Bridge River Water Use Plan

Lower Bridge River Riverine Wildlife
Reference: BRGMON-11B

Final Report

Study Period: 2012 – 2021

Wildtech Biological Services, Kamloops, BC

and

St'át'imc Eco-Resources Ltd., Lillooet, BC

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BRGMON-11B - LOWER BRIDGE RIVER RIVERINE WILDLIFE, FINAL REPORT- 2012 - 2021

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Cover photo: Lower Bridge River, Harlequin Duck female with young. Photo © Russ Walton, Wildtech Biological Services.

EXECUTIVE SUMMARY

With completion of the Terzaghi Dam in 1960, all upstream water from the Bridge River was diverted through Mission Mountain to the Seton watershed. Stopping the downstream flow of water resulted in approximately 4 km of dry riverbed immediately below the dam and severely reduced water flows along the remainder of the Lower Bridge River, fed only by inputs from small creeks and the Yalakom River. Concerns by the public, First Nations, and regulatory agencies about the ecological effects of the dam led to the development of a modified gate that could release a continuous flow of water through Terzaghi Dam. An adaptive management approach was developed to understand the ecological effects of different flows on the Lower Bridge River. Beginning in August 2000, an annual average flow rate of 3 cubic meters per second (cms) was released through Terzaghi Dam.

The Bridge-Seton Water Use Plan (WUP) was finalized in 2011, and a new Water Licence was issued to BC Hydro. Consequently, an average flow of 6 cms was initiated in 2011 as ordered under BC Hydro's Water Licence. The WUP (a.k.a. "6 cms") flow regime was characterized by releases of approximately 15 cms during the spring/summer freshet, with flows ramping down to 1.5 cms following the freshet, with an annual average flow rate of 6 cms.

In 2015, technical safety issues at hydroelectric water storage infrastructure upstream prevented BC Hydro from being able to adhere to WUP operations in the Lower Bridge River, ending BC Hydro's adherence to the WUP flow regime. BC Hydro was issued a variance to their Water Licence, and since then have been releasing water into the Lower Bridge River in more variable 'Modified Operations'. Considerably higher freshet flows were released in 2016-2018, with peaks at freshet approaching 130 cms under these Modified Operations. In the final years of this WUP-ordered study (2019 through 2021), Modified Operations on the Lower Bridge River were more comparable to WUP operations.

Harlequin Ducks were identified as a species of concern in an environmental management plan studying the potential impacts of a planned spill on the Lower Bridge River in 1997. Data were collected on Harlequin Ducks and other riverine birds prior to initiation of the 3 cms flow in 2000, and surveys continued intermittently until 2011, funded through the Bridge Coastal Restoration Program. BC Hydro was Ordered to monitor (impacts to) riparian habitat and riverine wildlife as a Water Licence Requirement; this commitment was implemented according to a Terms of Reference (TOR) written in 2012 for this study (BRGMON-11). Since 2012, riverine bird surveys have been conducted under BRGMON-11. BRGMON-11 TOR prescribed wildlife monitoring in six years between 2012 and 2021. In 2018, a revision was made to the TOR to separate the wildlife component (BRGMON-11B) from the vegetation component (BRGMON-11A). The BRGMON-11B TOR also added additional and more specific management questions to better assess the effects of flow regime on the riverine and riparian wildlife along the Lower Bridge River. This report concludes BRGMON-11B. For this report, data collected during the entire course of BRGMON-11 monitoring (2012-2021) are supplemented with data collections funded outside of the WUP program collected prior to this study, and collected in intervening years during this study.

In total, we addressed six management questions related to riparian and riverine wildlife along the Lower Bridge River. The first three management questions investigated the influence of flows on riverine birds, with the focus on Harlequin Ducks. Since 1999, we have conducted 80 riverine bird surveys during the breeding season and 7 surveys during the winter. Species-specific patterns of abundance and productivity were observed among the four main riverine bird species (Harlequin Duck, Common Merganser, American Dipper, and Spotted Sandpiper), which may reflect their unique ecological requirements and species-specific sensitivities to river regulation. However, given inconsistent and uneven character of operations among years, there are too few years of data to analyze, and no conclusions could be made at this time to address these three management questions conclusively. Harlequin Duck and Common Merganser abundance and/or productivity tended to decrease towards the end of the study during the Modified Operations years. Dipper abundance appeared to be the most stable over time. Spotted Sandpipers tended to be most abundant during 3 cms operations. Numbers of dippers increase substantially in the winter.

In contrast with 1 active beaver lodge detected during a May 1999 helicopter survey, the number of active beaver colonies on Reaches 2, 3 and 4 of the Lower Bridge River observed during this study was much greater. This is consistent with the probable improved habitat suitability for beavers afforded by reintroduction of flows in 2000. In recent years, the impact beaver herbivory was having on riparian vegetation became a concern; specifically, mature cottonwood trees were being disproportionately affected, and these trees, uncommon since dam construction, provide important wildlife habitat. Two management questions were developed to determine the number of active colonies using the Lower Bridge River and to assess if river morphology or flows affect the locations of winter beaver lodges. Since 2016 we conducted 5 beaver lodge surveys. Lodge numbers were stable during Modified Operations, although there were some indications that the number of beavers using the Lower Bridge River declined in the most recent survey. There was a tendency for lodges to be located in shallow parts of the river with low velocity; however, we postulated that winter lodge locations were likely based more on food availability than on river morphology or flows. External to this project, wire cages were installed during the implantation of BRGMON-11 monitoring to prevent the loss of some of the remaining large cottonwood trees along the Lower Bridge River.

The sixth management question addresses the vulnerability of riparian bird species to potential changes in riparian vegetation habitat at a local and regional scale. In June 2019, we conducted a 52 station point count survey over a consecutive 3-day period, generating almost 200 detections of 28 species along the Lower Bridge River. None of the species detected is considered to be vulnerable or threatened nationally or within BC, and the character/availability of riparian habitat in the Lower Bridge River was not assessed to be notable at the regional scale. In 2019 we also conducted a survey at 20 stations of Western Screech-Owls, a threatened species (none were detected).

This report summarizes all of the primary long term data collections performed for BRGMON-11A, and marks the conclusion of this study. Deviations from WUP operations during the study period provided unplanned opportunities to witness how operations affect riverine and riparian wildlife, but also diminished the study's ability to characterize the capacity of the Lower Bridge River to support riverine wildlife when operated according to the WUP. Results from monitoring riverine wildlife were highly variable over the study period, and the variability did not clearly correspond with operations. Nonetheless, the observed variability was biologically significant from a conservation perspective, and its possible that changing flow regimes account for some of these results. Additional years of monitoring are required to address most Management Questions.

Final status of BRGMON-11B

Management Question	Summary of Key Monitoring Results
MQ-1 How has the population of Harlequin Ducks in Reaches 3 and 4 of the Lower Bridge River (as enumerated prior to the nesting period with 'pair surveys') varied over time, and is this population index related to flow regime?	• Adult Harlequin Ducks were observed under all flow regime conditions since 1999, but numbers were highly variable, ranging from 0-6 pairs annually. • During the pre-nesting period, there was a tendency for more consistent showing of adult Harlequin Ducks during the 6 cms flow regime years, compared with other years. • Given the inconsistency of flow regime, the dataset was too sparse to consider for analysis examining effects of flows on Harlequin Duck population size. As a result, this MQ requires more survey years under consistent operational flows to be addressed more conclusively.
MQ-2 Are Harlequin Duck brood counts, monitored in Reaches 3 and 4 of the Lower Bridge River, influenced by flow regime?	• Harlequin Duck brood production was highly variable, with no broods being seen in 5 of 14 total survey years reviewed in this report. • Since 1999, a maximum of 3 Harlequin Duck broods was observed on Reaches 3 and 4 during a single survey; this result occurred on 4 of 14 years of monitoring. • The maximum brood count of 3 was observed in 1 of 3 years during 3 cms flows; 2 of 4 years during WUP (6 cms) flows; and 1 of 5 years during Modified Operations. During the latter period (2016-2021), the max brood count of 3 was observed in 2016, which was one of two years monitored during very high flows. • Since 1999, no Harlequin Duck broods were observed on Reaches 3 and 4 in 5 out of 14 years of monitoring. • Years of zero productivity were observed once during two years of monitoring prior to 3 cms regime, once during three years of monitoring during 3 cms regime, once during 4 years of monitoring during 6 cms regime, and twice during Modified Operations. During the latter period, zero productivity was observed once during 2 years of high flows, and once during 3 years of operations that closely approximated WUP (6 cms) flows. • Given the inconsistency of flow regime (and low repetition for each regime), the dataset was too sparse to consider for analysis examining the effects of flow regime on Harlequin Duck brood counts, so this MQ has not been well addressed. Given the biological significance of the observed variability in productivity, additional survey effort is recommended.

Management Question	Summary of Key Monitoring Results
MQ-3 Are other riverine bird species likely to be influenced by flow regime; if so, how?	• Potential responses to flow regime were unique for the 4 other riverine bird species monitored. • Given the inconsistency of flow regime, the dataset was too sparse to consider more robust statistical analyses examining the effects of flow regime on riverine birds. As a result, this MQ requires more survey years under consistent operational flows to be addressed more conclusively. • **Common Mergansers** ❖ A maximum of 3 merganser broods was observed using Reaches 3 and 4 in a single survey since 1999 ❖ There was a tendency for adult merganser numbers to decline and for brood counts to be more inconsistent with initiation of the Modified Operations in 2016. ❖ Food availability is likely the main factor influenced by flow regime. ❖ Present during the non-breeding season but unlikely to be affected unless winter flow rates change. • **American Dippers** ❖ Do not appear to have been influenced by flow regime changes since 1999. ❖ Flow regime is unlikely to affect dippers at the nesting stage, and we believe their natural adaptations to variable, high-flowing streams and/or their flexible use of tributaries during the breeding season dampens any potential negative effects on food availability from habitat changes caused by flow regime on the Bridge River during the breeding season. ❖ Densities increase substantially in fall and winter. Any potential changes to flow rates in winter should take dipper numbers into account. ❖ Winter diet comprised mostly of aquatic invertebrates, but fish eggs, alevin and fry formed 18 % of their observed diet during 2019, a dominant pink salmon year. • **Spotted Sandpipers** ❖ A tendency for more to be found during 3 cms flow regime; other flow regimes had similar numbers. ❖ We speculate that the 3 cms flow regime may offer the best combination of available semi-open shoreline habitat for breeding without unfavourable water level changes. ❖ Results should be treated cautiously because sandpipers were not as detectable by our surveys as American Dippers and Common Mergansers. • **Belted Kingfishers** ❖ We have very little evidence to assess this management question for kingfishers. Belted Kingfishers were difficult to observe reliably in this forested landscape with our survey methodology because birds tended to be observed in trees above the river.
MQ-4 How many active beaver lodges are there in Reaches 2, 3 and 4 of the Lower Bridge River in fall, how are they distributed, and how do these data vary among years?	• Total number of active beaver lodges in late fall varied from 5-10 lodges combined on Reaches 2, 3 and 4, giving a linear density of 0.23-0.46 active lodges per km of shoreline. • Most active lodges were distributed in Reaches 2 and 3, with Reach 4 having the fewest number of lodges. • The number of active beaver lodges was consistent during 2016-2020 surveys but showed a 44% decline in the 2021 survey. Anecdotally, food caches at some lodges appeared to be smaller in last 2 survey years, possibly suggesting fewer beavers are present. More years of surveys would improve confidence in whether the decline in 2021 lodge numbers is normal variation or a change in the population. • Beaver herbivory was noted to affect a large proportion of old cottonwoods in the Lower Bridge River. To preserve old cottonwood trees and replace lost nesting cavities, 169 cottonwood trees were protected in 2018 and 2019 with wire cages along Reaches 2, 3 and 4, and 15 nest boxes were installed for Western Screech-Owls and Common Mergansers reliant on large deciduous trees for cavity-nesting.

Management Question	Summary of Key Monitoring Results
MQ-5 Is the distribution of beavers in the Lower Bridge River influenced by river morphology or possibly by flows?	• We found evidence to support the hypothesis that the distribution of beaver lodges in late fall/winter along the Lower Bridge River is influenced by river morphology and flow using the Telemac 2D model. Beavers placed lodges at sites with less velocity and lower shear force than were generally available along Reaches 3 and 4. • At winter flows (1.5 cms), the lotic instream environment had a narrow range of conditions: depth (0.10-0.64 m), velocity (0.6-1.1 m/s), and shear stress (0.09-53.43 N/m^2). • Because this study relied upon model-derived data and there was uncertainty with mapping lodge locations precisely, we believe this conclusion should be treated cautiously. A field-based approach collecting data at beaver lodges would be a more powerful approach in our opinion. A field-based approach would have particular value where beavers may have been selecting microhabitat features like large boulders to create suitable conditions for bank lodges. • We believe the availability of food trees is more limiting to the establishment of lodges than flow or river morphology features, since food resources are patchily distributed along the Lower Bridge River.
MQ-6 Which riparian bird populations are most vulnerable to being impacted by changes to riparian habitat along the Lower Bridge River, and what ramifications do vegetation monitoring results have for riparian birds at the regional scale?	• We did not find evidence that any riparian bird populations along the Lower Bridge River are vulnerable to riparian habitat changes at the local or regional scale. • We surveyed riparian birds at 52 locations and observed 28 species (185 detections). None of these species has populations considered to be vulnerable or at risk, suggesting that the Lower Bridge River population is not critical at a regional or national scale. We also believe that riparian habitat along the Lower Bridge River does not contribute substantially to riparian habitat at a larger regional scale, nor does it contain any unique or unusual vegetation communities. Because of this, we do not believe that any potential changes to riparian bird populations are of concern at a larger scale. • Riparian vegetation has been affected by flows (especially High Flows under Modified Operations), but, due to the steep and rocky shoreline limiting riparian habitat expansion, we do not believe any potential gains or losses in riparian habitat are large enough to be significant at the scale of breeding territories. • Western Screech-Owls, a threatened species in British Columbia, were not detected at 20 survey stations along the Lower Bridge River in 2019. Our results are consistent with a previous survey in 2011 suggesting that the Lower Bridge River is not an important breeding habitat for Western Screech-Owls. There is an opportunity for recently installed nest boxes to be monitored each year for the presence of Western Screech-Owl. • A single session of point count surveys was used to detect riparian bird species in the riparian zone. Noise from fast-flowing water and the extreme narrowness of riparian habitat likely affected survey effectiveness. Despite this, we believe our approach adequately addressed this MQ. The bird species we detected were typical for this area and were consistent with our observations while conducting 80 shoreline surveys for riverine birds from 1999-2021.

