Duncan Dam Water Use Plan Monitoring Program

DDMMON-14 Duncan River Watershed Wildlife Monitoring

Study Period: Year 4 - 2018

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EXECUTIVE SUMMARY

In this report, Nupqu Development Corporation presents the findings from the fourth year of BC Hydro's Duncan River Watershed Wildlife Monitoring study (DDMMON-14), reflecting the rewritten Terms of Reference (TOR) from 2017. The revised TOR provided new Management Questions, to be applied within a smaller study area, and focused on wildlife habitat in the Duncan Reservoir and Lower Duncan River and on understanding how Alternative S(73) flow regimes (Alt-S73) could affect the identified habitat values in both areas (BC Hydro 2017) (**Table E-1**).

Table E-1: DDMMON-14 revised Management Questions.

Management Questions	Status and Summary
What are the wildlife habitat values (e.g., wildlife habitat suitability) of the wetland at the north end of Duncan Reservoir?	Habitat in the Upper Duncan Reservoir follows a vegetative gradient similar to other vegetated drawdown zones. Large expanses of *Equisetum* spp. and *Carex* spp. likely provide valuable spring forage opportunities for ungulates and bears. This habitat does not appear to provide valuable nesting habitat for birds. Little wetland habitat exists in this study area, with most wetland habitat characterized as low, wetted draws. One potential wetland restoration opportunity exists near full pool. Shrubby habitat is well developed in the drawdown zone, but while vegetation is prolific, many shrubs do not provide highly suitable nesting opportunities.
What are the wildlife habitat values (e.g., wildlife habitat suitability) of the riparian habitat along the Lower Duncan River?	The Lower Duncan study area is unique among regulated rivers in that it has well-developed riparian habitat, mature upland forest and a productive wetland. The Lower Duncan provides important habitat for a variety of life stages for birds, mammals, amphibians, and reptiles.
How could reservoir operations under Alternative S (73) affect wildlife habitat in the wetland at the north end of Duncan Reservoir?	Changes have likely occurred over the past 10 years, but the vegetative changes reported by DDMMON-8 probably do not correspond to substantial changes to drawdown zone habitat as perceived by wildlife in the Duncan wetland. Operational impacts to wildlife under Alt-S73 are mitigated by the late inundation of the more suitable nesting substrates.
How could reservoir operations under Alternative S (73) affect wildlife habitat along the Lower Duncan River?	Changes to the habitat along the Lower Duncan River as a result of Alt-S73 are minor. Changes to habitat along this section of river as a function of Alt-S73 are confounded by unregulated inputs from the Lardeau River, as well as Hammill and Cooper Creeks. The hydrograph under Alt-S73 is not substantially different from prior to its implementation.

The Upper Duncan wetland is a matrix of open, shrub and wetland habitat covering 113 ha at the north end of the Duncan Reservoir. Dominated by graminoids and forbs, the open habitat presents little value for nesting birds but likely is important for spring forage for ungulates and bears in this area. Shrubby habitat is vigorous in growth, but few birds were detected using this habitat, likely due to the low internal complexity of many of the shrub patches, which provides little internal concealment for nests. The high elevation and late inundation of these shrubby habitats provide an opportunity for habitat improvement initiatives that would benefit nesting birds, with little likelihood of detrimental impacts from nest flooding. One wetland on the western edge of the study area may provide opportunities for wetland restoration in a drawdown zone environment.

The Lower Duncan River habitat is a productive and diverse riparian ecosystem dominated by mature riparian forest and riparian mixed shrub habitat. The riparian forest is dominated by mature to old-growth cottonwood, which provide valuable habitat for over-wintering ungulates, forage and cover for bears, and high value forage and nesting habitat for birds. Riparian mixed-shrub habitat provides dense cover for wildlife, including high densities of breeding songbirds. Upland mature forest exists along higher elevations and includes old-growth components among mature coniferous and deciduous dominated habitat. These upland mature forests may hold suitable habitat for bat roosts.

A complex and productive wetland exists near the mouth of the Duncan River where it meets Kootenay Lake. The Argenta Slough is known breeding habitat for Western Painted Turtle, American Bittern and common wetland breeding songbirds. Important habitat for pond-breeding amphibians likely exists here as well.

An assessment of habitat change following the adoption of the Alt-S73 operation was conducted for both study areas. Little habitat change was seen to occur in the Lower Duncan River over the study period, likely because the Alt-S73 hydrological regime is very similar to the previous regime and any changes due to Alt-S73 are attenuated by the unregulated inputs from the Lardeau River. Upstream of the dam, the Upper Duncan River has seen vegetative changes, as reported by DDMMON-8 #2 (Duncan River Watershed Riparian and Cottonwood Monitoring, Duncan Reservoir), but because the changes observed under DDMMON-8 #2 reflect fine scale changes in vegetation this likely corresponds to little change to how habitat is perceived by wildlife in the reservoir. Changes to the operation of the Duncan Reservoir are also subtle, but since the implementation of Alt-S73, the hydrograph follows a more predictable pattern, reaching similar elevations at similar times among years as was experienced prior to implementation of the Alt-S73 changes.

KEYWORDS

River regulation, reservoir operations, habitat distribution, habitat suitability, nest flooding, Duncan Reservoir, Duncan River, BC Hydro, British Columbia.

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
ASL	above sea level
FLNRORD	Ministry of Forest Lands, Natural Resource Operations and Rural Development
MQ	Management Question
TOR	Terms of Reference

LIST OF SYMBOLS AND UNITS OF MEASURE

Symbol / Unit of Measure	Definition
ha	hectare
km	kilometer
m	meter
%	percent

1 INTRODUCTION

The Columbia River Treaty between Canada and the United States, ratified in 1964, dictated that “treaty dams” were to be built in Canada to provide downstream flood control and water storage for hydroelectric power generation (BC Hydro 2007). The first of three treaty dams in the Columbia River watershed, the Duncan Dam, was built in 1967 and impounds Duncan Lake and the Duncan River upstream of its confluence with the Lardeau River (Figure 1). The Duncan Dam regulates flow in the Columbia by modulating inputs to the system upstream of several dams along the Kootenay River. While smaller than the rivers dammed by the other treaty dams, the Duncan River collects run-off from the high-snowpack Selkirk and Purcell mountains and plays an important role in regulating flows in the Columbia River (BC Hydro 2007).

The Duncan Dam is operated similarly to other dams in the Columbia system in Canada, whereby water levels are drawn down through the winter to near-minimum levels in March or April. As the snowpack subsides, the reservoir fills to a maximum level (576.7 m ASL) by early August, when it begins its gradual annual drawdown through to the winter minimum (BC Hydro and Power Authority 2013). Because the Duncan Reservoir is not used for power generation, flows resulting from water impoundment are only constrained by flood control and are not regulated for optimizing power generation. Because of this, there is very little of the daily fluctuation of water levels usually associated with power generation.

In general, the regulation and impoundment of river basins causes considerable impact to riparian and wetland wildlife, initially through habitat destruction, and continually via the ongoing regulation of water (Nilsson and Dynesius 1994b). The footprint impact of Columbia River basin reservoirs has been estimated to cause a loss of 26% of wetlands, 21% of riparian cottonwood, and 31% of shallow water and ponds in the B.C. portion of the basin (Utzig and Schmidt 2011b). In place of these and other natural habitats that were lost, are the substantial drawdown zones of these reservoirs, typically comprised of steep, barren shorelines, with negligible value as habitat for wildlife. Rising water levels have the potential to affect the productivity of birds through inundation of nests and nesting habitat (see Espie et al. (1998), Desgranges et al. (2006), and Anteau et al. (2012), but van Oort et al. (2015) for a somewhat counter point). Reservoir drawdown areas have the potential to be ecological sinks for nesting birds because water regime changes during a critical life history period may affect avian populations either directly through mortality or indirectly through habitat changes (Espie et al. 1998, Schlaepfer et al. 2002, Robertson and Hutto 2006b, Anteau et al. 2012). However, in some parts of reservoir drawdown zones in B.C., valuable wildlife habitats persist, and may provide stopover habitat for migratory waterbirds, and suitable and productive nesting habitat in vegetation protected from nest flooding (Cooper Beauchesne and Associates 2010 p. 36, 2011, 2013a).

As part of the Water Use Planning process, B.C. Hydro has undertaken studies to better understand the impacts of reservoir operations on habitat affected by the regulation of the Duncan River. The Duncan River Watershed Wildlife Monitoring program (DDMMON-14) arose from this process to study the impacts of reservoir operations on wildlife habitat within the reservoir, as well as downstream, along the regulated portion of the Duncan River. Parallel to this study, monitoring programs DDMMON-8-1 and DDMMON-8-2 are studying vegetation changes as a result of implemented alternative flow regimes from the Duncan Dam (Alternative S(73), hereafter Alt-S73); these two studies are ongoing and have overlap with DDMMON-14 (Polzin and Rood 2016, 2017).

In 2005 the Duncan Water Use Plan (WUP) consultative committee finalized their recommendations of the alternative flow regime, which had as its goal balancing competing effects of reservoir operation on ecological, cultural and social values (BC Hydro 2007). The proposed conditions of Alt-S73 are to maximize performance of seven objectives:

- Cultural Resources
- Fish
- Flood Management (and Erosion Protection)
- Power Generation
- Quality of Life – Mosquitoes
- Recreation
- Wildlife

To achieve these performance measures the Duncan Reservoir is operated to reach full pool (576.6 m ASL) by early August each year, and then is stabilized at 575.5 m until early September after which date it is gradually drafted (lowered) to its lowest operating level of between 546 – 548 m in April and May.

The goal of these operational changes is to 'maximize the quality and quantity of available habitat for wildlife', but due to competing objectives it is recognized that there may be some detrimental effect on habitat for some species in the Duncan Reservoir due to losses of sedge and grass meadow areas in order to provide benefits to others (BC Hydro 2007).

