Poecile atricapilla*	Yellow	N/A	No	Resident
Mountain Chickadee	*Poecile gambeli*	Yellow	N/A	No	Resident
Nuthatches (Sittidae)					
Red-breasted Nuthatch	*Sitta canadensis*	Yellow	N/A	No	Resident
Wrens (Troglodytidae)		**Yellow**	**N/A**	**No**	
Pacific Wren	*Troglodytes pacificus*	Yellow	N/A	No	Resident
Dippers (Cinclidae)					
American Dipper	*Cinclus mexicanus*	Yellow	N/A	No	Resident
Bluebirds, Solitaires and Thrushes (Turdidae)					
Townsend's Solitaire	*Myadestes townsendi*	Yellow	N/A	No	Common Breeding Migrant
Swainson's Thrush	*Catharus ustulatus*	Yellow	N/A	No	Common Breeding Migrant
American Robin	*Turdus migratorius*	Yellow	N/A	No	Common Breeding Migrant

Common Name	Latin Name	Provincial List	COSEWIC[1]	Identified Wildlife	Bridge R. Status
Wagtails and Pipits (Motacillidae)					
American Pipit	*Anthus rubescens*	Yellow	N/A	No	Migrant
Waxwings (Bombycillidae)					
Cedar Waxwing	*Bombycilla cedrorum*	Yellow	N/A	No	Breeding Migrant
Wood-Warblers (Parulidae)					
Yellow Warbler	*Dendroica petechia*	Yellow	N/A	No	Common Breeding Migrant
Yellow-rumped Warbler	*Dendroica coronata*	Yellow	N/A	No	Common Breeding Migrant
Townsend's Warbler	*Dendroica townsedi*	Yellow	N/A	No	Breeding Migrant
MacGillivray's Warbler	*Oporornis tolmiei*	Yellow	N/A	No	Breeding Migrant
Wilson's Warbler	*Wilsonia pusilla*	Yellow	N/A	No	Migrant
Tanagers (Thraupidae)					
Western Tanager	*Piranga ludoviciana*	Yellow	N/A	No	Common Breeding Migrant
Tohees, Sparrows and Buntings (Emberizidae)					
Spotted Towhee	*Pipilo maculatus*	Yellow	N/A	No	Resident
Song Sparrow	*Melospiza melodia*	Yellow	N/A	No	Common Breeding Migrant
Dark-eyed Junco (Oregon Race)	*Junco hyemalis*	Yellow	N/A	No	Common Breeding Migrant

Reptiles (St John 2002 and Gregory and Campbell 1984)

Common Name	Latin Name	Provincial List	COSEWIC[1]	Identified Wildlife	Bridge R. Status
Northern Alligator Lizard (Northwestern)	*Elgaria coerulea principis*	Yellow	NAR	No	Common Resident
Common Garter Snake (Valley Garter Snake)	*Thamnophis sirtalis fitchi*	Yellow	N/A	No	Common Resident
Western Terrestrial Garter Snake (Wandering Garter snake)	*Thamnohpis elegans vagrans*	Yellow	N/A	No	Common Resident

Sources for Provincial and Federal rankings:

- B.C. Conservation Data Centre. 2017. BC Species and Ecosystems Explorer. B.C. Minist. of Environ. Victoria, B.C. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Jan 2, 2017). provincial endangered species tracking database;
- https://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1 Species at Risk Public Registry; and
- Province of BC. 2004. Identified Wildlife Management Strategy: Species at Risk and the Forest Practices Code. Ministry of Forests and Ministry of Water, Land and Air Protection. 180pp. Also see: http://www.env.gov.bc.ca/wld/frpa/iwms/iwms.html

Appendix 3
Breeding Phenology for five focal riverine bird species

Breeding stage	American Dipper	Harlequin Duck	Spotted Sandpiper	Belted Kingfisher	Common Merganser
Arrival on System	Year Round	Mid-April	3rd week in May	Mid-March	March – Mid April
Pair Period	March 31 to April 30	Apr 21 – May 21	May 24 – June 7	April 01 – May 7	March
Nest Initiation	April 15 – May 15	May 24 – June 7	May 24 – June 7	April 15 – Jun 15	Mid-April
Egg Laying	April 15 – May 15	May 24 – June 7	3 – 5 days after pair formation	May 15 – Jun 15	Mid-April to Mid-May
Incubation	14 -17 days	28 Days	21 days	22 days	32 days
Fledging[1]	24 -26 days	1 -2 Days after hatching	Within hours of hatching	27 – 29 days	1 -2 days after hatching
Brood Rearing	5 -25 days	28 days	21 days after fledging	1 – 2 weeks after nest departure	30 – 50 days after fledging

Sources: The dates mentioned in this table reflect a combination of local knowledge and a range of dates taken from the following literature (Pearce et al 2015, Reed et al 2013, Wilson and Kingery 2011, Kelly et al 2009, Robertson and Goudie 1999),
[1]Fledging has been taken to mean the date when chicks actually leave the nest not the date of first flight. Many waterfowl and shorebirds leave their nests long before flight is achieved.