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1.0 INTRODUCTION

Hydroelectric development on the Bridge River system began in 1927 with work on a 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. Upon completion of the Terzaghi Dam in 1960, all upstream water was diverted from the Lower Bridge River to powerhouses located on the Seton Reservoir.

Concerns about the effects of spills (Hill and Wright 2000) and the lack of a continuous flow below Terzaghi Dam on the aquatic ecosystem of the Lower Bridge River by the public, First Nations, and regulatory agencies (BC Hydro 2018), led to the development of a modified gate that could release water continuously through Terzaghi Dam from the Carpenter Lake Reservoir. An experimental flow release program was initiated in 1998 to better understand the response of the Lower Bridge River aquatic ecosystem to different flow release levels (BC Hydro 2018).

Harlequin Ducks (*Histrionicus histrionicus*) were identified as a species of concern in an environmental management plan studying the potential impacts of a planned spill on the Lower Bridge River in 1997 (Hill and Wright 2000). Preliminary surveys in 1997 confirmed that Harlequin Ducks used the Lower Bridge River for breeding, and further surveys were continued in 1998, 1999 and 2000 to establish baseline population data for Harlequin Ducks before the controlled release began on August 1, 2000. Data on other riverine birds observed during surveys were also collected.

Riverine bird surveys continued sporadically after 2000. Initially, surveys were conducted to document the return of riverine birds to Reach 4, the previously dewatered section below Terzaghi Dam (Walton and Heinrich 2004). Later, surveys of Reaches 3 and 4 were done to assess the effects of the 3 cms and 6 cms experimental flow regimes on riverine birds. In 2016, Modified Operations created new conditions by increasing freshet flows above the previous 6 cms regime, but still well below historic levels prior to the regulation of the river (Hall et al. 2009).

The Water Use Plan Consultative Committee for Bridge River recommended that the experimental flow regimes should be monitored for potential impacts effects on riparian vegetation and wildlife (BC Hydro 2018). As a result of this, since 2012 riverine bird monitoring has been a BC Hydro Water Licence Requirement, implemented as a riparian vegetation and wildlife monitoring program: BRGMON-11. In 2018, the BRGMON-11 Terms of Reference (TOR) was revised to separate the wildlife component (BRGMON-11B) from the vegetation component (BRGMON-11A). The BRGMON-11B TOR revised and added management questions to better assess the effects of flow regime on the riverine and riparian wildlife of the Lower Bridge River (BC Hydro 2018).

Additional management questions expanded investigations of flow regime on wildlife beyond riverine birds to include an assessment of riparian birds and the effects of beavers (*Castor canadensis*) on black cottonwood trees (*Populus trichocarpa*). Beavers were included because of concerns about their population increasing on the Lower Bridge River since the flow release in 2000, resulting in the overharvesting of large cottonwood trees, a critical resource for sustaining biodiversity in riparian forests of the Pacific Northwest (Polzin and Rood 2000; Rood et al. 2003; Naiman et al. 2005). These large trees are especially vulnerable because construction of Terzaghi Dam has disrupted cottonwood recruitment on the Lower Bridge River, and many of the larger trees are relics established before 1960 (Hall et al. 2009).

1.1.1 Objective of BRGMON11-B

The objective of this monitoring program was to document how riverine and riparian wildlife in the Lower Bridge River respond to alternate flow regimes regulated by the Terzaghi Dam.

2.0 STUDY AREA AND FLOW REGIMES

The study area is located on the east side of the Coast Mountains in southwestern BC. The Bridge River is approximately 120 km long and flows into the Fraser River just upstream of Lillooet. The Bridge River first became regulated by hydroelectric development in 1948 with completion of the Mission Dam. It is currently regulated by two dams: the La Joie Dam, which impounds the Downton Reservoir, and approximately 60 km downstream, the Terzaghi Dam (an enlargement of the Mission Dam in 1960), which impounds the Carpenter Lake Reservoir. The two dams partition the Bridge River into three main sections: the Upper Bridge River (above La Joie Dam), the Middle Bridge River (between the dams), and the Lower Bridge River (below Terzaghi Dam). The Lower Bridge River has a relatively steep gradient (0.7-3 %), passing through a canyon for approximately 41 km before it joins the Fraser River (Bradford et al. 2011).

Prior to damming, the Bridge River hydrograph, measured at the site of the Terzaghi Dam, had annual maximum flows of over 300 cms during spring freshet, sometimes reaching ~900 cms (Hall et al. 2009). After construction of the Terzaghi Dam, the 3.3 km section below the dam (Reach 4) was essentially converted to dry river bed (Bradford et al. 2011; Figure 1). In the 11.6 km downstream of Reach 4 to the Yalakom River confluence (Reach 3), the Lower Bridge River was fed by ground water and minor tributaries, averaging a mean annual discharge of 0.7 cms (Bradford et al. 2011). At the downstream extent of Reach 3, 14.9 km below the Terzaghi Dam, the unregulated Yalakom River added an average of 4.4 cms of water annually to this discharge (Bradford et al. 2011). Reach 2 begins at the Yalakom River confluence and extends 7 km downstream to the Camoo bridge (Figure 1). Below the Camoo bridge (Reach 1), the Lower Bridge River winds for 18.9 km through a steep, mostly inaccessible canyon to the Fraser River (Bradford et al. 2011).

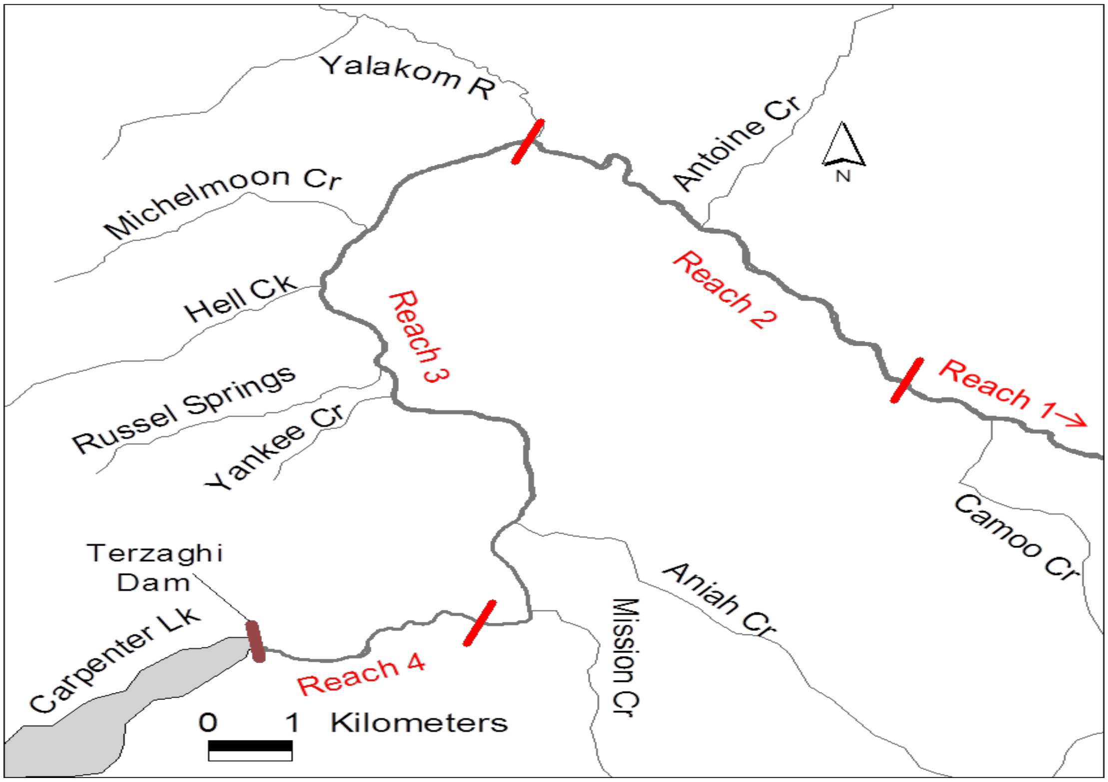

Figure 1 Map of the main study area. Faint lines indicate major creeks. Red lines and text show locations of reaches. Reach 1 not shown in its entirety.

In August 2000, a gate was installed at the base of Terzaghi Dam to allow a controlled release of water into the Lower Bridge River. The release was designed to approximate the timing of the natural spring freshet, with flows rising and falling between March and early August, then dropping to a release of approximately 1.5 cms overwinter. From 2001-2010, annual discharge from the dam averaged 3 cms (peaking at 5 cms); this increased to an average of 6 cms (peaking at 15 cms) beginning in 2011 (Figure 2). After 2015, peak freshet flow increased dramatically under Modified Operations (MO), peaking at 97cms, 127 cms and 102 cms in 2016, 2017 and 2018, respectively (Sneep et al. 2020). For this report, this is referred to as the High Flow regime. In 2019 and 2020, still under Modified Operations, the flow regime more closely resembled the 6 cms discharge, peaking around 16 cms. In 2021 flows were slightly higher, peaking at 26 cms on June 30. We categorized these three years of Modified Operations as the "6 cms_MO" flow regime, since it was very similar to flows from 2011-2015 (Figure 2). We chose to separate these last 3 survey years from the initial 6 cms flow regime because, based on our anecdotal observations of changes caused by High Flows like the scouring of the shoreline and the shifting of gravel bars, we believed that the 2 periods were not directly comparable. In all years with Modified Flow Operations, flows dropped to earlier regime levels by early August and remained the same until March (Figure 2).

Upstream of the Yalakom River, the Lower Bridge River is located within the IDFxc (Interior Douglas-fir very dry cold zone) biogeoclimatic zone; downstream of this, the river flows through the PPxh2 (Ponderosa Pine very dry hot zone) biogeoclimatic zone (Meidinger and Pojar 1991). Dominant tree species along the shoreline in both biogeoclimatic zones include Douglas-fir (*Pseudotsuga menziesii*), paper birch (*Betula papyrifera*) and black cottonwood (*Populus trichocarpa*), with Ponderosa Pine

(*Pinus ponderosa*) present in drier sections. Large cottonwood trees are an important resource for biodiversity (Johnson et al. 1977, Polzin and Rood 2000, Naiman et al. 2005), especially for wildlife species that use large trees for nesting and roosting (Martin and Eadie 1999, Bunnell 2013). Cottonwood trees are dependent on alluvial groundwater and occasional flooding events to create habitat for seedling establishment (Rood et al. 2003, Hall et al. 2009), and these conditions were disrupted after completion of the Terzaghi Dam. Shoreline shrubs in both biogeoclimatic zones are predominately mountain alder (*Alnus incana*), willow (*Salix spp.*) and red-osier dogwood (*Cornus stolonifera*), with alder dominating. The riparian zone of the river is narrow and rocky.

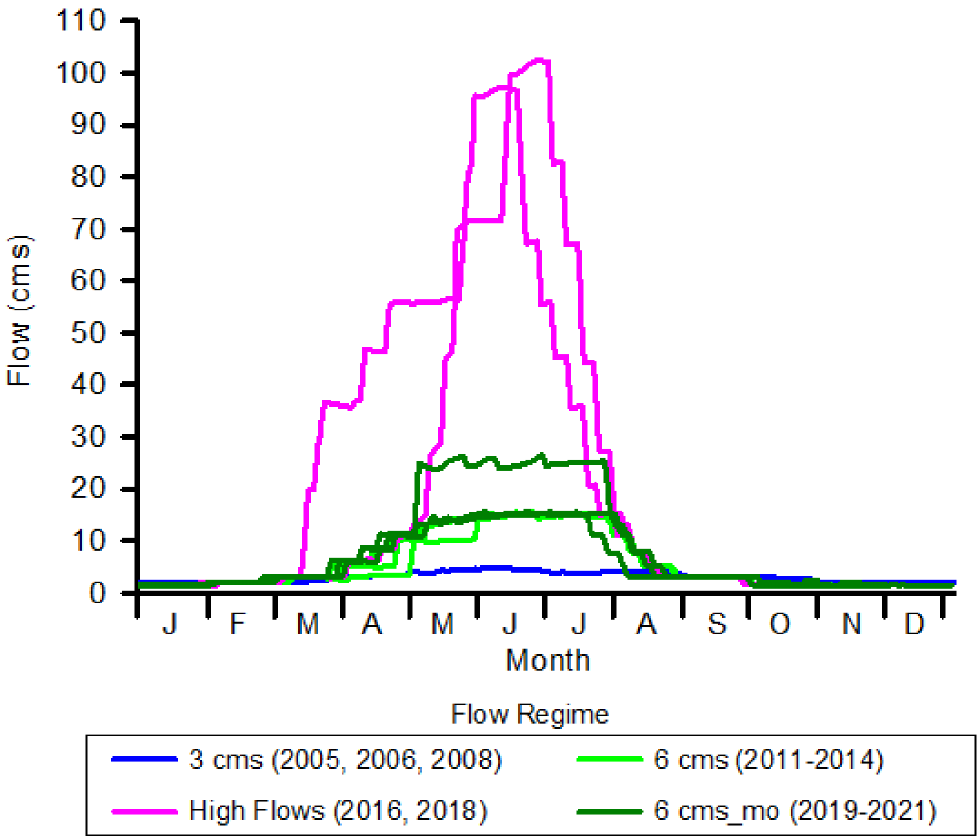

Figure 2. Flow release from the Terzaghi Dam. Lines represent individual years except for the 3 cms flow regime, which is an average of flows from 2000 to 2004. In the legend, "6 cms_MO" indicates flows done under Modified Operations that were similar to the original 6 cms flow regime from 2011-2015.