1.1 DDMMON-14: Study History

DDMMON-14 was originally designed as a four-year study to be implemented over a 10-year period. The study objective was to assess the performance of the Duncan Dam Water Use Planning on wildlife communities in the Lower Duncan River and Duncan Reservoir riparian areas. Objectives were outlined in Clause 6(d)[1] and Clause 6(h)[2] of the Order (File No. 76975-35/Duncan) for the Duncan Dam Water Use Plan. The first two years of the study (2009 and 2011) were completed (Isaac and Pomeroy 2010, Hallstrom and Isaac 2012); the remaining two years (i.e., 2014 and 2018) were postponed when it became apparent that this study would be unable to answer the Management Questions as written in 2008. In 2017, BC Hydro revised the Terms of Reference (TOR) for DDMMON-14 to provide new Management Questions, to be applied within a smaller study area and focused on wildlife habitat in the Duncan reservoir and Lower Duncan River (BC Hydro 2017).

[1] Clause 6(d): monitor cottonwood recruitment and wildlife habitat use in the Lower Duncan River floodplain.

[2] Clause 6(h): monitor riparian vegetation and wildlife habitat, including nesting birds, in the drawdown zone of the Duncan Reservoir.

1.2 DDMMON-14: Study Objectives

The objectives of DDMMON-14 are to identify wildlife habitat values in both the Lower Duncan River and the wetland at the north end of the Duncan Reservoir, and to describe how Alt-S73 could affect the identified habitat values in both areas. This report addresses the four revised Management Questions.

- **MQ-1**: What are the wildlife habitat values (e.g., wildlife habitat suitability) of the wetland at the north end of Duncan Reservoir?
- **MQ-2**: What are the wildlife habitat values (e.g., wildlife habitat suitability) of the riparian habitat along the Lower Duncan River?
- **MQ-3**: How could reservoir operations under Alternative S (73) affect wildlife habitat in the wetland at the north end of Duncan Reservoir?
- **MQ-4**: How could reservoir operations under Alternative S (73) affect wildlife habitat along the Lower Duncan River?

2 STUDY AREAS

The Duncan Dam is a water storage facility located within the Duncan River watershed that operates under the Columbia River Treaty. Duncan Dam is located upstream of the confluence of the Duncan and Lardeau Rivers and impounds the Duncan Reservoir. At full pool (576.4 m to 576.7 m elevation), the reservoir is 45 km long and has an area of 7,150 ha. The Lower Duncan River occurs south of the Duncan Dam and flows southwards into the north end of Kootenay Lake.

The two DDMMON-14 study areas occur in the Duncan River watershed, which is located within the Regional District of Central Kootenay near Meadow Creek, approximately 85 km north of Nelson, B.C. The Upper Duncan Reservoir study area focused on the wetland habitat at the north end of the reservoir, and the Lower Duncan River study area focused on riparian habitat along the Lower Duncan River between Duncan Dam and Kootenay Reservoir (**Figure 1**).

The DDMMON-14 study areas overlap with the Interior Cedar-Hemlock (ICH) biogeoclimatic zone. Both the Upper Duncan Reservoir and the Lower Duncan River study areas occur within the moist-warm subzone (variant 2), but the Lower Duncan River study area transitions to the dry, warm subzone (variant 1) as the river approaches Kootenay Lake. The ICH zone occurs at lower to middle elevation and has a continental climate with cool, wet winters and warm, dry summers. Although extensive wetlands are uncommon in the ICH zone due to the steep mountainous terrain, abundant riparian and lakeshore wetlands can be found associated with lakes, reservoirs, and waterways in the ICH zone (BC Hydro 2017).

Legend

Study Area

Sources

- Aerial Image: Bing Maps Aerial
- Inset Basemap: ESRI World Topographic Map

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid to the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

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DDMMON-14 Duncan River Watershed Wildlife Monitoring Report
Duncan River, BC

DDMMON-14 Study Areas

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3 METHODS

3.1 Overview

The focus of this study was on air photo interpretation to identify and quantify habitats in the Upper Duncan Reservoir wetland and the Lower Duncan River. Air photo interpretation was combined with ground-truthing to inform and improve the habitat mapping. Wildlife surveys were not a formal component of the ground-truthing surveys, but signs of wildlife use, as well as nests found, and bird species detected were recorded opportunistically. The suitability of habitat for nesting birds was assessed qualitatively by the lead author with more than 10 years' experience monitoring nesting ecology in reservoir drawdown zones. In addition, relevant literature was reviewed to help inform habitat value for species known to occur, but not detected during the field surveys.

3.1.1 Air Photo Interpretation

Air photos used for habitat interpretation in the Upper Duncan Reservoir wetland were captured in May of 2018 using a remotely operated drone. Imagery was captured as soon as leafy vegetation was anticipated to be well-developed and the site was accessible after the winter snowpack had subsided. Imagery resolution was high, with horizontal resolution for the 2018 data measured at 5 cm.

Air photos used for interpretation of habitat in the Lower Duncan River came from 2009 and 2015 and had cell resolutions of 10 cm.

Habitat interpretation from air photos followed methods developed from projects conducted previously by Cooper Beauchesne and Associates Ltd. (CBA): MacInnis et al. 2011, Cooper Beauchesne and Associates Ltd (CBA) 2013b p. 40, 2016). Methods for photo interpretation as described by the Vegetation Resource Inventory were also referenced (FLNRORD, Forest Analysis and Inventory Branch 2018).

Habitat polygons were delineated at a scale of 1:2,000 for both the Upper Duncan Reservoir wetland and Lower Duncan River. Polygons differentiate habitat types at a habitat patch, or "macrohabitat" scale (Saab 1999) and were generally identified based on the presence of vegetation, general habitat structure (forests, shrubs, wetlands, and open habitats), dominant growth form of vegetation (wetland vs. herbaceous vs. woody vegetation) and, in some cases, species. Within each of these general habitat strata, polygons were further divided to capture heterogeneity within the broader habitat strata.

Habitat strata, and the finer subdivision of "category," were initially defined by reviewing existing mapping, and then refined as the study areas were examined at the mapped scale (Krebs et al. 2013, Polzin and Rood 2016). As mapping proceeded, these divisions were refined to capture broadly distributed habitat types, as well as more unique habitat features identifiable in aerial photography.

3.1.2 Ground-truthing Polygons

Air photos were not available prior to the ground-truthing component of this project. Consequently, no habitat delineation was done prior to site visits. For this reason, the study areas were divided into 1 ha squares stratified by the five anticipated broad habitat strata (unvegetated, open, shrub, forest, and wetland) (**Figure 2**). Squares to be sampled were selected prior to the field visit and were distributed among each of the strata in areas which were accessible. Once in the field, staff added other accessible sample squares to capture replicates of similar habitats to sample the variability of habitat in the two study areas.

Each square was examined for dominant growth form (herbaceous, shrub, forest), dominant species (by area) of vegetation for each vertical structural layer (tree, shrub, herbaceous, and open) (Rowland and Vojta 2013). For each plot, one of the five strata was assigned to the square, and species of vegetation from each vertical layer were recorded. All habitat features identifiable on air photos were drawn to scale on field maps.

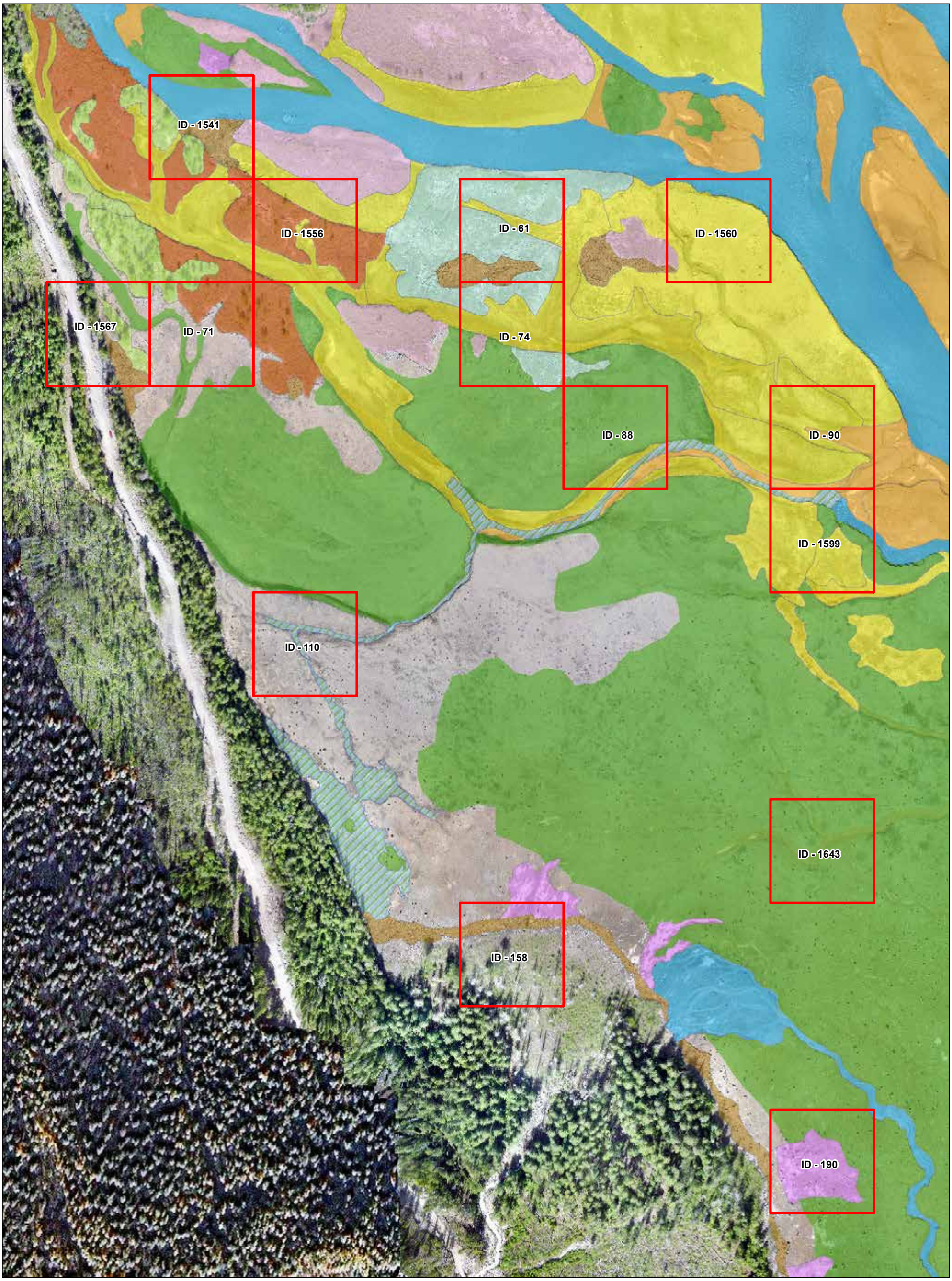
3.1.3 Assessing Wildlife Value

Field visits were conducted from June 4-8, 2018 to coincide with low reservoir levels, site access, green vegetation and the peak of the bird breeding season. During the site visits wildlife value of drawdown zone habitat was evaluated for each 1 ha plot surveyed.