3.0 METHODS

3.1 *Overview*

Briefly, BRGMON-11B methods involved: shoreline walking surveys along Reaches 3 and 4 (Figure 1) to count riverine birds; shoreline walking surveys along Reaches 2, 3 and 4 to identify active beaver lodges in early winter; a comparison of active beaver lodge locations with river morphology as determined by the Telemac 2D model (Galland et al. 1991); and point count surveys of riparian songbirds during the breeding season in all four reaches.

Detailed descriptions of study design and field protocols are outlined in the annual reports (e.g., Walton and Heinrich 2022).

3.1.1 Riverine Bird Surveys

Riverine bird surveys were conducted by observers walking 14.9 km upstream along the western shoreline (roadside) of Reaches 3 and 4. In each survey year, two surveys were walked during the pre-nesting period (early- to mid-May) and three surveys were walked during the brood-raising period (late June – late July). We documented all riverine bird species encountered (see Appendices in annual reports), but we focused on five main species: Harlequin Duck, American Dipper (*Cinclus mexicanus*), Common Merganser (*Mergus merganser*), Spotted Sandpiper (*Actitus maculatus*) and Belted Kingfisher (*Ceryle alcyon*). We also documented riverine birds observed during early winter beaver lodge surveys for Reaches 3 and 4 (see 3.1.2).

Because Spotted Sandpipers are a late spring migrant and are still appearing on the study area during pair surveys, we focused our analysis on brood-rearing surveys.

Riverine bird surveys of the same reaches using the same methodology were conducted in 1999, 2000, 2005, 2006, 2008, and 2011 during earlier BC Hydro studies on riverine birds in this system (Walton and Heinrich 2015). We included these historic data because they are directly comparable to surveys conducted during this WUP reporting period, and they extend the range of flow conditions studied for riverine birds on the Lower Bridge River, increasing sample size and providing important context.

3.1.2 Active Beaver Lodge Surveys

Observers walked 21.9 km along the shoreline (highway side) of Reaches 2, 3 and 4 to document the presence of active beaver lodges in early December. An active lodge was identified by the presence of freshly cut branches (food cache) stored in the water near the lodge (MELP 1998). Active beaver lodge surveys began in 2016.

3.1.3 River Morphology and Active Beaver Lodge Locations

We used the Telemac 2D model (Galland et al. 1991) to estimate water depth, velocity and shear force stress along Reaches 3 and 4. We modelled flow conditions at 1.5 cms, the typical flow rate experienced by beavers in autumn and winter. Active beaver lodge locations were compared to the availability of these three measures of river morphology (see Walton and Heinrich 2020 for methods used for analyses).

3.1.4 Riparian Songbird and Western Screech-Owl Surveys

Riparian songbird surveys were conducted in 2019. Point count surveys occurred in mid-June in riparian habitat along all four reaches of the Lower Bridge River using an unlimited radius, distance-based point count technique (Ralph et al. 1995, RIC 1998). The most common habitat types (in order of dominance: tall shrub, young deciduous, mature deciduous, young coniferous, herbaceous, mature coniferous, rock/gravel and low shrub) that were accessible were prioritized (Walton and Heinrich 2020). In total, we sampled at 52 survey stations.

Western Screech-Owl (*Megascops kennicottii macfarlanei*) surveys were also conducted in 2019 during the breeding season at 20 stations along the Lower Bridge River using a call playback technique (Hausleitner 2006; see Walton and Heinrich 2020).

Analytical methodologies for both surveys are described in Walton and Heinrich (2020). Data were entered into an Excel spreadsheet. Analyses performed for this report used the data sets described below.

3.2 *Datasets*

3.2.1 Riverine Bird Survey Data

This Access dataset (*BRGMON11B_RiverineBirdSurveys.accdb*) was generated by the riverine bird surveys. Data include observations from 80 surveys conducted from 1999-2021. Seven winter surveys are included. In total, the data include 1635 observations of the 5 main riverine species for a total of 2544 individual birds. Variables documented for each observation include date, time of day, general weather conditions, species, sex, group size, brood size, number of pairs, number of broods, and location coordinates.

3.2.2 Active Beaver Lodge Survey Data

This Access dataset (*BRGMON11B_BeaverFoodCacheSurveys.accdb*) was generated by the active beaver lodge surveys. It includes 8 surveys conducted in early winter from 2016-2021. There are a total of 35 observations. Variables recorded include date, lodge location (coordinates), presence of active food cache, and whether it had been occupied during early surveys.

3.2.3 River Morphology and Active Beaver Lodge Locations

A point dataset (*LBR34Telemac.xlsx)* with values for water depth, velocity, and shear force stress at each point was created by Harry von Oort for Reaches 3 and 4 using BC Hydro's Telemac 2D model for the Lower Bridge River (Galland et al. 1991). The model was set to a flow rate through Terzaghi Dam of 1.5 cms, matching typical winter conditions. The model generated 48,865 points of data along Reaches 3 and 4. Locations of active beaver lodges (see 3.2.2) from 2016-2019 surveys were superimposed upon these points for analysis.

3.2.4 Riparian Songbird and Western Screech-Owl Surveys

A point count dataset (*2019 Riparian Bird Data.xls)* was created for the Riparian Songbird point count surveys conducted in 2019. This dataset includes data collected during 52 point count stations.

A Western Screech Owl dataset (*Western Screech Owl Data Spring2019.xls)* was created by the Call playback surveys conducted for Western Screech Owl in 2019. A total of call playback 20 stations were surveyed twice for a total of 40 stations of call playback surveys and a total of 420 minutes of surveys.

4.0 Management Questions

4.1 *MQ1: How has the population of Harlequin Ducks in Reaches 3 and 4 of the Lower Bridge River (as enumerated prior to the nesting period with 'pair surveys') varied over time, and is this population index related to flow regime?*

Harlequin Ducks migrate to the Bridge River from coastal wintering grounds in late April and early May (Bond et al. 2007). During the pre-nesting period (which we interpreted as being prior to incubation), breeding pairs feed, choose nest locations, and begin egg laying. Females may begin incubation as early as May 5th in this system but most females begin incubation after mid-May (Esler et al. 2007). We have studied the population of Harlequin Ducks on Reaches 3 and 4 during the pre-nesting period since 1999, conducting surveys in 14 years over a range of flow regimes.

The number of adult birds using these reaches was highly variable across years (Figure 3). There was a tendency for more individual Harlequin Ducks to be present between 2008 and 2014, a period which mostly coincides with the 6 cms flow regime of WUP operations (Figure 3). This potential relationship was not corroborated later in the study when the similar 6 cms_MO flow regime was observed (Figure 3), however, suggesting that annual operational flow regime alone is not a good predictor of Harlequin abundance over time. More years of monitoring will improve power to assess flow-abundance relationships; inconsistent operations combined with too few monitoring years precluded the application of more robust statistical analyses. As such, the BRGMON-11B program was inadequate for addressing MQ-1 due to the length of study coupled with unplanned changes to operations.

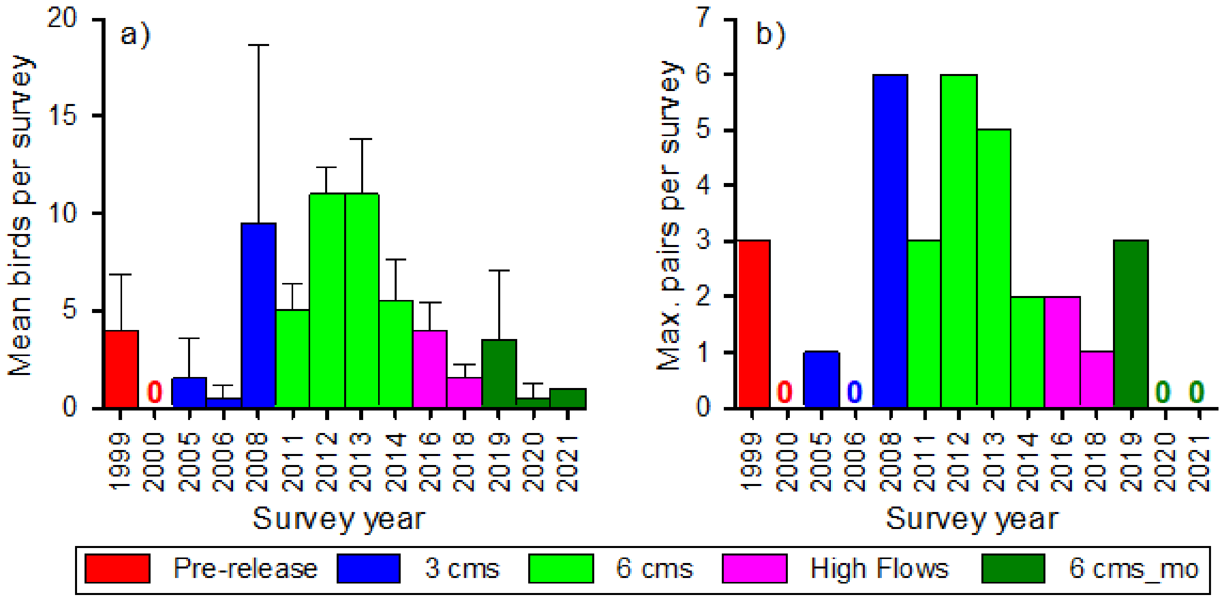

Figure 3. a) Average number (± 1 SD) of adult Harlequin Ducks observed and b) maximum number of pairs observed during pair surveys. Colour-coded zeros indicate that no birds were observed in that survey year and the flow regime.

There are two main ways flow regime can influence Harlequin Ducks during the pre-nesting period. First, breeding females rely on acquiring nutrients from aquatic invertebrates on breeding streams to form eggs (Bond et al. 2007), and this could be negatively affected by high flow rates (Hansen et al. 2019) and by flow variability (LeBourdais et al 2009). Since Harlequin Ducks have evolved to breed on mountain river systems subjected to natural flow increases in May, we suspect that experienced female Harlequin Ducks can still forage successfully under moderately increasing flows. However, the effect on females of unusually high flow increases in May like that observed in High Flow years (Figure 2) is unknown, and our survey methodology would not have been able to capture this effect directly. Hansen et al. (2019), for instance, found that higher average stream flow values during the pre-incubation period resulted in lower Harlequin Duck brood production.

The second main way flow regime can affect breeding Harlequin Ducks during this period is through nest flooding as eggs are being laid. Harlequin Duck nests are typically placed on the ground close to water and are susceptible to significant increases in water level (Robertson and Goudie 1999, Hansen et al. 2019, Cassirer and Groves 1994). We will discuss potential effects of flow regime on nest flooding in more detail in section 4.2, but large increases in flow like that observed during the High Flow regime in 2016 and 2018 (Figure 2) may have flooded nests along the Lower Bridge River.

4.1.1 MQ1: Challenges and Opportunities

There are four study design considerations that have the potential to obscure our ability to assess the response of Harlequin Ducks to changing WUP operations. These have contributed to BRGMON-11B being unable to address MQ1 adequately.

i) Inconsistent operations

BRGMON-11B was initially set up to monitor Harlequin Duck populations over 10 years of steady WUP operations to see if the population was showing signs of a response. With the interruption to WUP operations, this goal became impossible, and the project pivoted to assess how operations were affecting these birds. Modified Operations were not consistent, and in the end the project monitored years with operations that differed in partially categorical ways (3 flow regimes over the 10-year WUP period; Figure 2).

ii) Small sample size and statistical analysis

Related to 1 above, BRGMON-11B did not occur over a long enough time period to generate the sample size necessary given the complexity of the required analyses. Flow regime itself was a challenge to classify during the 10-year WUP period (see Section 2.0). We believe lack of monitoring in 2017, especially, was unfortunate because 2017 had the highest maximum flow (Sneep et al. 2020) and its inclusion would have provided an additional year of data during the High Flow regime. With the small sample size, any statistical analysis became severely lacking in power due to the degrees of freedom required to estimate multiple parameters, and to poor representation across a spectrum of flow regimes. More complex analyses such as the detection of lag effects, in which the response is delayed beyond the year of flow regime change, were not possible.

iii) Non-closed population during migration

We believe some Harlequin Ducks were still migrating through our study area in early May during our first survey, inadvertently inflating the number of birds that we estimated to be using these reaches for breeding. This may have increased variability in the number of Harlequin Ducks we detected on the Lower Bridge River during the pair period, although the maximum number of pairs observed, especially, does not vary widely among years (Figure 3b). To some extent, this potential effect was controlled by initiating surveys around the same date each year.

iv) Non-closed population during nest initiation and brood-rearing

Harlequin Ducks appeared to treat the unregulated Yalakom River and the regulated Lower Bridge River as one continuous system, meaning that at least some birds we documented on the Lower Bridge River were likely using the Yalakom River as part of their breeding habitat as well. Evidence from work with tagged birds before the controlled release in 2000 suggested that most females nested on the Yalakom River and then raised their broods on the Lower Bridge River (Hill and Wright 2000, Wright and Goudie 2000, Wright and Walton 2001a). One radio-tagged female nesting on the Yalakom River, for example, flew 12 km during incubation breaks to the Lower Bridge River to feed (Wright and Walton 2001a). Whether and how this affected our pre-nesting results is not well-understood. Prior to the controlled release, few adult birds were observed on the Lower Bridge River during pre-nesting surveys, and most of these birds were seen near the confluence of the two rivers (Hill and Wright 2000). Movement between the Yalakom River and the study area during the pair surveys may have introduced unbiased count error. Isolating the impact of different flow regimes on birds is challenging in an open system like this in which birds may not be completely reliant on the regulated river for the entire breeding season.

4.2 *MQ2: Are Harlequin Duck brood counts, monitored in Reaches 3 and 4 of the Lower Bridge River, influenced by flow regime?*

Harlequin Duck eggs hatch from mid-June to early July on the Lower Bridge River system (Esler et al. 2007). Young leave the nest within 1-2 days of hatching (Robertson and Goudie 1999). During the brood-rearing period, females remain with their young until they fledge in late July or August. After this, females migrate to the coastal wintering grounds with their young (Regehr et al. 2001). Our brood surveys took place between late June and late July. We have studied the population of Harlequin Ducks on Reaches 3 and 4 during the brood-rearing period since 1999, conducting surveys in 14 years over a range of flow regimes.

Brood production can be variable because it relies upon successful completion of two distinct stages: egg incubation during nesting, and rearing of young birds until they fledge. Harlequin Duck productivity on the Lower Bridge River was highly variable among years, and there was no indication that flow regime affected brood counts on these reaches (Figure 4). The 5 survey years in which we did not detect broods were spread evenly across all flow regimes, occurring once in each (Figure 4). Our study, in which broods were only detected in 9 of the 14 survey years (Figure 4), is consistent with other studies that found high variability in annual brood production for Harlequin Duck populations (e.g., Smith et al. 2000, Bond et al. 2008, Hansen et al. 2019).

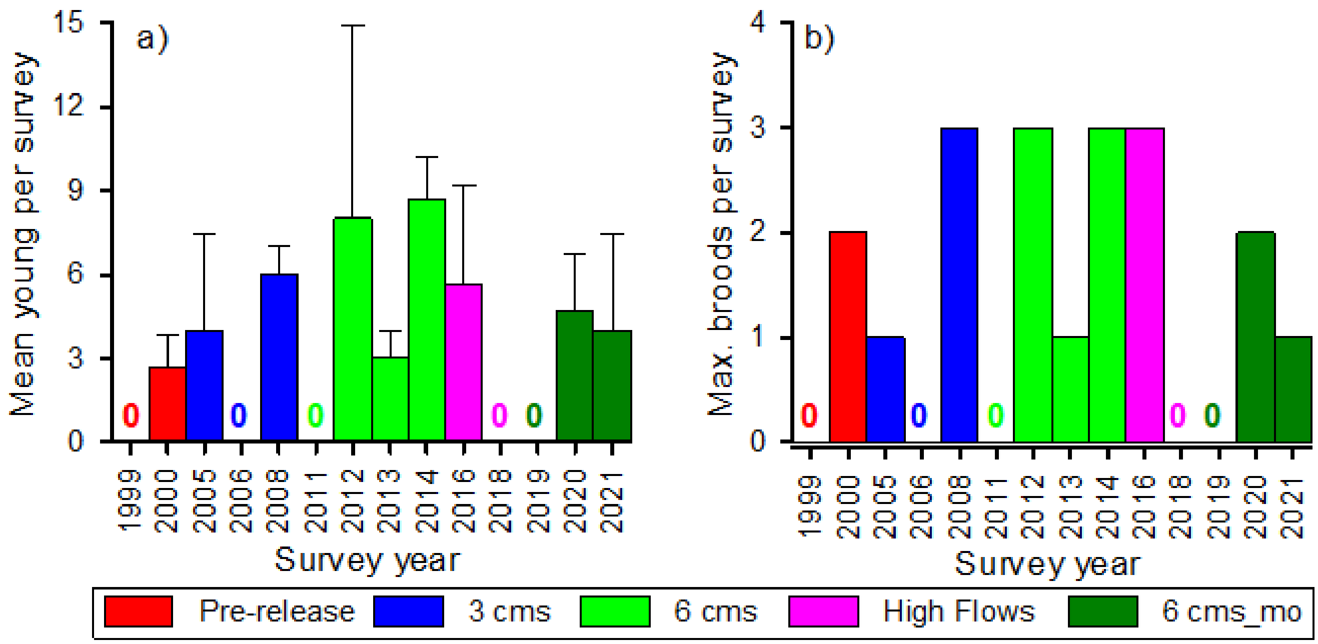

Figure 4. a) Average (± 1 SD) number of Harlequin Duck young observed and b) maximum number of broods observed during brood surveys. Colour-coded zeros indicate that no birds were observed in that survey year and the flow regime.

Harlequin Ducks nest close to the water's edge (Robertson and Goudie 1999, Hansen et al. 2019). Although Harlequin Ducks have evolved to nest on mountain river systems subject to seasonal fluctuations in flow, nest flooding can occur when water levels suddenly increase (Cassirer and Groves

1994, Esler et al. 2007, Hansen et al. 2019). In 1999, for example, a sharp increase in flow flooded a Harlequin Duck nest we were monitoring in mid-June on the unregulated Yalakom River (Wright and Walton 2001a). In our study area, incubation has been documented as early as May 5th, although most females began incubation after mid-May (Esler et al. 2007). Any large increases in flow in May or June, like that seen during High Flows (Figure 2), may flood Harlequin Duck nests along Reaches 3 and 4.

However, although a Harlequin Duck nest has been found on Reach 3 (Esler et al. 2007), we do not believe most females nest on the Lower Bridge River. Before the controlled release began in 2000, banded and radio-tagged females nested on tributaries like the Yalakom River, primarily, and moved their broods to the Lower Bridge River after hatching. This strategy of separating nesting and brood-rearing habitat is similar to that documented in the Rocky Mountains by MacCallum et al. (2016) who found Harlequin Ducks chose different river sections for each stage of brood production. If Harlequin Ducks continued to separate nesting habitat from brood-rearing habitat after water was released through Terzaghi Dam in 2000, then flow regime on the Lower Bridge River is unlikely to be an important factor for most breeding Harlequin Ducks at the nesting stage. Without radio-tracking females to locate their nests, however, we cannot test this hypothesis.

On the Lower Bridge River, flow regime is more likely to have an influence on Harlequin Duck production during the brood-rearing stage when young forage for their own food. Increased flows can increase turbidity, making it more difficult for young, inexperienced birds to find and capture aquatic invertebrates (Martin et al. 2007, Hansen et al. 2019). Availability of invertebrates is also influenced by flow regime. Studying rivers in the Coast Mountains, including the Lower Bridge River, LeBourdais et al. (2009) found that aquatic invertebrate abundance during the breeding season was positively related to a lower rate of flow variability. Compared to other rivers they studied, macroinvertebrate production was so high on the regulated Lower Bridge River at the 3 cms flow regime that LeBourdais et al. (2009) had to exclude these data from their analyses. Other work on Reaches 3 and 4 has confirmed this pattern. Although Sneep et al. (2022) sampled aquatic invertebrates in autumn and their data include invertebrates too small to be used as food by Harlequin Ducks, they found both species richness and the density of aquatic invertebrates were significantly lower during the highly variable High Flow regime between 2016 and 2018 compared to other flow regimes. They found no significant difference for these measures among the 0 cms (pre-release), 3 cms and 6 cms flow regimes, although there was a tendency for aquatic invertebrate density to be highest prior to initiation of the controlled release in Reach 3. In contrast to this, Walton and Heinrich (2018a) did not find aquatic invertebrate abundance to be unusually low in late June along Reaches 3 and 4 during High Flows in 2016. These results should be interpreted cautiously, however, due to the lack of replication and to the potential presence of a lag effect in the response of existing, large aquatic invertebrates to the new High Flow regime (Walton and Heinrich 2018a).

Studies have found the relationship between Harlequin Duck productivity and aquatic invertebrate biomass to be important (e.g., Esler et al. 2007, MacCallum et al. 2015, but see Cassirer and Groves 1994). Since Reaches 3 and 4 of the Lower Bridge River appear to be important brood-rearing habitat for Harlequin Ducks, the flow regime during June, July and August likely influences brood production on these reaches. Our consistent observations of 3 broods being produced in most years (Figure 4b), however, suggests that brood-rearing by Harlequin Ducks can be successful on Reaches 3 and 4 at all flow regimes monitored during this study.

Brood production can also be influenced by predation. Hansen et al. (2019) report predation on Harlequin Duck eggs by pine marten (*Martes americana*), American mink (*Neovison vison*), red squirrels (*Tamiasciurus hudsonicus*) and gray wolf (*Canis lupus*). Mink and avian predators are commonly cited as predators of adult females and ducklings (Robertson and Goudie 1999, Smith 2000, Heath et al. 2008). In our study, we found the headless carcass of an adult female we were radio-tracking, probably killed by a mink (her brood was not seen again; Wright and Walton 2001b). Esler et al. (2007) also documented an adult female killed by a predator while incubating eggs on Reach 2 of the Lower Bridge River. Bond et al. (2008) reported adult female survival to be lowest during incubation, likely due to predation, at four breeding sites in Alberta, British Columbia and Oregon. MacCallum et al. (2016) postulated that predator avoidance was a stronger factor influencing the selection of brood-rearing habitat by Harlequin Ducks on their study area than food availability. Incorporating both stream flow and predation, Hansen et al. (2019) suggested that flow conditions are the major factor limiting Harlequin Duck brood production in years with high and variable flows, but predation and other factors are more important in years with more moderate flow conditions.

4.2.1 MQ2: Challenges and Opportunities

There are three study design considerations that have contributed to BRGMON-11B being unable to address MQ2 adequately. As discussed in Section 4.1.1, the original MQ was intended to assess if there was a relationship between flow regime and Harlequin Duck brood counts under steady WUP operations, but this was not possible under Modified Operations, which led to small sample sizes for multiple flow regimes and a lack of statistical power to detect a relationship. Harlequin Ducks also treated the Lower Bridge River and the unregulated Yalakom River as a single, connected system, and our study design did not allow us to separate potential effects of flow regime through Terzaghi Dam from conditions present on the Yalakom River. For a more detailed explanation, refer to Sections 4.1.1(i,ii, and iv).

4.3 *MQ3: Are other riverine bird species likely to be influenced by flow regime; if so, how?*

Four other riverine bird species use Reaches 3 and 4 of the Lower Bridge River for breeding: Common Mergansers, American Dippers, Spotted Sandpipers and Belted Kingfishers. Each of these species had unique responses to differing flow regimes.

Common Mergansers

There was weak evidence that Common Mergansers appear to be influenced by flow regime, although sample sizes were not large enough to test this relationship statistically. Since 1999, numbers of adult mergansers were relatively stable up to and including 2016, the first year of the High Flow regime (Figure 5). In surveys after 2016, we recorded the lowest numbers of merganser pairs and individual adults since surveys began (Figure 5).

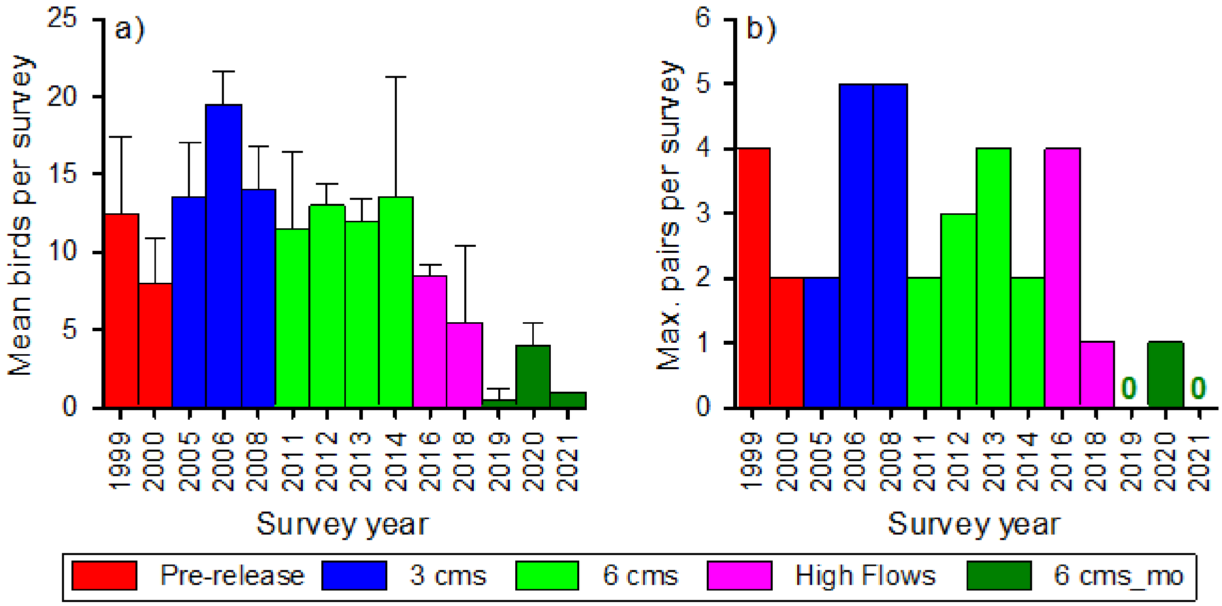

Figure 5. a) Average number (± 1 SD) of adult Common Mergansers observed and b) maximum number of pairs observed during pair surveys. Colour-coded zeros indicate that no birds were observed in that survey year and the flow regime.