Use of habitats by birds was a primary focus largely due to their use of drawdown zone habitat for nesting. Professional opinion was used to assess the value of habitats encountered, and this was supported by information gathered on site of evidence of breeding, and occupation of habitat by singing males. A five-minute point count at the center of each plot was conducted to determine the species present (Resources Inventory Committee 1999). Dedicated nest searching was not conducted, but opportunistic searches were made when behaviours suggested a nest was nearby.

Originally, focal species were to be studied to inform the effects of reservoir operations on related taxa. However, to get any meaningful data from studying focal species would require a longer-term study, to understand the specific effects of the Duncan reservoir operations. Regionally, much is known about reservoir operations and the effects of annual inundation on birds (Cooper Beauchesne and Associates 2018a, 2018b), amphibians and reptiles (Hawkes et al. 2016). We felt that with this knowledge, combined with experienced observers focal species would not substantially improve our ability to assess habitat and the effects of reservoir operations on taxa within the drawdown zone. Instead, we chose to focus on species detections for all taxa and use that as a relative measure of habitat importance.

Observations during ground-truthing were assigned to the plot in which they were made. On occasions where a bird species was recorded on a plot which lacked suitable breeding habitat for that species, either that observation was dropped, or it was assigned to the nearest, suitable habitat class. These observations were then used to calculate the number of bird species occurring within each habitat class.



Legend

- sample square
- early - seral riparian
- mature
- old forest
- existing cutblock
- shrub
- sparse vegetation
- wetland
- riparian shrub
- riverine wetland
- shrub savannah
- fine mineral
- low shrub
- wetted channel
- woody debris

Sources

- Aerial Image: ESRI World Aerial
- Inset Base map: ESRI World Topographic Map

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
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Watershed Wildlife Monitoring Report
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1-ha Sampling Squares

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3.1.4 Assessing Habitat Change Over Time

3.1.4.1 Upper Duncan Reservoir Study Area

For the Upper Duncan Reservoir study area, no comprehensive orthographic photos exist prior to the current study year. To measure current habitat distribution, we used air photo interpretation, but for pre-Alt-S73 habitat we studied the results of Year 3 of DDMMON-8 #2 (last available study year). Using changes in vegetation reported by the authors of that project, we used professional judgement to estimate changes to habitat under Alt-S73.

3.1.4.2 Lower Duncan River Study Area

To assess broadscale changes to habitat over time, two sets of air photos were used to delineate habitat in the Lower Duncan River study area. Habitat in air photos from 2009 was compared to similar- resolution air photos captured in 2015 by mapping habitat in these two years (hereafter “study period”). The distribution and change in area of each habitat category for vegetated polygons was compared between the two years using ArcGIS and R geographic information systems (ESRI 2011, R Core Team 2015). For unvegetated categories, only comparisons at the strata level were performed.

3.1.4.3 Assessing the Effects of Inundation on Habitat Availability

A digital elevation model for the Upper Duncan study area with a 20cm horizontal resolution was used to determine elevations of each of the mapped habitat polygons. Minimum, maximum and mean elevations for each polygon were determined and these values were used to assess the timing, and threat of inundation due to reservoir operations. A range of values for each of the habitat categories was then derived from individually mapped polygons. Historic reservoir operations was used in conjunction with these elevations to determine the probability of inundation of each habitat category, throughout the spring and summer.

3.2 Data Sets

3.2.1 Strata and Category Definitions

Tables 1 and 2 define each of the habitat categories and examples of key habitat types (or stratum) as mapped. Each category in **Table 2** is derived from its coarser-scale stratum, with common categories grouped under one stratum.

Table 1: Strata Used to Delineate Broad Habitat classes.

Stratum	Dominant Cover
forest	Predominant vegetation type is tall trees, greater than 5 m. This stratum is further subdivided into sub-forest types as described by “fine category.”
open	Mostly herbaceous habitat with little woody vegetation. Open grassland, sedge, and equisetum meadows are captured under this stratum.
shrub	Shrubby habitat which ranges from low, dense shrubs, and riparian shrub in the Upper Duncan Reservoir, to vigorous and productive riparian mixed shrub in the Lower Duncan River.
unvegetated	Unvegetated polygons. Gravel, coarse rock, fine material, and woody debris are captured in this stratum.
water	Polygons predominantly comprise wetted channels. Includes mainstem of Duncan River, as well as back channels, creeks, and shallowly flooded areas.
wetland	Riverine wetlands. Includes productive marshes, sedge wetlands, and oxbow wetlands.

Habitat was further subdivided within each of these habitat strata into a finer "category." This category delineated specific habitats within each stratum. Unique habitats in each study area are captured in this "fine category" descriptor, and each is described in **Table 2**, with example photographs in **Appendix A**.

Table 2: Category Descriptors for Habitat Mapping for the Upper Duncan Reservoir (UD) and Lower Duncan River (LD) Study Areas.

Strata	Fine category	UD	LD	Description
forest	*early seral riparian forest*	Y	Y	Young cottonwood dominated stand, most common in UD, but some areas of LD study area (**Photo 1**).
forest	*mature riparian forest*		Y	Floodplain mature cottonwood dominated stand. Some cedar. Vigorous understory with variable canopy closure (Photo 2).
forest	*multi-storied open*		Y	Multi-storied polygons dominated by shrub and herbaceous cover, but with sporadically placed deciduous. Understory has well-developed structural diversity (Photo 3).
forest	*mature upland forest*		Y	Mature forests adjacent to flood plain. Variable crown closure with areas of vigorous understory. However, mostly dominated by canopy species. These forests have areas of old-growth within them, but old-growth trees exist intermittently, and could not constitute a separate class (Photo 4 and 5).
open	*equisetum*	Y		UD study area. Broad swathes of equisetum and sedge grasslands dominant in the lower elevations of the drawdown zone. Often within a matrix of stumps. In higher elevation areas of this habitat, reed canarygrass can be found in significant quantities (Photo 6).
open	*mixed grass*	Y		UD open strata habitat type which exists at higher elevations of the drawdown zone. This and the equisetum category are continuous, but this category is higher and dominated by graminoids, but still with an equisetum component (Photo 7).
open	*low herbaceous*		Y	Graminoid- and forb-dominated open habitat, mostly found in LD. Often this ground cover is among more woody vegetation, but there are areas of open, herbaceous vegetation. Mostly occurs in the delta of the Duncan River (Photo 8).
open	*scouring rush*	Y		Low draws in the UD are dominated by northern scouring rush. Patches occur elsewhere, but are most common in these low draws near the north end of the drawdown zone (Photo 9).
open	*sparse vegetation*	Y	Y	Usually sandy substrate with sparse graminoid or shrubby vegetation growing in low densities within the seasonally flooded area of the Lower Duncan River (Photo 10).
shrub	*low shrub*	Y		Limited to the UD. Generally, willow growing less than 2 m. Dense patches occur, but also occurs singly much like shrub savannah habitat (Photo 11).
shrub	*riparian mixed shrub*		Y	Highly productive and diverse tall shrub patches usually ~5 m tall (Photo 12 and 13). Occur in the richest sites of the LD. Can be extremely dense and has high value for nesting birds and over-wintering elk.

Strata	Fine category	UD	LD	Description
shrub	*riparian shrub*	Y		Growth form of willow spp. in the UD. Dense stands of willow 2-5 m tall. Stem density is high, but of little value for nesting due to low internal complexity of shrubs. Leaf cover limited to outer branches due to density (Photo 14).
shrub	*shrub savannah*		Y	Similar to multi-storied open, but lacking trees. Few areas of this type of habitat occur. In the LD the dominant shrub species is red-osier dogwood (no representative photo).
unvegetated	*coarse rock*	Y	Y	Rip-rap or rocky banks (Photo 15).
unvegetated	*developed*		Y	Urban sites. Often vegetated, but human altered so not categorized as natural habitat (no representative photo).
unvegetated	*fine mineral*	Y	Y	Sandy or silty bars in both study areas (Photo 16).
unvegetated	*gravel*	Y	Y	Gravel bars, mostly occur in the LD (Photo 16).
unvegetated	*woody debris*	Y	Y	Larger areas of woody deposits from previous flooding. Likely these grow over time and move around (Photo 17).
water	*wetted channel*	Y	Y	Mainstem and continuously wetted channels (Photo 18).
wetland	*riverine wetland*		Y	Wetlands associated with riverine habitat (Photo 19). Often oxbow wetlands or vegetated back channels. Often herbaceous or dense shrubby vegetation. Open water wetlands, as well as marshes dominated by cattail and bulrush are included (Photo 20).

3.3 Addressing Management Questions

This report is focused on answering Management Questions presented in the DDMMON-14 TOR, rewritten in 2017 (BC Hydro 2017). Prior to the re-write of the DDMMON-14 TOR, two years of study was completed to answer the original Management Questions (Hallstrom and Isaac 2012). In 2017, the Management Questions were rewritten to be simplified and narrowed in scope, and with an emphasis on mapping habitat in both the Upper Duncan Reservoir wetland, and along the Lower Duncan River. In addition to mapping wildlife values, an assessment of habitat changes due to the implementation of Alt-S73 was completed.

4 MANAGEMENT QUESTIONS

4.1 MQ-1 What are the wildlife habitat values (e.g., wildlife habitat suitability) of the wetland at the north end of Duncan Reservoir?