As with Harlequin Ducks, brood production by Common Mergansers was highly variable, and we did not detect broods in 5 of the 14 years we surveyed Reaches 3 and 4 (Figure 6). A maximum of 3 broods were detected using the Lower Bridge River over the years (Figure 6b), although the number of individual young birds observed varied widely (Figure 6a). Three of the 5 years with no brood production occurred after initiation of High Flows in 2016, including 3 consecutive years without broods, the first time consecutive broodless years been observed since surveys began.

During both pair and brood surveys, there was a tendency for Common Merganser numbers to be reduced or to be more inconsistent after initiation of High Flows in 2016. Since mergansers are known to choose breeding areas based on conditions encountered during the previous summer (Wood 1986), it was not unexpected that adult merganser numbers, at least, would be similar to the previous flow regime in 2016 and that any potential effects of High Flows would not be expressed until the following year. In 2016, we observed only 1 young bird during brood surveys; although this low count provides some support for our speculation that conditions changed for mergansers after initiation of High Flows in 2016, this low count is similar to low numbers of young birds detected in 2008 and 2011 (Figure 6a), and the evidence is inconclusive.

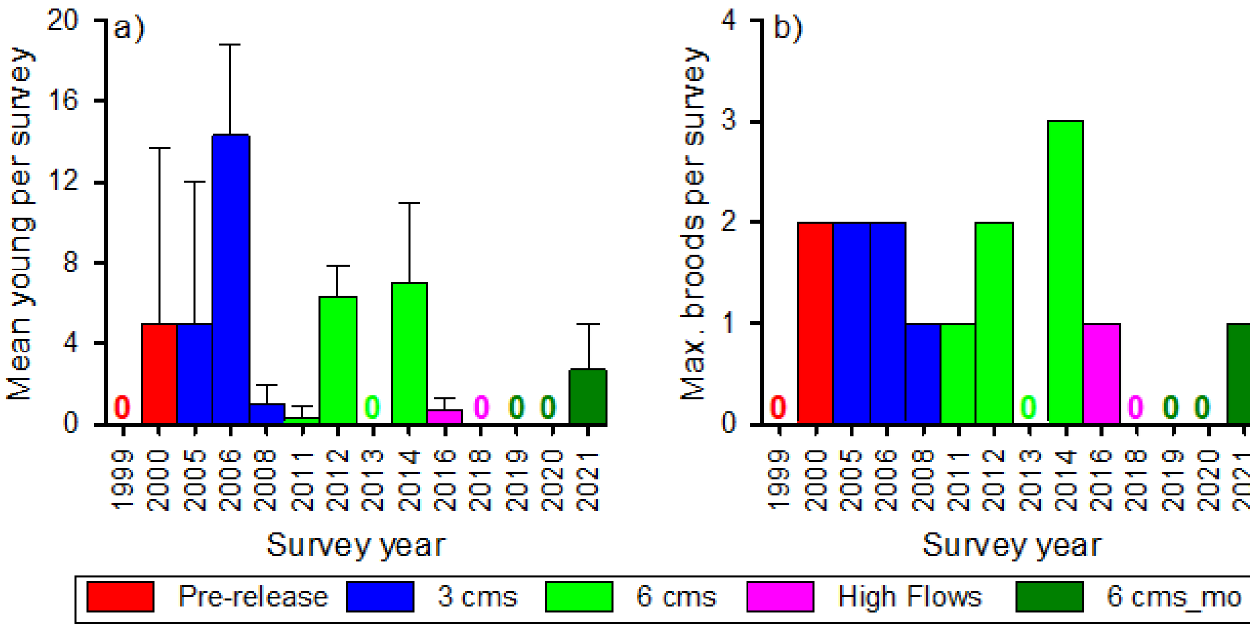

Figure 6. a) Average (± 1 SD) number of Common Merganser young observed and b) maximum number of broods observed during brood surveys. Colour-coded zeros indicate that no birds were observed in that survey year and the flow regime.

Common Mergansers mainly eat fish, although very young birds rely upon aquatic macroinvertebrates for their diet (Pearce et al. 2015). Sneep et al. (2022) found aquatic invertebrate densities on Reaches 3 and 4 did not change significantly during the 3 cms and 6 cms flow regimes, although the abundance of small fish increased with increasing flows. Both small fish and aquatic invertebrate abundance, however, declined sharply with initiation of High Flows in 2016 (Sneep et al. 2019). This decline in available food may be linked to the tendency we observed for Common Merganser numbers to decline after initiation of High Flows in 2016.

Nest flooding is not a factor for this cavity-nesting species, but availability of suitable nesting cavities can be limiting (Pearce et al. 2015). Since water was released through Terzaghi Dam, the number of active beaver lodges has increased on Reaches 3 and 4 and many of the larger cottonwood trees capable of providing nesting cavities for mergansers have been felled (Walton and Heinrich 2019b). In this scenario, increased flow leading to more beavers leading to the depletion of cottonwood trees large enough to house merganser nests could result in a negative and indirect effect of flow regime on merganser numbers. Availability of suitable nesting cavities, however, does not appear to be limiting on the Lower Bridge River since 10 nest boxes installed along Reaches 2, 3 and 4 in 2019 designed for Common Mergansers have not been occupied to date (Krahn 2022).

We documented Common Mergansers using the Lower Bridge River during both breeding season and early winter surveys (Walton and Heinrich 2022, Appendix 2). Since fall and winter flow rates have been consistent since 2000 (Figure 2), flow regime is not a concern in the non-breeding season for Common Mergansers unless current flow regimes change.

American Dippers

American Dipper numbers did not appear to be influenced by flow regime on the Lower Bridge River during the breeding season (Figure 7) or during early winter (Walton and Heinrich 2020). Of the riverine birds we studied, dippers were the only species that we observed with young produced every survey year (Figure 7b).

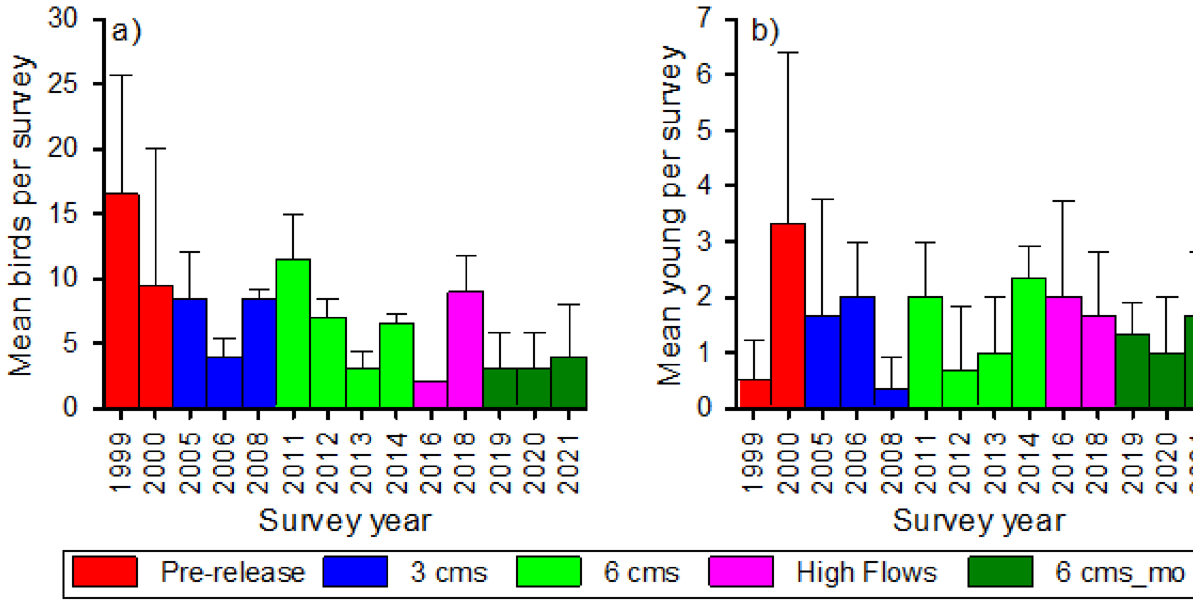

Figure 7. a) Average (± 1 SD) number of adult American Dippers observed during pair surveys and b) average number (± 1 SD) of young observed during brood surveys.

One way in which river regulation and flow regime could impact dippers during the breeding season is by affecting nesting. Nest flooding is unlikely to be an issue since dippers attach their nests to inaccessible, elevated surfaces like canyon walls and large boulders, and their nests are not typically vulnerable to rising water levels (Willson and Kingery 2011). Nest site availability, however, is thought to be the main factor limiting the location of a breeding territory (Osborn 1999, Price and Bock 1983). Although we found a few nests along Reaches 3 and 4 (e.g., the canyon wall below Aniah Creek; a large mid-stream boulder downstream of Michelmoon Creek), we believe most dipper nests were located on canyon walls along tributaries such as Hell Creek and Aniah Creek (Figure 1). We frequently observed dippers flying back and forth between the Bridge River and tributaries during surveys, sometimes carrying food in their beaks. For these reasons, we do not believe dipper nests were vulnerable to potential effects of flows through Terzaghi Dam.

Food availability is another way in which flow regime could affect dippers by modulating food abundance or their ability to detect and capture food (Willson et al. 2009). Dippers are visual predators that mainly feed upon aquatic invertebrates, although they will eat fish eggs and small fish (Willson and Kingery 2011). Sneep et al. (2022) found species richness and the density of aquatic invertebrates to be significantly lower on Reaches 3 and 4 during the highly variable High Flow regime between 2016 and 2018 compared to other flow regimes. Despite this, dipper numbers during the breeding season did not appear to be negatively affected by the High Flow regime (Figure 7). We propose two possible explanations for this apparent insensitivity:

1) Dippers have evolved to live in fast-flowing stream habitats. Higher sedimentation can interfere with dipper foraging (Willson et al. 2009), but the increase in sedimentation and the decline in prey availability (Sneep et al. 2022) caused by High Flows was within an acceptable range of conditions for dippers, and could be offset by finding suitable microhabitats.

2) Dippers do not need to rely exclusively upon the Lower Bridge River for foraging habitat. Dippers mainly nested along tributaries like Aniah Creek that were not affected by flow regimes on the Lower Bridge River. These tributaries could act as habitat buffers, providing an alternate food supply if conditions on the Lower Bridge River became too challenging.

Changes in foraging habitat suitability are potentially more noticeable in winter when dippers are less territorial and congregate in productive reaches as streams freeze over at higher elevations (Packard 1945, Price and Bock 1983, Morrissey et al. 2004). We began winter surveys of dippers in 2016 (Heinrich and Walton 2018 a, b), and we continued them as part of the beaver lodge surveys (Walton and Heinrich 2022). Although winter densities did not reach as high as the 10.8 dippers per km observed by Walton and Wright (2008) at the nearby Seton River, winter densities were typically 2-5 times higher (as high as 3.1 dippers per km, Walton and Heinrich 2022) than summer densities (0.4-1.7 dippers per km; Walton and Heinrich 2015). We observed dippers feeding mostly on aquatic invertebrates during winter surveys, but fish eggs, alevin and fry made up 18 % of their observed diet during 2019 (Walton and Heinrich 2020), a dominant pink salmon (*Oncorhynchus gorbuscha*) year. Since fall and winter flow rates have been consistent since 2000 (Figure 2), flow regime is not a concern for American Dippers in the non-breeding season unless current flow regimes change.

Spotted Sandpipers

Although sample sizes were too small to test for statistical differences among flow regimes with any power, there was a tendency for Spotted Sandpiper numbers to increase with initiation of the 3 cms flow regime, averaging 17-23 birds per survey, and to average between 7 and 12 birds per survey for all other flow regimes (Figure 8). This indicates that Spotted Sandpipers may be influenced by flow regime on the Lower Bridge River. Oring et al. (1983) note that Spotted Sandpipers are adept at occupying new habitat, which may explain the increase in numbers after the dry riverbed below Terzaghi Dam was rewatered. Oring et al. (1983) also report, however, that Spotted Sandpipers abandon breeding habitat with increased flooding and as shoreline vegetation overgrows semi-open areas, their preferred habitat. It is possible that the 3 cms flow regime offered the best combination of breeding habitat for sandpipers along Reaches 3 and 4: a high availability of semi-open shoreline habitat, but with the least increase in shoreline flooding.