The wetland in the Duncan Reservoir can be more accurately characterized as a matrix of open shrub and wetland habitats within the drawdown zone environment. We defined 12 habitat categories within the study area, five of which were unique to the Upper Duncan Reservoir (**Table 2**). Habitat found within the study area generally resembles the vegetated drawdown zones found at the head of other reservoirs (CBA 2016). Like the Kinbasket and Arrow Lakes Reservoirs, drawdown zone habitats in the Duncan Reservoir are comprised of vegetation which follows a gradient of tolerance for inundation (**Figure 3**). The deepest portions of the annually exposed drawdown zone in the Duncan Reservoir are unvegetated, with grass and forb cover beginning approximately 7 m below the full pool mark. Moving upwards along this elevational gradient, shrubby vegetation begins approximately 2 m below full pool (shrub savannah) and generally becomes more developed until full pool is reached, where early seral riparian forest is found.

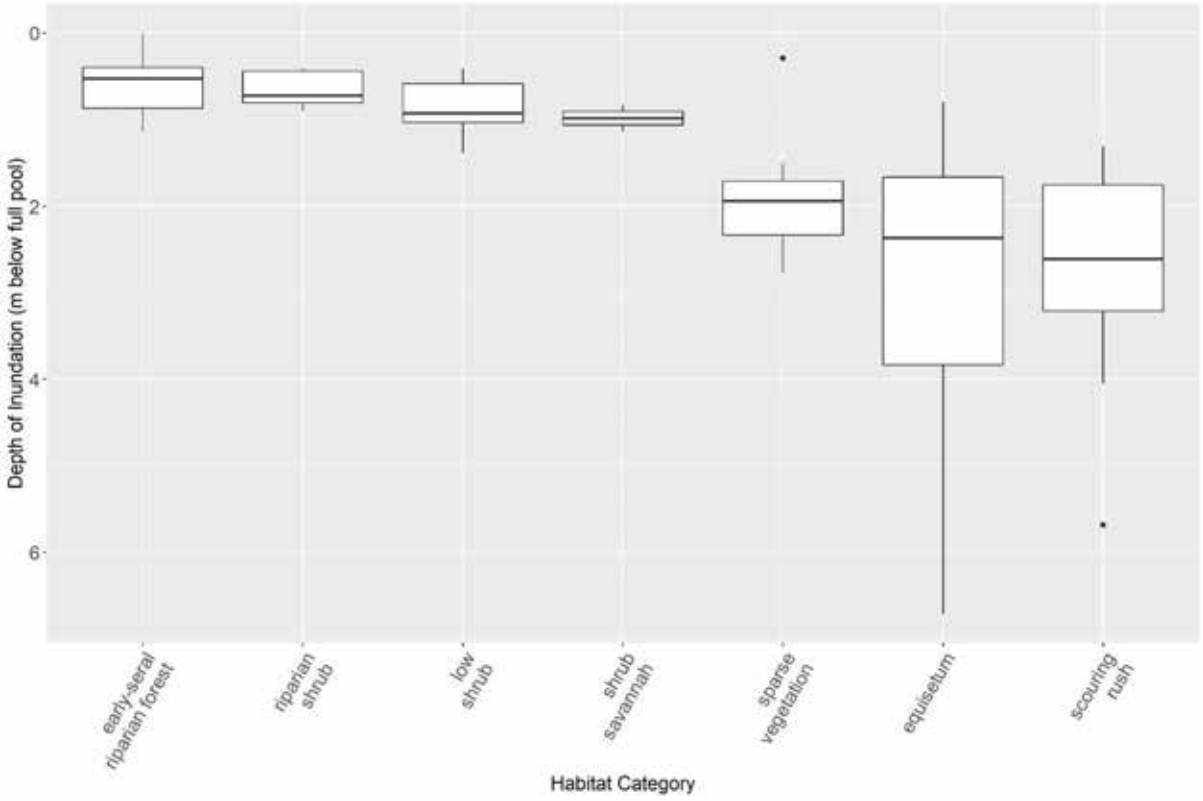

Figure 3: Terrestrial habitat categories and the range of depths at which they occur in the drawdown zone, below full pool (576m ASL). On the y-axis, 0 indicates no inundation, and 6 indicates 6 m below full pool.

We noted wildlife use of all habitats encountered in the drawdown zone (**Appendix B**). In addition, prior to the field surveys we reviewed species listed under Schedule 1 of the *Species at Risk Act* (SC 2002, c 29), which may occur in the region and noted suitable habitat in which those species may occur (**Appendix C**).

The expansive equisetum habitat category comprised of *Equisetum arvense* and *Carex* spp. was the dominant vegetated cover of the study area covering 72% (81 ha) of the mapped habitat. This habitat grew at the lowest vegetated levels of the drawdown zone, 6.7 m below full pool. During the field survey low densities of Canada Goose (*Branta canadensis*), Savannah Sparrow (*Passerculus sandwichensis*), Lincoln's Sparrow (*Melospiza lincolnii*), and Mountain Bluebird (*Sialia currucoides*) were detected in the equisetum habitat. It is also likely that ungulates (white-tailed deer (*Odocoileus virginianus*), Rocky Mountain elk (*Cervus canadensis nelsoni)*, and both species of bear (black bear (*Ursus americanus*) and grizzly bear (*Ursus arctos*)) graze in this habitat when it is available.

At the upper margins of the equisetum habitat, low draws bisect the study area and are often bounded by habitat categories dominated by woody vegetation (low shrub, shrub savannah, riparian shrub and early seral cottonwood forest). These low channels are generally covered by northern scouring rush (*Equisetum variegatum*), with bare ground (fine sediment) along the bottom of the channel. Many elk tracks were seen in these draws, suggesting they are travel corridors between the lower elevations and more dense and shrubby higher elevations (**Figure 4**). Scouring rush habitats occur between 570 m and 575 m ASL, an elevation band usually flooded by mid-late June. Few bird species are expected to use this habitat for nesting, and those which were detected here (spotted sandpiper (*Actitis macularius*) and Canada goose) would find it more suitable as a foraging substrate than for nesting.

Figure 4: Scouring rush dominated draw bounded by riparian shrub habitat in the Upper Duncan Reservoir Study Area. These draws had much evidence of use by elk as travel corridors and potentially winter use.

Other habitats are far less common in the Upper Duncan Reservoir study area, and none are highly valuable for any particular species. The shrub categories low shrub and shrub savannah provide breeding habitat a limited number of songbird species, but at low densities because of the sparse nature of this habitat (**Appendix C**). In the low shrub habitat category, three bird species were detected during the breeding season: chipping sparrow (*Spizella passerina*), Lincoln's sparrow and savannah sparrow. This habitat category provides suitable, if limited, nesting opportunities in the drawdown zone and occurs between 574 m and 575 m ASL. The riparian shrub habitat category has diminished value for nesting birds due to high stem density, and low internal structural complexity, with leafy cover only vigorous on the outside of the bush (**Figure 5**). Similar to a forest with high canopy closure, these shrubs offer little internal cover useful for nesting. We detected common yellowthroat (*Geothlypis trichas*), gray catbird (*Dumetella carolinensis*) and yellow warbler (*Setophaga petechia*) in these patches. All three of these species could nest in this habitat but given the structural complexity of riparian shrub in this environment there are probably very few high-quality nest site locations in the drawdown zone.

Figure 5: Riparian Shrub Habitat in the Upper Duncan Reservoir Study Area. This habitat grew as dense patches, but internal structure was low, with high stem density and little leafy structure within the shrubs. It appeared as good nesting habitat from the outside, but the low internal complexity reduced its value as a nesting substrate.

The early seral cottonwood forest habitat was of variable value for wildlife, and areas with well-developed habitat were generally above the drawdown zone. Within the drawdown zone, this habitat consisted mostly of small balsam poplar with a marginally developed understory. Productive growth of this habitat may be limited by periodic inundation where the anoxic environment created by flooding limits vigorous growth (Amlin and Rood 2001). Few bird species were detected in this habitat as is expected of early seral cottonwood forests with low structural complexity (MacArthur and MacArthur 1961). However, while nesting substrate is likely of low value, these broadleaf forests are important foraging areas for many of the insectivorous bird species observed.

Wetland habitat in the Upper Duncan Reservoir study area is less productive than in other wetlands above the drawdown zone, and in the Lower Duncan River study area (described in **Section 4.2**). Back channels exist but have little emergent vegetation and do not offer high value breeding and cover habitat for birds or amphibians. Most of the riverine wetland habitat in the Upper Duncan Reservoir study area is bordered by open habitat lacking complex riparian mixed shrub, or mature riparian forest habitat along its margins. One prominent wetland occurs in the Upper Duncan Reservoir study area on the west side of the reservoir (Figure 6). Composed of open, shallow water supplied from Puddingbowl Creek, emergent vegetation and some woody debris, this wetland provides suitable habitat for pond breeding amphibians.

Figure 6: Potential Wetland Restoration Site. Open, flooded area is just upstream of this photo.

Amphibians known to occur in the region which are also likely to occur in the drawdown zone are: Columbia spotted frog (*Rana luteiventris*), northern Pacific treefrog (*Pseudacris regilla*), western toad (*Anaxyrus boreas*) and long-toed salamander (*Ambystoma macrodactylum*). Only adult western toads were detected during surveys. Life history requirements for each of these species varies, but all require aquatic environments for breeding. The primary wetland described above fulfills breeding habitat requirements for all four species to varying degrees, with each laying eggs in shallow ponds, with variable substrates and aquatic vegetation (Lannoo 2005, Matsuda et al. 2006). These amphibians most often complete metamorphosis by mid to late summer and either leave their natal ponds and move upland (western toad, long-toed salamander, Pacific chorus frog), or disperse to other ponds (Columbia spotted frog) (Lannoo 2005).

The number of breeding bird species associated with each mapped habitat category in the Upper Duncan Reservoir study area was estimated based on habitat characteristics and field observations. Location and habitat characteristics for each bird detection were recorded, and efforts were made to associate birds with the plot surveyed (Table D-1). This information was combined with the minimum elevation at which each habitat type occurs thereby giving an estimated date of impact to breeding birds from reservoir operations (**Table 3**).

Table 3: Upper Duncan Reservoir habitat categories showing number of bird species detected in each habitat type, and earliest flooding dates under Alt-S73.