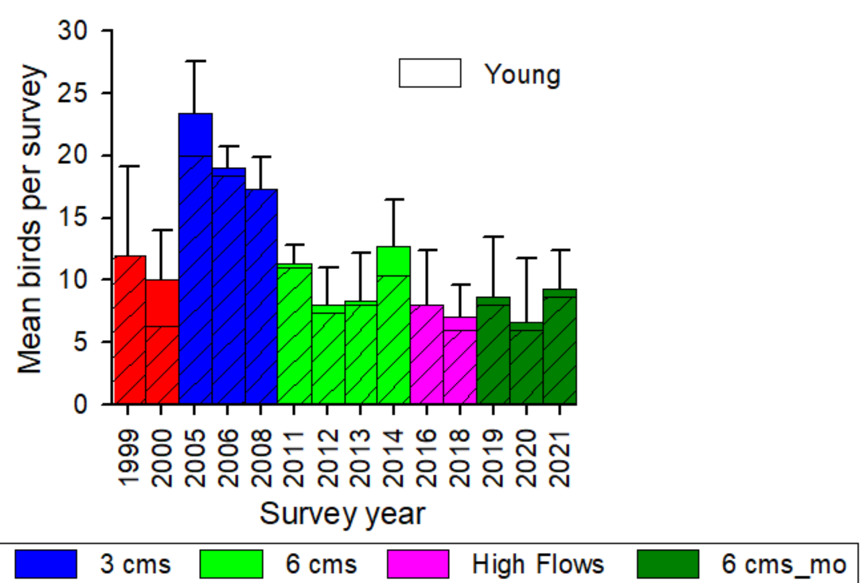

Figure 8. a) Average (± 1 SD) number of adult and young Spotted Sandpipers observed during brood surveys.

Belted Kingfishers

We do not believe our surveys are reliable for surveying Belted Kingfisher numbers (see section 4.3.1), so we cannot assess whether flow regime had an effect on their numbers. We did observe Belted Kingfishers using Reaches 3 and 4 during all survey years except 2021, although their numbers were highly variable during both pair (Figure 9a) and brood surveys (Figure 9b).

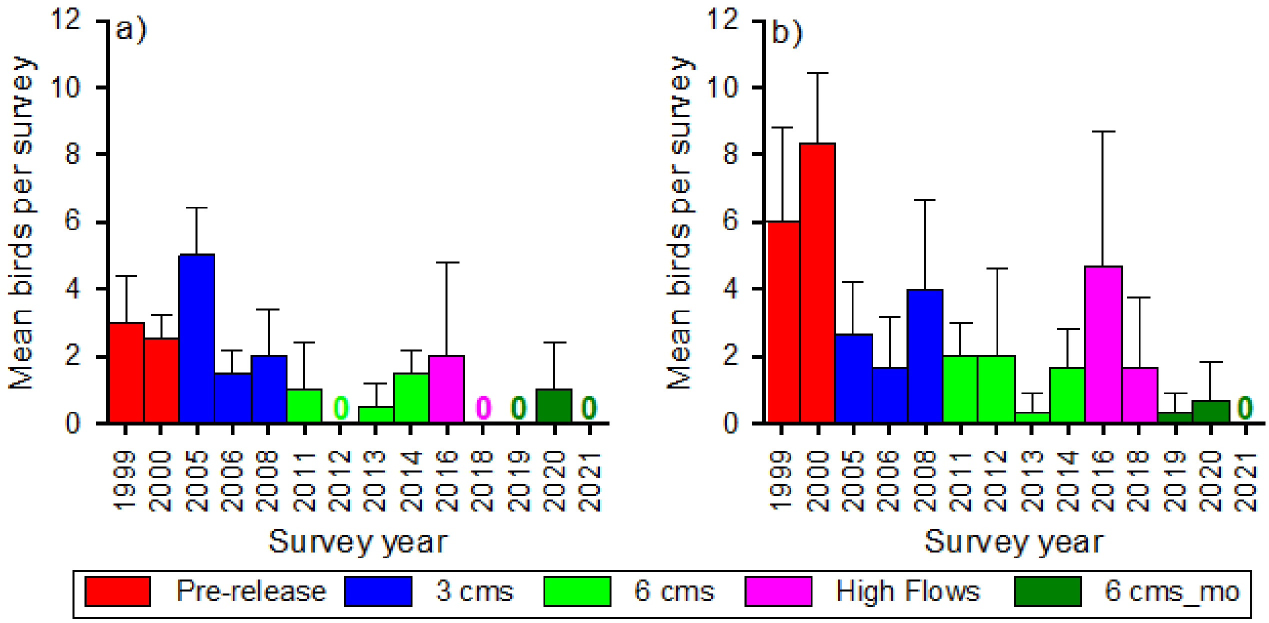

Figure 9. a) Average (± 1 SD) number of Belted Kingfishers observed during a) pair and b) brood surveys. Brood survey counts may include young kingfishers. Colour-coded zeros indicate that no birds were observed in that survey year and the flow regime.

4.3.1 MQ3: Challenges and Opportunities

The purpose of this MQ was to assess whether other riverine bird species could be influenced by flow regime and to identify the factors that might be involved. Although we believe we were successful in identifying both tentative effects of flow regime and potential mechanisms for other riverine bird species using the Lower Bridge River, we identify these 3 challenges with addressing MQ3.

i) Inconsistent operations, small sample size, and statistical analyses

The same issues relating to changing WUP operations and its effect on sample size and the resulting statistical options detailed in Section 4.1.1 (i and ii) apply to MQ3 as well.

ii) Varied detectability of other riverine bird species

Surveys were originally designed for Harlequin Ducks (Hill and Wright 2000), and data on other riverine bird species were not collected consistently before 1999 (Appendix 1). While we believe our surveys do reliably document use of Reaches 3 and 4 by Common Mergansers and American Dippers because they are generally found on or close to the water like Harlequin Ducks, we are not as confident for Spotted Sandpipers and Belted Kingfishers. Adult sandpipers were sometimes seen metres from the water's edge, making them more difficult to observe and easier for them to escape detection in vegetation. Spotted Sandpiper young are also difficult to observe due to their behaviour and colouration (Reed et al. 2013). Belted Kingfishers perched on branches metres above the river, and frequently flew when they saw us from far away, making their detections especially unreliable. Juvenile kingfishers were impossible to distinguish from adult kingfishers in these brief glimpses.

iii) Different life histories and use of alternate habitats

Common Mergansers, American Dippers, Spotted Sandpipers, and Belted Kingfishers all have different life history strategies and habitat needs that influence their susceptibility to flow regimes on the Lower Bridge River. Dippers did not rely completely on the Lower Bridge River for all their habitat needs, using tributaries for nesting and most likely for foraging as well. Spotted Sandpipers, although reliant on the Lower Bridge River and associated tributaries for habitat, are shoreline feeders and are not directly connected to obtaining food from the river itself. Belted Kingfisher do rely on hunting fish in the river, but, unlike Harlequin Duck and Common Merganser which have young that actively forage on the river and are restricted to it until they fledge, Belted Kingfisher young are fed by adults in their nests until they fledge (Sullivan et al. 2009). Adult kingfishers and their fledged young could also potentially fly to alternate habitats such as the Carpenter Lake Reservoir instead of relying completely on the Lower Bridge River. To effectively address this MQ for each species, methodologies should be tailored to address each individual species' requirements and life history strategies.

4.4 *MQ4: How many active beaver lodges are there in Reaches 2, 3 and 4 of the Lower Bridge River in fall, how are they distributed, and how do these data vary among years?*

During the 2016-2021 late fall surveys, the number of active beaver lodges on the 14.9 km of Reaches 3 and 4 was consistent, ranging from 3 to 6 active lodges annually. In 2019 we began surveying the 7 km of Reach 2, and we documented 2-4 active lodges annually. Combined across all 3 reaches, we found 5-10 active lodges each year, giving an overall linear density of 0.23-0.46 active beaver lodges per km.

Initially lodge numbers did not vary much among years; however, we documented a decline of 4 active lodges (44 %) in our final 2021 winter survey. Anecdotally, we observed smaller food caches at some of the lodges in 2020 and 2021, suggesting that some of the active lodges we documented may house solitary beavers (Walton and Heinrich 2022; Appendix 2021). These observations are consistent with an emerging trend for beaver numbers to be declining along Reaches 2, 3 and 4. More monitoring would be required to confirm this change.

Most active lodges were found in Reaches 2 and 3, with Reach 4 having the fewest lodges (Figure 10). Beavers reused some lodges: of the 25 individual lodges we observed, 4 lodges were used twice and 3 lodges were used 3 times during our surveys. Active lodges were rarely located closer than 1 km to each other (Figure 10).

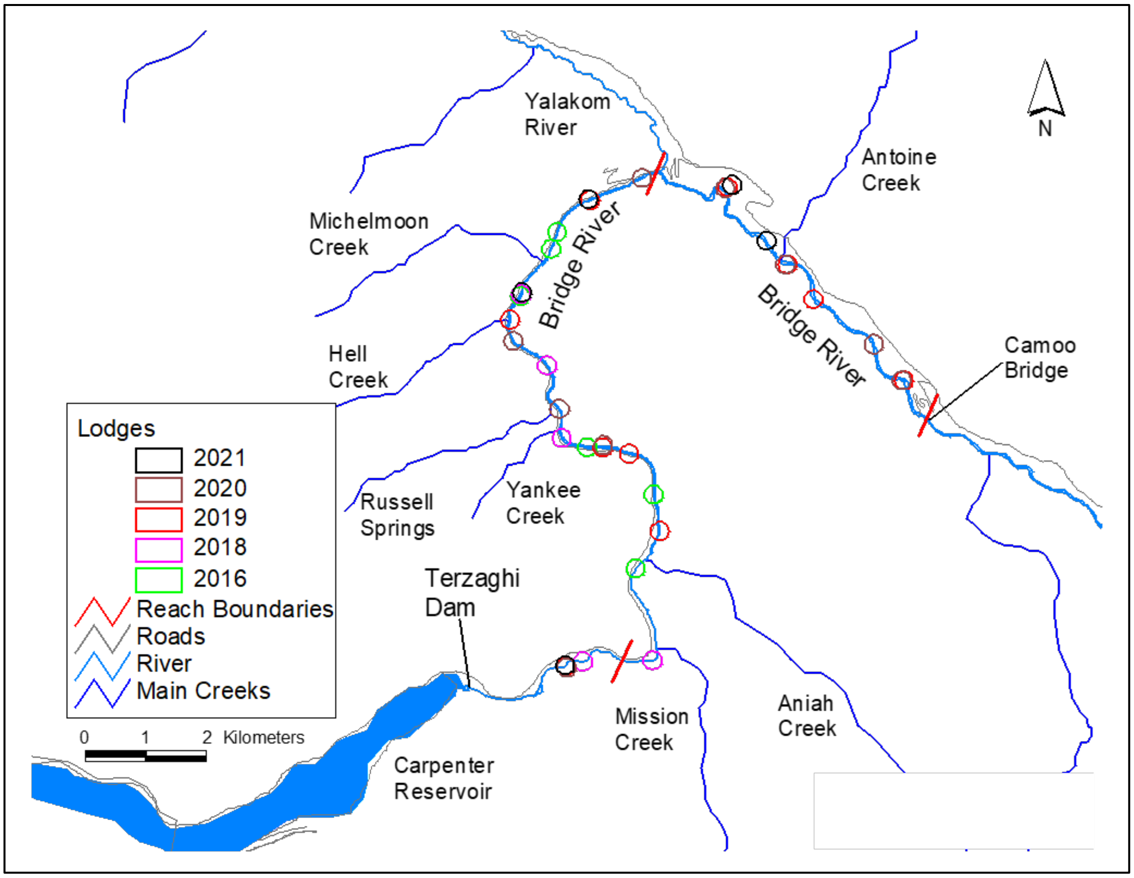

Figure 10. Active beaver lodge locations during early winter surveys from 2016-2021 along Reaches 2, 3 and 4.

Since the controlled release began in 2000, the number of active lodges has increased by up to 10 times along Reaches 2, 3 and 4 based on a May 1999 helicopter survey that detected 4 active beaver lodges, one in Reach 3 and the remainder in Reach 1 (Wright 2000; Walton and Heinrich 2022). The idea that river regulation influences suitability of habitat for beavers has been explored previously on other rivers comparable to our system. Breck et al. (2001) found similar densities of active lodges in northwestern Colorado on the regulated Green River (0.5-0.6/km) and on the unregulated Yampa River (0.35/km). Like the Lower Bridge River, these rivers are too swift for beavers to construct dams and beaver lodges are built on river banks. Higher base level flows on the regulated Green River provided beavers with year-round access to trees farther from the riverbank than on the unregulated Yampa River, and the resulting increase in cutting changed the structure of the willow (*Salix sp.)* community (Breck et al. 2001). Similarly, we believe the higher base flow in winter through Terzaghi Dam has allowed beavers to colonize more locations along the Lower Bridge River, resulting in greater pressure upon large cottonwood trees that were mostly established during flooding events before the river was dammed (Hall et al. 2009). Scholz et al. (2017) documented declines in cottonwood trees along the Lower Bridge River prior to High Flows, and they found that even during the High Flow years the number of stems damaged by beavers was relatively consistent (Scholz and Gibeau 2020). These findings, in conjunction with our more targeted surveys in 2016 to study beaver damage on cottonwoods (Walton and Heinrich 2018b), suggests that beavers may be causing a shift in size structure in cottonwoods from large, mature trees to smaller saplings and more shrub-like forms along the Lower Bridge River.