Fine Category	Area (ha)	Mean Elevation	Number of Bird Species	Amphibian	Large Terrestrial Mammals
early-seral riparian forest	2.5	575.4	2	adult post breeding, juvenile dispersal	browse, security cover
equisetum	92.2	573.3	2	adult post breeding, juvenile dispersal	spring grazing
fine mineral	32.9	571.4	2	none	likely none
low shrub	6.8	575.1	2	adult post breeding, juvenile dispersal	browse
mixed grass	146.7	573.1	0	adult post breeding, juvenile dispersal	spring grazing
riparian shrub	2.8	575.3	3	adult post breeding, juvenile dispersal	browse, security cover
riverine wetland	1.6	572.7	2	breeding, rearing	water
scouring rush	17.5	573.2	2	adult post breeding, juvenile dispersal	grazing[3]
sparse vegetation	2.1	574.1	1	none	likely none

[3] Personal observations in Kinbasket reservoir suggest that elk will graze on scouring rush in winter by excavating craters in low snow areas. Observations in the Upper Duncan study area of elk winter fecal pellets indicate a similar use here.

Suitable over-wintering and calving habitats for elk exist at the margins of the mapped habitat. Dense, young, regenerating coniferous stands, riparian habitats, and old-growth forests offering thermal protection, provide life history requirements for elk, and abundant grazing opportunities in the drawdown zone likely helps support this species in the area (Poole and Park 2003).

4.1.1 Effects, Challenges, and Opportunities

Ground-truthing of the Upper Duncan Reservoir study area was spatially comprehensive and detailed. Ground-truthing squares captured the variability of habitat, but as with the Lower Duncan, there were areas which were not accessible due to high-water and strong currents. Imagery used for habitat delineation was high resolution but was collected slightly earlier than would have been optimal to capture variability within homogenous-appearing habitat. Air photos and field visits were difficult to time with snowmelt, green-up, and sufficiently low reservoir levels to ensure access. However, the timing for each of these components of the study worked well. We feel confident that the habitat mapping for the Upper Duncan Reservoir study area is accurate and representative of habitats occurring there.

Habitat mapping effectively captured the range of habitats which exist in the Upper Duncan Reservoir study area and this is corroborated by the species of birds observed. Although few species were detected, each observation matched an identified habitat type and no birds were detected which could not logically be associated with habitats defined.

Shrub habitat in the Upper Duncan Reservoir study area has vigorous leafy growth, but low diversity in structure and species composition. Improving the diversity and structure of this habitat would benefit nesting birds by increasing the suitability of this habitat. Because this shrubby habitat occurs at elevations not inundated until late in the breeding season, it is possible this habitat could be made more attractive to birds without the associated reservoir impacts seen in other reservoirs. Mechanically pruning existing shrubs to increase their structure and planting other species of shrubs would improve nesting habitat at higher elevations of the reservoir.

Legend

Potential Wetland Restoration Site

Contour (5 m interval)

Sources

- Aerial Image: ESRI Maps Aerial

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

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DDMMON-14 Duncan River Watershed Wildlife Monitoring Report
Duncan River, BC

Potential Wetland Restoration Site in the Upper Duncan Study Area

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4.2 MQ-2 What are the wildlife habitat values (e.g., wildlife habitat suitability) of the riparian habitat along the Lower Duncan River?

The Lower Duncan River study area is composed of highly variable habitat, notable for the intactness of the ecosystem within the ecological corridor of a regulated river. Habitat varies from sparsely vegetated sand/gravel bars to highly productive riparian mixed shrub and mature riparian forest habitats. Wetlands exist within the riverine corridor, and an extensive wetland near the mouth of the Duncan River provides cattail, bulrush, and sedge habitat for amphibians and wetland breeding birds.

Several Habitat Conservation Trust Fund properties exist within and adjacent to this study area. Previous wildlife inventories have been conducted on these properties, and comprehensive lists of known and suspected wildlife have been compiled (Krebs et al. 2013, Wright et al. 2017).

The most notable features of the Lower Duncan River study area are mature riparian and upland forests, mixed riparian shrubland, and unique shrub-savannah habitats. Very large balsam poplar trees are found throughout the Lower Duncan River study area, which are important habitat features for taxa known to occur in the area including Vaux's Swift (*Chaetura vauxi*), Western Screech Owl (*Megascops kennicottii*), Bald Eagle (*Haliaeetus leucocephalus*), Osprey (*Pandion haliaetus*), fisher (*Martes pennatii*)), and bats known to roost in mature forests such as northern myotis (*Myotis septentrionalis*), and little brown myotis (*Myotis lucifugus*).

There were 17 habitat categories identified in the Lower Duncan River study area, of which four were of little value to wildlife (coarse rock, wetted channel, woody debris and developed). The remaining habitat types were variably important for wildlife, with those more complex habitats supporting a greater number of species. **Table 4** describes the 13 habitat types which have value to wildlife and the life stage or guild likely associated with them. Table D-1 shows all species detected in each of the habitat types found in the Lower Duncan study area.

Table 4: Lower Duncan River Habitat and Associated Wildlife Values.

Fine Category	Area (ha)	Mean Elevation	Number of Bird Species	Amphibian	Large Terrestrial Mammals
cattail wetland	4.360	533.613	4	all life stages	forage and water
early-seral riparian forest	8.181	533.049	2	adult post breeding, juvenile dispersal	browse, security cover
fine mineral	24.324	535.575	2	none	likely none
gravel	7.621	538.844	1	none	none
low herbaceous	95.199	536.404	6	adult post breeding, juvenile dispersal	forage
mature riparian forest	199.389	537.374	23	adult post breeding, juvenile dispersal	security cover, forage
mature upland forest	87.009	541.480	15	adult post breeding, juvenile dispersal	security cover, thermal cover, forage
multi-storied open	17.106	533.022	-[4]	adult post breeding, juvenile dispersal	security cover, forage
riparian mixed shrub	137.910	536.287	8	adult post breeding, juvenile dispersal	security cover, forage
riparian shrub	0.086	544.310	3	adult post breeding, juvenile dispersal	security cover, forage
riverine wetland	30.254	536.069	11	breeding, rearing	water
shrub savannah	9.619	534.697	6	adult post breeding, juvenile dispersal	browse, security cover
sparse vegetation	1.560	532.625	2	none	likely none

We found evidence of Rocky Mountain elk (*Cervus canadensis nelsoni*) use in most habitats surveyed in the Lower Duncan study area, which suggested late-winter use of those valley bottom habitats. In addition, Poole and Park (2003) studied movements of collared elk in the Lardeau and Duncan valleys and found use during winter was highest in riparian habitats with some use of adjacent forested habitats, corroborating our findings. Black bear use was noted in rich riparian habitats along the Lower Duncan and these habitats likely provide important forage and cover sites during spring and summer. The Duncan/Lardeau and Meadow Creek spawning channel are productive spawning habitat for Kootenay Lake kokanee (*Oncorhynchus nerka*) and Gerrard rainbow trout (*Oncorhynchus mykiss*), which are a strong draw for black and grizzly bears (Irvine 1978, Sanders 2016, Zimmer et al. 2016). Habitats adjacent to these spawning channels provide travel corridors and security cover for these predators during spring and fall spawning periods.

Observations of wildlife use of the Lower Duncan study area were highest in the mature riparian forest polygons with evidence of use by 30 species of wildlife detected, primarily breeding birds[5] (**Appendix D**). This habitat type constitutes the majority of habitat in the Lower Duncan covering 32% (199 ha) of the terrestrial mapped area (**Table 4**). The mature riparian forest category is characterized as having a dominant component of balsam poplar (*Populus balsamifera*), but with a well-developed understory providing vigorous

[4] Due to limited access multi-storied open habitat was not directly sampled.

[5] Due to their ease of detection during breeding season, birds were the primary taxa of wildlife observed. Sign of other wildlife was recorded, but few detections were made due to the cryptic nature of wildlife.

and diverse habitat for birds, mammals, and amphibians. This habitat acts as an interface between the rarer mature upland forest and the more aquatic categories found adjacent to the wetted channel. Less common bird species in the area were detected in this habitat: Bullock's Oriole *(Icterus bullockii*), MacGillivray's Warbler (*Oporornis tolmiei*), Magnolia Warbler (*Dendroica magnolia*) and Veery (*Catharus fuscescens*). These species are not considered rare, but are associated with rarer habitats in the region, and in the Lower Duncan study area this habitat type is well represented particularly on lands under conservation covenants.

The mature upland forest habitat category comprises 11% (87 ha) of the mapped area and is confined to the margins of the study area. This habitat type is at the highest elevations in the floodplain surrounding the Lower Duncan River and is found mostly between the confluence of the Lardeau and Duncan Rivers, downstream to just below the inflow of Cooper creek. Forests in these polygons are characterized by having a large component of mature to old-growth western red cedar (*Thuja plicata*), intermixed with large cottonwoods (**Figure 8**).

Figure 8: Mature Upland Forest in the Lower Duncan River Study Area. Habitat is dominated by western red cedar and balsam poplar, but with other tree species at low densities.

Canopy closure varies, but openings are dispersed throughout. In areas where canopy closure is high, little understory is present, but in the openings the understory can be well developed and offer diverse habitat for wildlife, including foraging and breeding habitat. These openings are similar to riparian mixed shrub polygons but occur at a scale too small to be mapped. Wildlife values of these polygons includes abundant wildlife trees in various stages of decay, which provide habitat for cavity nesting birds (e.g., pileated woodpecker (*Dryocopus pileatus*), thermal cover and browse for over-wintering ungulates, and forage and

cover for other mammals and amphibians. Pacific Wren (*Troglodytes pacificus*), Hammond's Flycatcher (*Empidonax hammondii*) and Western Tanager (*Piranga ludoviciana*) are notable bird species in this habitat. As with mature riparian forest, but to a lesser extent, mature upland forest is captured under several Nature Conservancy properties along the Duncan River.

Wetlands in the Lower Duncan River study area made up 5% (39 ha) of the mapped area. This habitat ranged from shallowly flooded, back channels with emergent vegetation to well-developed cattail and bulrush wetlands in the Argenta Slough. The Argenta Slough is a well-known wetland near the mouth of the Duncan River where it meets Kootenay Lake (**Figure 9**).

Figure 9: Open water and cattail habitat of Argenta Slough.

A much-studied wetland (Ellis 2013, Krebs et al. 2013, Wright et al. 2017), it is a known breeding site of the western painted turtle (*Chrysemys picta*) (Herbison 2011). Bird species detected using this wetland include Canada Goose, Common Yellowthroat (*Geothlypis trichas*), Red-winged Blackbird (*Agelaius phoeniceus*), Song Sparrow, (*Melospiza melodia*) and Yellow Warbler. Wetland habitats found in the Argenta Slough serve as important nesting and brood-rearing habitat for the avian species observed, as well as for other species which likely occur in the area but were not observed. American Bittern (*Botaurus lentiginosus*), a Blue-listed species provincially, has been documented in this area, as has Bobolink (*Dolichonyx oryzivorus,* federally listed under Schedule 1 of Sara as 'Threatened'), an open habitat species with affinity for wet meadows like those found near this productive wetland (Wright et al. 2017). Few wetland wildlife species were recorded on our field visit as access to the most productive habitat was limited. High water from Kootenay lake cut off access to many habitat patches which would have produced notable wetland species. In particular, Sora Rail (*Porzana carolina*), Virginia Rail (*Rallus limicola*) and Marsh Wren (*Cistothorus palustris*) are species common to these habitats but were not detected on the field visit.

4.2.1 Unique Habitats

The intact riparian habitat adjacent to the Duncan River represents a unique ecosystem within a regulated river. Seldom do mature upland and riparian forests persist in a developed landscape, particularly one which is managed for hydroelectric operations (Utzig and Schmidt 2011b). In addition to the previously described habitats, there are patches of habitat within some of these categories that are unique. The riparian mixed shrub habitat near the north end of the Argenta Slough is dominated by red-osier dogwood (*Cornus stolonifera*) growing in open habitat, and distributed in a pattern unusual for that species, but more commonly found in the willow species (*Salix* sp.) (**Figure 10**). A song sparrow nest was found near the base of one of these shrubs and concealed by reed canarygrass (*Phalaris arundinacea*).

Figure 10: Red-Osier Dogwood near the Argenta Slough, in a vigorous shrub form.

Also in this area, Wood's rose (*Rosa pisocarpa*) was found growing in a shrubby form evenly distributed among other shrubs, rather than large thickets as it is more commonly found (Klinkenberg 2017). Wood's rose was found primarily in lowland areas near the mouth of the Duncan River.

Due to channel configuration, a large patch of mature riparian habitat was not sampled. Within this patch were substantial patches of multi-storied open habitat which, due to the vegetation and complex structure of the habitat, likely support high densities of breeding songbirds. However, direct sampling was not possible.

4.2.2 Effects, Challenges, and Opportunities

The Lower Duncan River study area is well studied, and valuable wildlife habitats have been identified previously (Poole and Park 2003, 2003, Herbison 2011, Polzin, M.L., B. Herbison and S.B. Rood 2015, Zimmer et al. 2016, Wright et al. 2017). The mapping and habitat categories presented in this report build on previous, comprehensive vegetation mapping completed under DDMMON-8 #1 (Polzin, M.L., B. Herbison and S.B. Rood 2015, Polzin and Rood 2017).

The habitat categories are effective for identifying the different habitat types encountered at the scale mapped. Within some of the mapped polygons habitat will undoubtedly be mischaracterized, but in general, we feel most habitat features are well-represented at the scale mapped (1:2,000). Habitat features which were unique, but not distinguishable from more common features on air photos could be missed, but we believe we surveyed sufficient diversity of habitat to capture the most important habitat types in the study area.

Ground-truthing the 1 ha plots was an effective way to identify unique habitat from air photos, as well as provide a good understanding of the structure of habitat and distribution of wildlife species using the area. The 1 ha squares were large enough to capture variability, but still offered enough detail to accurately map the habitat. However, it was not possible to effectively survey all habitats because water levels hindered our ability to access some islands of habitat. Timing the field season between the easing of freshet and high reservoir levels was less critical in the Lower Duncan study area, but high flows and wide channels still limited our ability to range freely into all areas. From data compiled during field visits we counted the number of bird species detected in each habitat type and have added that as a field to the attribute table. While this is cannot be considered a ‘habitat suitability index’ or a measure of diversity, it can be used to inform the relative value of each of the mapped habitat types for bird species. From this, it becomes obvious that mature riparian forest supports the greatest diversity of songbirds (29 bird species – Appendix D). The habitat attributes which make it attractive likely appeal to mammals and amphibians, but few observations of these taxa were recorded.

4.3 MQ-3 How could reservoir operations under Alternative S (73) affect wildlife habitat in the wetland at the north end of Duncan Reservoir?

Changes in the Upper Duncan Reservoir study area hydrograph as a result of Alt-S73 are subtle. **Figure 11** shows pre and post Alt-S73 reservoir operations, with the red lines of the hydrograph representing the flood regime associated with annual operations since the implementation of Alt-S73. The most substantive changes are a tightening of the timing of operation of the reservoir, with late winter drafting and spring and summer filling being more predictable annually. Prior to Alt-S73 operations were less consistent, but most notably, filling in the spring was shifted to the left on the figure, inundating drawdown zone habitat earlier than under Alt-S73. These differences are minor relative to the overall impact of the reservoir operation, and we expect that impacts of reservoir operations remain largely unchanged for wildlife and wildlife habitat.

The operations affect habitat in two ways:

1) Long term impacts to habitat through changes to vegetation as a result of operational regimes.
2) Seasonal inundation of habitat in the reservoir drawdown zone.

These two impacts are discussed separately below in relation to orthophotos which we used to compare changes to habitats between the years 2009 and 2015.

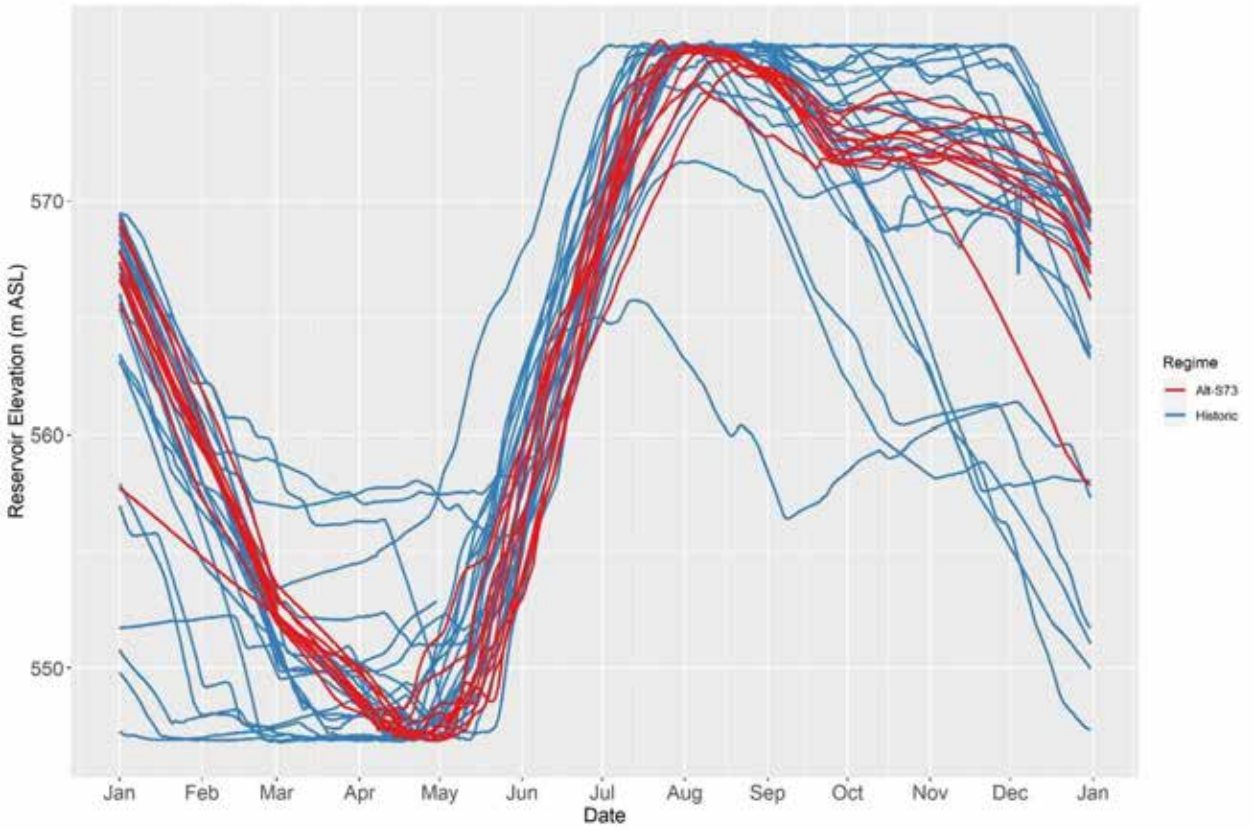


Figure 11: Upper Duncan Reservoir Study Area Hydrograph. Red is reservoir operations under Alt-S73, blue shows historic operation of the Duncan Reservoir. Reservoir elevation is on the y axis, and date is on the x axis.

4.3.1 Impacts to Habitat Distribution and Suitability

Orthographic photographs of the Duncan Reservoir prior to the implementation of Alt-S73 were not available so we were not able to assess distribution of habitat prior to 2008 when this alternative operating regime was implemented; however, changes to vegetation were monitored in detail under a separate study (DDMMON-8, module 2), which provides detail on how vegetation communities have been responding. DDMMON-8-2 was initiated in 2009 and was specifically designed to determine whether and how Alt-S73 influenced riparian habitat (BC Hydro 2008). Annual reports from DDMMON-8-2 are available from each year of implementation of this module (2009, 2012, and 2015; the 2018 report is in preparation and has not been reviewed here).