In response to these surveys, 169 cottonwood trees were protected by wire cages along all three reaches beginning in 2018 (Walton and Heinrich 2019b, Fowler 2020). Subsequent checks have shown the cages to be effective at preventing damage by beavers (Fowler 2020). Common merganser (10) and Western Screech-owl (5) nest boxes were also placed along these reaches in 2019 to compensate for the loss of large cottonwood trees with potential nesting and roosting cavities (Fowler 2020; Krahn 2021). To date, these nest boxes have not been occupied by either species during the breeding season (Krahn 2021).

4.4.1 MQ4: Challenges and Opportunities

The beaver population on the Lower Bridge River has undoubtedly been influenced by historic river regulation. While this MQ focussed on monitoring current population size and distribution (using number of lodges as a surrogate for population size), there may also be opportunities to better understand linkages to operations by considering how historic herbivory changed over time. It may be possible to core large stumps in order to determine the approximate year of when they were cut by beaver, and to build a better picture of herbivory pressure over time. This, in conjunction with current riparian vegetation studies (e.g., Scholz et al. 2017; Scholz and Gibeau 2020), would provide a more complete picture of the effects of the controlled release on the riparian vegetation community.

4.5 *MQ5: Is the distribution of beavers in the Lower Bridge River influenced by river morphology or possibly by flows?*

Walton and Heinrich (2020) examined beaver lodge locations in relation to BC Hydro's Lower Bridge River Telemac 2D model (Galland et al. 1991) (Table1). The lotic instream environment was not highly variable within the study area under winter flow conditions (Table 1; Figure 11). Water depth only ranged from 10-64 cm deep (Table 1). Median lodge depth only varied by 2 cm from available depths (Table 1) and this small difference was not statistically significant for depth classes shown in Figure 11a (X^2 = 2.107, df = 4, P = 0.716).

Despite the limited variability available, lodge locations were placed in locations with lower velocity than was generally available (Figure 11b; X^2 = 10.595, df = 4, P = 0.003), and there was a strong tendency for lodges to be placed in river sections with lower shear force stress (Figure 11c; X^2 = 8.219, df = 4, P = 0.084). This suggests that the distribution of beaver lodges is influenced to some extent by flows. For a number of reasons (see Section 4.5.1), however, we believe this result should be treated cautiously.

Table 1. Median, minimum and maximum values for water depth, velocity and shear stress at winter beaver lodge plots and availability plots in Reaches 3 and 4. Values are based on Telemac 2D data modelled at a winter flow through Terzaghi Dam of 1.5 cms. Adapted from Walton and Heinrich 2020.

Variable	Flow Rate	Plot Type	Median	Minimum	Maximum
Water Depth (m)	1.5 cms	Lodge	0.26	0.17	0.42
		Available	0.24	0.10	0.64
Velocity (m/s)	1.5 cms	Lodge	0.41	0.21	0.84
		Available	0.52	0.06	1.10

Shear stress (N/m^2)	1.5 cms	Lodge	8.94	1.65	30.32
		Available	13.77	0.09	53.43

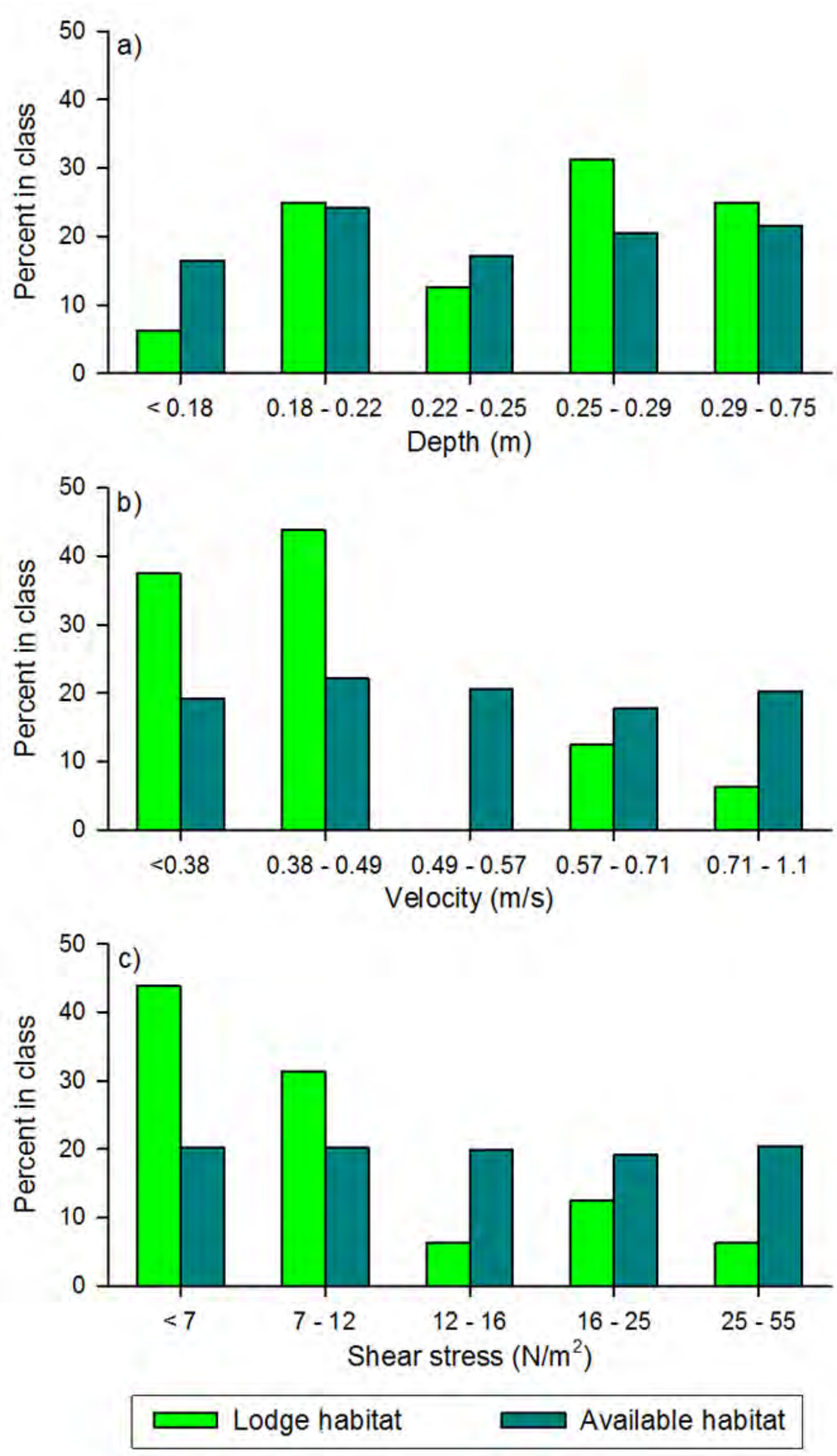

Figure 11. Water a) depth, b) velocity and c) shear stress habitat chosen by beavers for lodge placement compared to available habitat in 2016, 2018 and 2019. Flow data are modelled using Telemac for autumn and winter conditions (1.5 cms flow).

4.5.1 MQ5: Challenges and Opportunities

The purpose of this MQ was to assess whether the distribution of beaver lodges was affected by river morphology or flow. Although we found that beavers placed winter lodge locations in river sections with lower velocity and shear force stress, we identify the following 4 challenges with addressing MQ5 and we suggest this result should be interpreted cautiously.

i) Difficulty in comparing habitat conditions with other rivers

Numerous studies have examined potential relationships between environmental factors and beaver bank lodge placement (e.g., Hay 1958; Beier and Barrett 1987; Dieter and McCabe 1989; Parish 2016). However, it is difficult to extrapolate the importance of environmental variables like water depth, velocity and shear stress, and riverbank slope and substrate from other study areas because their relevance is constrained by the range of local conditions present at those sites. On the Lower Bridge River, there was a very small range of flow conditions during winter, and these conditions cannot be meaningfully compared to other rivers.

ii) Ability of beavers to use microhabitat features

We were surprised by lodges being located at water depths of less than 30 cm based on model estimates. From observations in the field, we frequently observed bank lodges located downstream of large boulders that created small eddies (e.g., Figure 12), similar to the “hydraulic control features” found to be important for bank lodge placement by beavers along a California river (Parish 2016). This suggests that even if general river morphology and flow conditions may be suboptimal for beaver lodge placement along the Lower Bridge River, beavers can still find microhabitat features that create suitable habitat. Selection for microhabitats cannot be detected by data produced by the Telemac 2D model.

Figure 12. Bank lodge and food cache constructed downstream of a large boulder.

iii) Difficulties with using a model to assess habitat conditions

We relied on a model to provide a grid of data points along the river with values for depth, velocity and shear stress. Because of this, all values were estimated by the model, rather than measured in field, and interpretations of our results should be treated cautiously. For example, we calculated the estimated water depth at a lodge as the average of all water depth values within a 10 m radius centred in the middle of the river, not at the actual location of the lodge on the river bank (Walton and Heinrich 2020). Because of microhabitat features like eddies downstream of large boulders, water depth at the actual lodge locations may have been different from estimated depths. Added to this uncertainty is the inherent inaccuracy in locating lodge positions using GPS technology for mapping, and the accuracy of the Telemac 2D model itself. Field-based measurements, although more time-intensive, would have been a more direct approach to answering this management question.

iv) Relative importance of flow versus other factors

In our opinion, the availability of food has a much stronger influence on beaver lodge placement than flow or river morphological conditions along the Lower Bridge River. It is well-documented that beavers abandon areas as their food supply dwindles (e.g., Hay 1958; Bergerud and Miller 1977; Collen and Gibson 2001; Naiman et al. 2005). Cottonwood, a preferred forage species, is not distributed evenly along the Lower Bridge River (Scholz et al. 2017; Walton and Heinrich 2018b; Scholz and Gibeau 2020), and we observed anecdotally that lodges were consistently placed close to patches of cottonwood or paper birch trees. These observations, combined with the relative consistency of beaver lodge numbers in all survey years and evidence that beavers can choose microhabitat features to position their lodges, suggest that while beavers may be influenced by river morphology and flow along the Lower Bridge River, they are not generally limited by it.

4.6 *MQ6: Which riparian bird populations are most vulnerable to being impacted by changes to riparian habitat along the Lower Bridge River, and what ramifications do vegetation monitoring results have for riparian birds at the regional scale?*

Based on results from our riparian bird surveys (Walton and Heinrich 2020) and vegetation monitoring studies (Scholz et al. 2016; Scholz and Gibeau 2020), we do not believe that changes to riparian habitat caused by flows since 2000 have negatively affected riparian bird populations along the Lower Bridge River or at the regional scale.

Over three days of riparian bird surveys in 2019 along the Lower Bridge River, we detected 185 individual birds representing 28 bird species (Walton and Heinrich 2020). None of the 28 bird species we detected during surveys (Walton and Heinrich 2020) is considered to have populations at risk (B.C. Conservation Data Centre. 2019), indicating that even severe changes to riparian vegetation along the Lower Bridge River are unlikely to have effects at a larger watershed, regional, or provincial scale.

Western Screech-Owl, a species listed as Threatened in Canada (COSEWIC 2012) and protected by the Species At Risk Act, is known to nest in the Bridge-Seton region and has potential to nest along the Lower Bridge River. Western Screech-Owl was not detected in 2019 (Walton and Heinrich 2020) or earlier in 2011 (Young et al. 2011). One potential site (Apple Springs) was initially identified by Hobbs (2013) but was later dropped due to insufficient habitat, suggesting that the Lower Bridge River does not provide sufficient breeding habitat for this vulnerable species.

The areal extent of riparian habitat likely increased modestly along the Lower Bridge River with initiation of the 3 cms and 6 cms flows, but effects on riparian vegetation were difficult to quantify due to the absence of early benchmark data (Scholz et al. 2017). Recent High Flows have eliminated any of this potential expansion, however, reducing vegetation species richness, distribution and cover in the previously existing riparian zone (Scholz and Gibeau 2020). Conversely, High Flows have expanded the recruitment of riparian vegetation species beyond the zone created by the 6 cms flows, especially for woody species like cottonwood, suggesting that High Flows could lead to the development of a wider band of riparian habitat over time (Scholz and Gibeau 2020).

Even with recent changes caused by High Flows, we do not anticipate a large increase in the area of riparian habitat along the Lower Bridge River because this zone is too confined by steep banks and rocky terrain to expand significantly in most locations. Along Reaches 3 and 4, 25 ha of the riverbank was flooded during High Flows compared to almost 5 ha during the peak of the 6 cms flow (Scholz and Gibeau 2020). Spread along 15 km, this extra 20 ha of wetted area does not increase riparian habitat substantially at the scale used by riparian birds. Yellow warblers (*Setophaga petechia*), for example, the most common riparian bird detected during our surveys (Walton and Heinrich 2020), have breeding territories that range from 0.14 ha to 0.47 ha (Lowther et al 2020). Because of the limited extent of riparian habitat along the Lower Bridge River and the buffering presence of other forest habitat situated close by (Walton and Heinrich 2020), we do not believe riparian bird populations are vulnerable to potential changes in riparian habitat at the flow rates implemented since 2000.