The 2015 report indicated a general decline in vegetated cover of the drawdown zone since 2009 (Polzin and Rood 2016). Most changes detected under DDMMON-8-2 occurred in herbaceous communities at the lowest vegetated margins of the reservoir (569 m). There is some congruence of habitat classes between this project and DDMMON-8-2 and because of this we can estimate the mapped habitat classes in which the greatest changes have occurred among years. The habitat category ‘equisetum’ matches with the DDMMON-8-2 vegetation class ‘H1’ (horsetail) which saw only a modest decrease in vegetated area between the years examined (Polzin and Rood 2016). Other graminoid and forb classes saw more substantial decreases in area, but we did not map at this scale, and these vegetative features are scattered

throughout the broader habitat classes. There was little evidence of a trend in changes to tree and shrub composition over the duration of the DDMMON-8-2 study, with only minor changes in the area covered by woody vegetation (Polzin and Rood 2016).

Alt-S73 could have played a part in the observed trends, however the two years compared had drastically different weather patterns, which could also have impacted vegetation (Polzin and Rood 2016). In 2012, higher than normal precipitation caused surcharging of several of the dams in the Columbia watershed, including the Duncan (CBA 2013, Polzin and Rood 2015). The moist, cool conditions in 2012 contrast with the warm and dry summer of 2015, which could have contributed to the observed differences in vegetative growth (Polzin and Rood 2016). In addition, the authors of that report suggest increased woody debris near the full pool mark (unrelated to Alt-S73) may have negatively impacted shrub recruitment (Polzin and Rood 2016).

Examining the results of DDMMON-8-2 and the relatively small change to the hydrograph, it is unlikely that wildlife will be impacted in any way that is biologically notable. Most changes to vegetation occur at lower elevations (where habitat classes equisetum and scouring rush dominate) and exist as an increase in unvegetated surfaces. Our observations from the field visit did not detect high use in these low elevation habitats, and therefore we feel it is unlikely there is a quantifiable impact to habitat as a result of Alt-S73. Higher elevation habitats would benefit from Alt-S73 as the annual predictability of reservoir operations will influence where flood tolerant vegetation can grow (De Jager et al. 2012). Refer to **Section 4.1** for more detailed description of habitat distribution in the Upper Duncan Reservoir.

The reduction in area of the equisetum habitat may have an impact on Canada geese, ungulates, and bears by reducing opportunities for grazing during spring green-up (Poole and Park 2003, Ministry of Environment 2004). However, the changes in abundance of vegetation is small so it is unlikely to have a population level effect on those species. Limited use of equisetum habitat by songbirds during the breeding season was noted, although Savannah Sparrow and Lincoln's Sparrow were detected, likely using these areas for foraging. In other reservoirs, reducing low elevation grassland habitat available for nesting in the drawdown zone could be a positive change for nesting birds because it reduces the likelihood of nest failure due to reservoir operations (Cooper Beauchesne and Associates 2018b). This risk is found to be small in the Duncan Reservoir, as noted in the following section. The increased shrub and tree recruitment in higher elevation shrubby polygons which are not inundated before mid-July will benefit species using that habitat with little detrimental effect from reservoir operations.

Given the scale of changes detected, we therefore conclude that Alt-S73 has not altered the regional significance of habitats for wildlife in the Upper Duncan drawdown zone.

4.3.2 The Impact of Habitat Inundation

Annual reservoir filling and drafting results in seasonal inundation of habitat. The timing of inundation of the drawdown zone habitats, and how these habitats are distributed among elevations is key to understanding seasonal reservoir-mediated impacts to wildlife. The timing of inundation can be prior to, or during the time when wildlife could be utilizing the Upper Duncan wetland area. The historic reservoir operations data, Digital Elevation Model (DEM), habitat mapping, and observations made during ground-truthing was used to inform the severity and distribution of impacts to wildlife, particularly for birds and amphibians. **Appendix E** presents the probability of inundation of each, mapped habitat type in the Upper Duncan Reservoir. These probabilities are calculated from annual reservoir levels since the implementation of Alt-S73.

Under Alt-S73, reservoir operations typically begin to inundate the low elevation terrestrial vegetated drawdown zone habitat by mid to late June (**Table 3**). However, these lower elevation habitats that are initially inundated are composed of equisetum and scouring rush, which have low value for nesting birds (see **Appendix D**) and probably have greatest value for grazing ungulates and bears – especially in early spring prior to inundation. In these regards, wildlife impacts from flooding of equisetum and scouring rush habitat types is low (**Appendix E**).

Higher in the drawdown zone, the shrubby habitats are more likely to support nesting birds, and this is where impacts from reservoir operations are more likely to be seen. However, these higher value habitats are unlikely to become flooded under the Alt-S73 regime until late June to mid-July. By late June most bird species nesting in drawdown zone habitat would have fledged young by this time, given successful nesting. Habitats which are most suitable for nesting birds (early-seral riparian forest, riparian shrub and sparse shrub) have a low probability of being inundated until late July (see **Figure 14** of Appendix E). Historically, inundation from operations prior to the implementation of Alt-S73 likely saw these habitats inundated slightly earlier (by approximately 1 week). However, the greatest difference operations between historic and Alt-S73 is that the reservoir is now more consistent in the timing of filling among years (**Figure 11**).

Pond-breeding amphibians are also unlikely to experience substantial impacts from inundation at a local population level from inundation. For the majority of their life history requirements, the primary wetland in the Upper Duncan Reservoir provides suitable habitat for these species and has a low probability of inundation until late summer. However, for Columbia spotted frog, the drawdown of the reservoir through autumn and winter possibly creates an ecological trap for overwintering. Columbia spotted frog select ponds deep enough to remain ice free where they hibernate at the bottom beginning in late August-October (Bull 2005). This overwintering period coincides with drawdown of the Duncan reservoir, which has the potential to dewater these habitats, thereby potentially increasing mortality.

From the distribution of habitat in the Upper Duncan Reservoir and the timing of reservoir filling, we can conclude that for the few bird species which may nest in the open habitats there will be some impacts during the breeding season. For species selecting the shrubby habitats at higher elevations of the reservoir impacts from flooding will be mitigated by the late date which the reservoir reaches these elevations. With this information, we feel that habitat improvement in the upper elevations of the Upper Duncan Reservoir could benefit breeding birds. Improving the diversity and density of shrubs above 575 m ASL could improve the nesting potential of low shrub and riparian shrub habitats with minimal impacts of flooding on nest success under Alt-S73.

4.3.3 Effects, Challenges, and Opportunities

The decrease in herbaceous cover observed under DDMMMON-8-2 was not reflected as changes to wildlife habitat in this study. This is not surprising as we were not examining habitat at the same, fine scale as the surveys which were conducted to examine vegetative changes over time. In the context of this study, landscape ecology is the study of biotic and abiotic factors which, together with their spatial distribution, constitute habitat (Turner 1989). Vegetation is an important component, but on its own does not define the value of habitat (McCoy and Bell 1991).

Changes wrought from a modified reservoir operation regime can affect the biotic component of habitat; in this case by modification of the distribution and abundance of vegetative growth (Polzin and Rood 2016, M.T. Miller et al. 2018). But the changes reported under DDMMON-8-2 occur at such a fine scale it is unlikely they represent changes to habitat quality for wildlife.

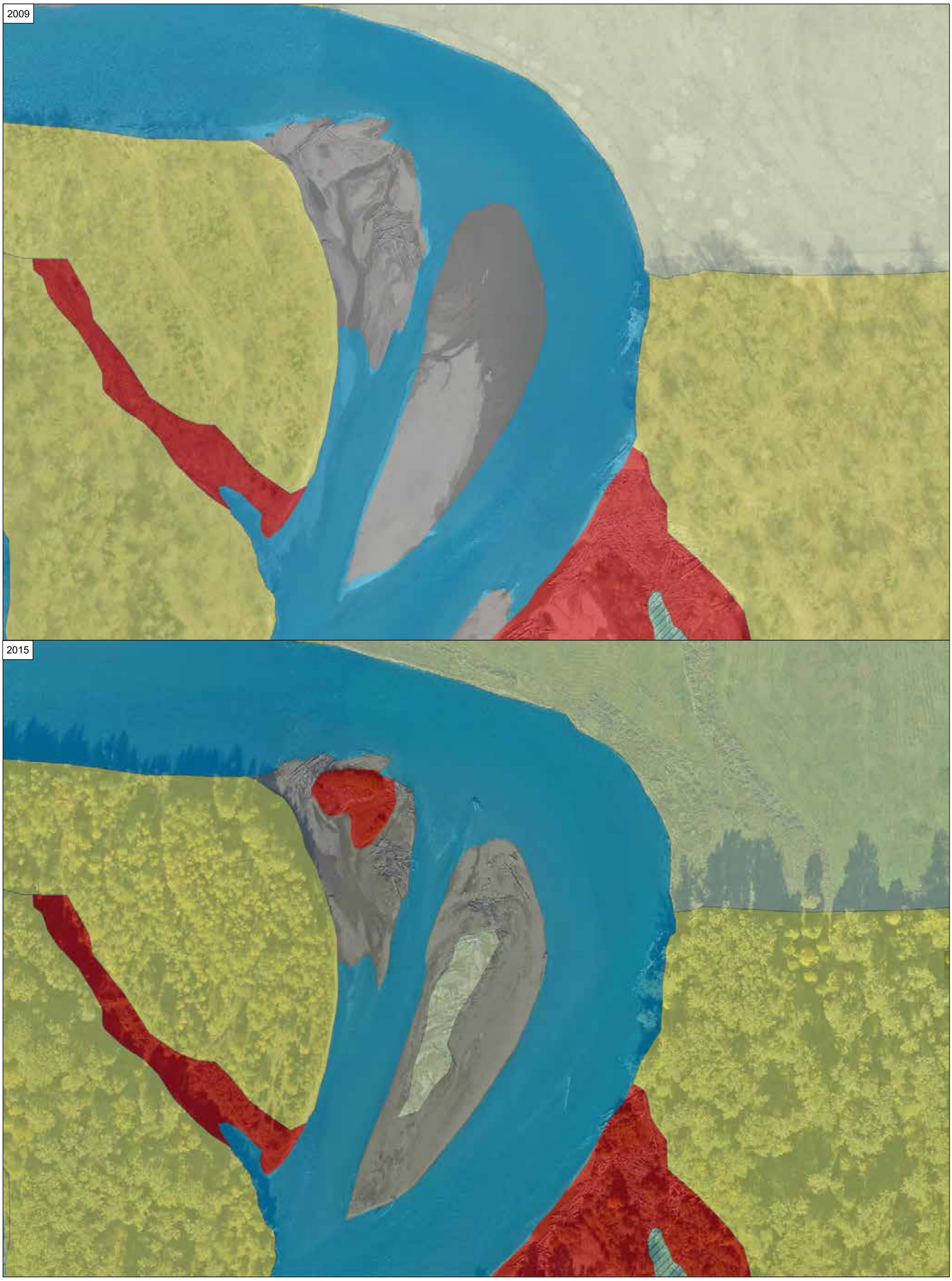
It is likely that after 10 years of operation under Alt-S73, habitat composition is not likely to continue to change substantially from what it consists of presently. The rate of change reported in DDMMON-8-2 suggests any changes to habitat over the previous 10 years have been minor, leading us to conclude that Alt-S73 has had minimal impact to wetland habitat in the Upper Duncan Reservoir study area.