At a regional scale, we do not believe that riparian vegetation along the Lower Bridge River represents a substantial proportion of the riparian vegetation available in the area. From our anecdotal observations, more expansive riparian habitat along the Bridge River is available where the topography is less steep, such as in places along Downton Lake and Carpenter Lake and the area in between by Gold Bridge. Nearby Seton and Anderson Lakes also provide more habitat with riparian vegetation. The Lower Bridge River also does not appear to support unique riparian vegetation habitat not present elsewhere (Scholz and Gibeau 2020). For these reasons, we do not believe that changes in riparian habitat along the Lower Bridge River will have significant impacts on riparian birds at a regional scale.

4.6.1 MQ6: Challenges and Opportunities

Benchmark data prior to initiation of the flows in 2000 would have been useful to detect potential changes in riparian bird populations, and it would have been preferable to survey more than once within a breeding season to detect early and late migrant arrivals. Although point counts are routinely used to census bird populations (Ralph et al. 1995), this approach has weaknesses when applied to the Lower Bridge River. At some locations the noise of fast flowing water likely obscured the sounds of species with quieter vocalizations or birds farther away from the survey centre. As well, surveys were intended to detect birds in riparian vegetation habitat, but this zone is so narrow along the Lower Bridge River that our 50m radius plots almost always extended our coverage beyond riparian habitat into upland or cliff habitat (34% of all bird detections; Walton and Heinrich 2020). It would have been helpful to conduct a pilot study using different survey approaches along river sections with known bird species to determine the best survey type for these difficult conditions. Despite these challenges, we believe our surveys adequately addressed this MQ. Bird species detected were typical for the area and are consistent with anecdotal observations we collected during 80 shoreline surveys for riverine birds from 1999-2021.

Our surveys of Western Screech-Owls in 2019 supported the results of the 2011 survey by Young et al. (2011) that these owls were not present along the Lower Bridge River during the breeding season. With the recent installment of nest boxes along Reaches 2, 3 and 4 (Walton and Heinrich 2019b; Fowler 2020; Krahn 2022), there is an opportunity to use nest box checks to monitor the presence of Western Screech-Owl on the Lower Bridge River. We recommend that nest boxes be inspected and maintained prior to the breeding season each year, and that nest boxes be checked at the end of the breeding season for use. If identification of feathers or egg fragments in nest boxes cannot conclusively confirm occupation by Western Screech-Owl, trail cameras could be installed by the nest boxes for the next year.

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6.0 APPENDIX 1. Timeline of BRGMON-11B

Table 6.1 Timeline of BRGMON-11B Important Developments and Activities

Year(s)	Developments and Activities
1997	• Preliminary survey of Harlequin Ducks on the Lower Bridge River to address a planned spill in July 1997 and potential future spills (Hill and Wright 2000)
1998	• Surveys of Harlequin Ducks during pair and brood-rearing periods during a non-spill year (Hill and Wright 2000). (Original data are not available from 1998.) • Harlequin Ducks marked and banded for studying movements and breeding ecology (Hill and Wright 2000).
1999	• Riverine bird survey data collected and available for all riverine bird species (Wright and Walton 2001a). • Harlequin Ducks banded and radio-tracked for movements and nest locations (Wright and Walton 2001a). • Habitat sampling and behavioural observations done along Reaches 3 and 4 and on the Yalakom River to understand Harlequin Duck habitat use and nesting ecology (Wright and Walton 2001a).
2000	• Last riverine bird surveys conducted at 0 cms before controlled release of water through Terzaghi Dam (Wright and Walton 2001b). • 3 cms flow regime begins on August 1.
2001-2004	• Riverine bird surveys along Reach 4 (previously dewatered section) in 2001 and 2002 by Ken Wright (Walton and Heinrich 2004). • In 2004, Russ Walton and Ralph Heinrich repeated riverine bird surveys on Reach 4 (Walton and Heinrich 2004). Funding provided by BC Hydro Bridge River Coastal Fish and Wildlife Restoration Program (BCRP).
2005 - 2008	• In 2005, 2006 and 2008, riverine bird surveys conducted along Reaches 3 and 4 at the 3 cms regime flow (funded by BCRP).
2011	• Riverine bird study included (BRGMON-11) in the Water Use Plan (WUP) to address the following management question (MQ): *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?* • Riparian vegetation monitoring and riverine bird monitoring are grouped together as part of the Terms of Reference (BC Hydro 2018). • 6 cms flow regime begins in early May prior to the first pair survey.
2011 - 2014	• Riverine bird surveys conducted along Reaches 3 and 4 in 2011, 2012, 2013 and 2014 at the 6 cms flow regime.
2015	• Early version of a synthesis report comparing effects on riverine birds of the 0 cms, 3 cms and 6 cms flow regimes (Walton and Heinrich 2015).
2016	• High Flows under Modified Operations begin, reaching peaks of 97 cms, 127 cms and 100 cms in 2016, 2017 and 2018 respectively (BC Hydro 2018). • Concerns about the timing and extent of the hydrograph in 2016 led to the development of additional management questions concerning dipper winter habitat and abundance, beaver presence on the Lower Bridge River and their effect on cottonwood trees, and the effect of high flows on aquatic invertebrate availability to young riverine birds. • First year of riverine bird surveys at High Flows.

	• First winter dipper (Heinrich and Walton 2018b) and beaver lodge surveys (Walton and Heinrich 2018b) conducted. • Surveys done to assess possible effects of beavers on the availability and size of cottonwood trees (Walton and Heinrich 2018b). • Aquatic invertebrates sampled in late June, the beginning of the brood-rearing period for Harlequin Duck young (Walton and Heinrich 2018a).
2018	• The TOR were officially revised, and the objectives, MQs, and hypotheses were refined to improve direction and clarity. BRGMON-11 was separated into BRGMON-11A (riparian vegetation) and BRGMON-11B (riverine birds). The original single MQ from the 2011 TOR addressing riverine wildlife was expanded into 6 more specific MQs. Two management hypotheses were specified to improve clarity for MQs 3 and 5 (BC Hydro 2018). • Second set of riverine bird surveys conducted at High Flows (peak of 100 cms). • First assessment done of the diet of overwintering dippers (Walton and Heinrich 2019a). • Second year of active winter beaver lodge surveys (Walton and Heinrich 2019a). • 81 large cottonwood trees protected by cages from beavers along Reaches 2-4 (Walton and Heinrich 2019b).
2019	• Flows (6 cms_MO) become more similar to 6 cms flow regime. • Riverine bird surveys conducted. • Single year surveys of Western Screech-owls (*Megascops kennicottii macfarlanei*) and riparian birds were conducted to address MQ #6 (Walton and Heinrich 2020). • Third winter survey of active beaver lodge locations repeated and expanded to include Reach 2 (Walton and Heinrich 2020). • Second assessment of the diet of overwintering dippers. Observations were made during a dominant pink salmon run (Walton and Heinrich 2020).
2020	• Riverine bird surveys and winter beaver lodge surveys repeated (Walton and Heinrich 2022).
2021	• Riverine bird surveys and winter beaver lodge surveys repeated (Appendix 2).

7.0 APPENDIX 2. Summary of 2021 Field Season

7.1 *Introduction*

Initially, field surveys were not scheduled to occur in 2021. In mid-May, the decision was made to continue surveys to collect another year's worth of data for the final analysis. This account is a brief summary of work done in 2021. Results from 2021 have been incorporated into the main body of this report.

In 2021, we continued long-term surveys to address the following four MQs:

MQ-1 How has the population of Harlequin Ducks in Reaches 3 and 4 of the Lower Bridge River (as enumerated prior to the nesting period with 'pair surveys') varied over time, and is this population index related to flow regime?

MQ-2 Are Harlequin Duck brood counts, monitored in Reaches 3 and 4 of the Lower Bridge River, influenced by flow regime?

MQ-3 Are other riverine bird species likely to be influenced by flow regime; if so, how?

MQ-4 How many active beaver lodges are there in Reaches 2, 3 and 4 of the Lower Bridge River in fall, how are they distributed, and how do these data vary among years?

7.2 *Methods*

7.2.1 Riverine Bird Surveys

We only performed four riverine bird surveys in 2021: one breeding pair survey and three brood surveys. This is a departure from all previous years in which two pair surveys were conducted. Surveys began between 8:00 – 9:30 a.m. and finished by 3:00 p.m. The pair survey was conducted on May 21, and brood surveys were done on June 27, July 15 and 30. Survey techniques were consistent with those followed in previous survey years and followed guidelines proposed by the Resources Inventory Committee (1998).

Surveys in 2021 were conducted by two biologists hiking separately in an upstream direction along the western river bank to maximize bird detections. In previous years a technician accompanied each biologist, but due to COVID precautions, no technicians walked the river in 2021. The first biologist began walking upriver at the Yalakom River confluence and the second biologist began walking upstream approximately halfway between the Yalakom River and Terzaghi Dam. Starting locations for the two biologists (RW and RH) were rotated among surveys to guard against observer bias. Each biologist carried binoculars (10 power) to assist with identification.

In 2021, visual coverage was complete except for portions of back-channels on the opposite side of four small islands (approximately 250 m). Initial bird locations were fixed by handheld GPS (Garmin Colorado 300 and Garmin GPSMap64s, accuracies ranged from ± 3m to ± 35m) and later mapped to correspond with Digital Terrain Inventory Mapping (TRIM) features. Since handheld GPS accuracies ranged widely due to steep canyon terrain, TRIM features were used to ensure that field locations were mapped within a reasonable range of known features (e.g., major tributaries).

When a bird was spotted, it was kept in sight until the bird moved downstream, the biologist passed it while moving upstream, or the bird flew out of sight upstream. If the bird flew upstream, we used two approaches to avoid double-counting. For dippers and sandpipers with relatively short territories, we did not record a new sighting for a species if we saw a single bird again within 100 m upstream of the last location; in other words, we would have to see two birds within a 100 m section simultaneously to record two birds. For more mobile species like waterfowl, we noted the age and sex of birds that flew upstream and avoided recounting those birds 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 Terzaghi Dam. If birds flew upstream or downstream towards the other survey team, we communicated by radio to avoid double-counting.

7.2.2 Active Beaver Lodge Surveys

On December 2, 2021, two biologists walked the western shoreline between the Yalakom River confluence and Terzaghi Dam (14.9 km) using the same route and approach as that used during summer riverine bird surveys. On December 6, we used the same methods to survey Reach 2 (7.0 km). We recorded the number of active beaver lodges based upon the presence of food caches (clumps of freshly cut branches and saplings piled nearby in the water). The presence of a food cache in late autumn is considered the best indicator that a beaver colony is actively using a lodge (MELP 1998). Bank lodges on both sides of the river were counted. Only beaver lodges with a cache of freshly cut branches and saplings were recorded as being active. Locations of active lodges were fixed by GPS (Garmin handheld receivers, accuracies ranged from ± 3m to ± 35m) and later mapped to correspond with digital TRIM coverage for the Bridge River to compensate for small inaccuracies in location. We additionally documented observations of riverine birds along Reaches 3 and 4. Riverine bird observations followed the same procedures used during breeding season surveys.

7.3 *Dataset*

Data from riverine bird and beaver lodge surveys are included the in multi-year databases for the project (see sections 3.2.1 and 3.3.2).

7.4 *Analysis*

7.4.1 Riverine Bird Surveys

Data from the 2021 field season were incorporated into the multi-year analyses addressing MQs 1, 2 and 3. For the overall analyses of riverine bird data, we considered survey type (pair or brood-rearing) and survey year to be the basic sample units for each species. We calculated the average (± 1 SD) number of adult and young (hatch-year) birds observed during pair and brood periods separately for each survey year. For 2021, only 1 survey was available for the pair period. For waterfowl, we also presented the maximum number of pairs and broods seen during pair or brood surveys, respectively. We chose the maximum values rather than presenting averages because we believe the maximum values better indicates the total number of birds resident on these reaches. We did not present counts of pairs and broods for other riverine bird species because these counts are less reliable for species not restricted to the water like waterfowl.

7.4.2 Active Beaver Lodge Surveys

Data from the 2021 field season were incorporated into the multi-year analyses addressing MQs 4. The sample unit used for analyses is the number of active lodges in a year (done separately for Reach 2 and for Reaches 3 and 4 combined).

7.5 *Results*

7.5.1. Riverine Bird Surveys

Table 7.5.1. 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 2021. Values are totals of adults and juveniles combined. Numbers in parentheses indicate the number of juveniles observed.

Survey	American Dipper	Harlequin Duck	Spotted Sandpiper	Belted Kingfisher	Common Merganser	**Total**
Pair						
May 21	4	1	12	0	1	*18*
Brood						
June 27	11 (1)	1 (0)	6 (0)	0	5 (4)	*23 (5)*
July 15	4 (3)	9 (6)	12 (2)	0	5 (4)	*30 (15)*
July 30	4 (1)	9 (6)	10 (0)	0	0	*23 (7)*
Total	*23 (5)*	*20 (12)*	*40 (2)*	*0 (0)*	*11 (8)*	*94 (27)*

7.5.2. Active Beaver Lodge Surveys

We observed 3 active beaver lodges along Reaches 3 and 4 on December 2. During this survey, we recorded 45 American Dippers, 26 Common Mergansers and 1 Belted Kingfisher. Riverine bird data were added to the main database (section 3.2.1).

On the December 6th survey of Reach 2, we found 2 active beaver lodges. All beaver lodge locations are included in the main database (section 3.2.2).

7.6 *Discussion*

Data collected during the 2021 field season were part of a multi-year analyses. Please refer to the main body of the report.