Information on amphibians in the Upper Duncan study area is limited, and this represents a gap in knowledge, particularly for Columbia spotted frog, which may experience an impact on overwintering habitat during reservoir drafting in the fall and winter.

4.4 MQ-4 How could reservoir operations under Alternative S (73) affect wildlife habitat along the Lower Duncan River?

Habitat changes in the Lower Duncan River study area between 2009 and 2015 are characterized by erosion of banks along the river channel, redistribution of woody debris, and successional changes to early seral categoriesas evidenced by orthophoto comparison.

Channel erosion caused little change in the area of affected habitat types. Most habitat affected by this erosion was along the high-velocity outside corners of the main channel (**Figure 12**), and the alluvial fans of both Cooper and Hamill Creeks. On **Figure 12** below, the outside of this curve erosion caused minor loss of mature riparian forest. On the unvegetated island new herbaceous growth can be seen on the 2015 ortho photos.



Legend

- gravel
- low herbaceous
- mature riparian forest
- riparian mixed shrub
- riverine wetland
- wetted channel

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

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DDMMON-14 Duncan River
Watershed Wild life Monitoring Report
Duncan River, BC

Channel erosion and vegetation development on the mainsteam of the Duncan River.

989446-01	Production Date: Dec 19, 2018	Figure 12

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Hamill Creek in particular showed substantial changes during the study period, a result of an erosional event during 2013 (Polzin, M.L., B. Herbison and S.B. Rood 2015). Channel erosion impacted open herbaceous and to a small extent mature riparian forest habitat, where less than 1 ha of habitat was converted to wetted channel during the study period.

Under the current study, there was a substantial increase in the area of mapped woody debris over time, but distribution changed very little. In 2009, 7 ha of habitat was mapped as woody debris, but this increased to 10 ha in 2015. This increase could likely be attributed to the erosional event of 2013.

By far the most evident changes to habitat came as a reduction in unvegetated habitat (16-ha reduction), which was a result from vegetative growth largely in the riparian mixed shrub category (6.6-ha increase), shrub savannah (3-ha increase in area). Low herbaceous vegetation was also reduced in area and was most often converted to riparian mixed shrub habitat according to the mapping (**Figure 13**).

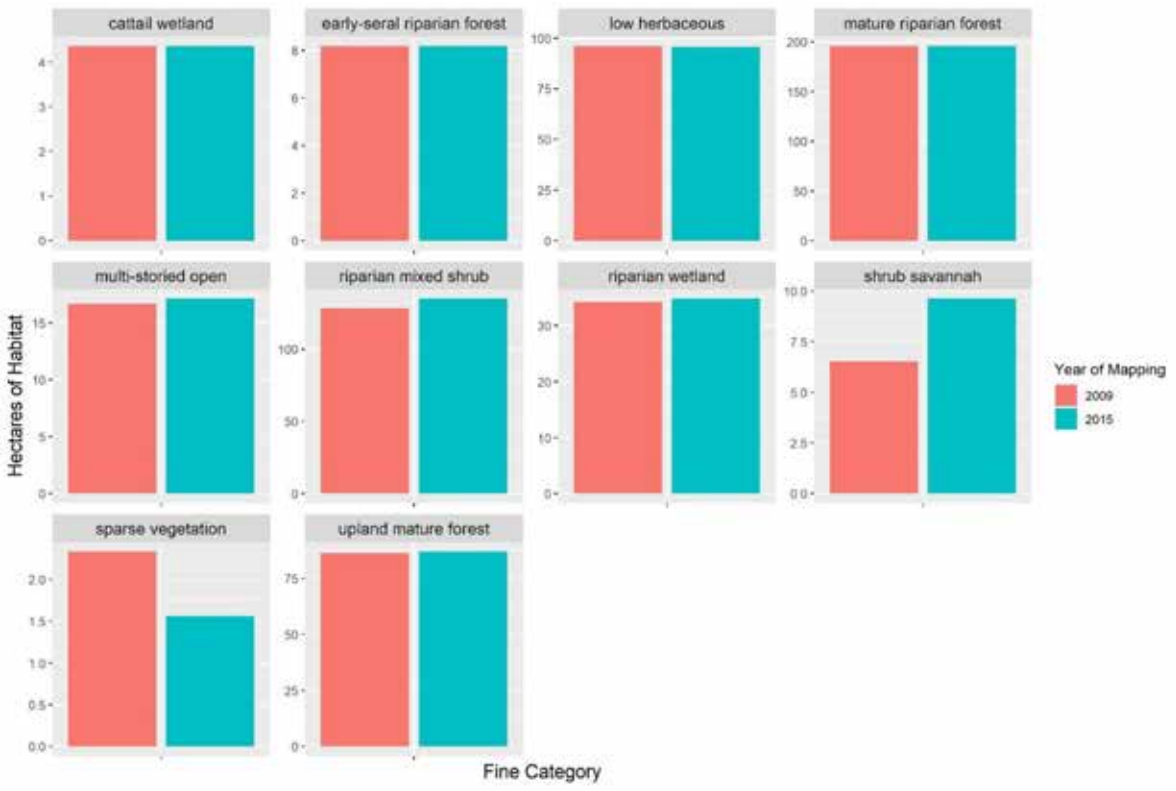

Figure 13: Change in mapped habitat between 2009 and 2015 for the Lower Duncan River. Little change was detected, but some classes saw substantial change in area between the two years mapped. Generally, there was an increase in vegetated habitat, particularly from younger seral categories to older. The largest changes were the conversion of sparse vegetation to shrub savannah, and an increase in riparian mixed shrub habitat.

The remainder of the difference between unvegetated and vegetated habitat during the study period came from differences in water flow levels between the orthophotos, with wetted channel comprising a 7.7 ha increase in area from 2009 to 2015.

As expected, mature riparian forest, upland old-growth forest habitat categories did not change over time appreciably.

Answering this MQ in the general context of 'wildlife habitat', we can conclude that there is no evidence that modified flows as a result of Alt-S73 have had a negative effect on wildlife values in the Lower Duncan River. Rather, during the monitoring period there was an increase in both riparian mixed shrub and shrub savannah habitat categories. This trend directly increased the available habitat for the 22 bird species (**Appendix D**) found in these habitats. Elk use was also noted in these habitats, and likely benefit from this trend. However, whether advancing seral stage in riparian habitat is directly correlated with Alt-S73, or a combined result of operational changes plus stochastic, inter-annual events cannot be known with absolute confidence.

4.4.1 Effects, Challenges, and Opportunities

Changes to vegetation were quantified by comparing the two sets of orthophotos for the Lower Duncan River study area. However, as with any ortho photo rectification, no two sets of ortho photos will align exactly with another so there will always be some error in the accuracy of habitat delineation. In addition to the rectification error, imagery captured in the two years showed slightly different levels of flow out of the Duncan Reservoir. For this reason, wetted channel and unvegetated mapping likely is inconsistent between the two years. However, some of the changes observed to riparian habitats were considerable and could not be attributed to any orthophoto-related bias. As such, we believe this monitoring approach was successful at detecting changes to riparian habitats on the Lower Duncan River.

One limitation of this analysis was that unvegetated habitat categories (fine material and gravel) were lumped together and assessed as 'unvegetated' due to the difficulty of differentiating between those two habitats in orthophotos. Fine, silty material is more likely to be deposited in low velocity sections of the river, while gravel can withstand higher erosional forces (Church 2006). However, because bird species detected using these unvegetated areas during ground-truthing have little dependence on one over the other, we elected to lump them together.

We feel our ability to discern habitat differences between 2009 and 2015 resulted in an accurate assessment of changes to riverine vegetation growth and distribution between the two years examined. The successional changes observed indicate recruitment has been occurring over those intervening years (**Appendix A: Figure A7 – A9**). However, interpreting the causation of these results to be solely in the context of Alt-S73 must be done with caution for three reasons:

1) Flow changes in the Lower Duncan River from Alt-S73 are relatively minor and the effects from this change may not be discernable at the scale mapped.
2) Unregulated inputs from the Lardeau River may overwhelm any minor flow adjustments of Alt-S73.
3) Erosion and succession (changes) are both natural processes that will be observed despite changes to river regulation – its difficult to disentangle which changes are caused by Alt-S73.

In the Lower Duncan study area there is only one small patch of riverine habitat which occurs upstream of the Lardeau River, and as a result is only influenced by flows from the Duncan tailrace. In this area, vegetative changes are obvious and succession from unvegetated to low herbaceous, and low herbaceous to riparian mixed shrub is likely as a result of Alt-S73. Indeed, these changes are evident throughout the reach and, while caution should be exercised in interpreting these results, it is likely hydrological changes as a result of Alt-S73 are the underlying mechanism.

In the Lower Duncan study area impacts from BC Hydro operations from the Duncan reservoir are limited. With unregulated input from the Lardeau River, and other pressures on the landscape (forestry and rural development) there is little opportunity for BC Hydro to make substantial changes to operations which would improve habitat or reduce impacts to wildlife along this corridor. Much of the most valuable habitat is already protected with large parcels of Nature Conservancy Lands throughout this section of river.

4.5 Species at Risk

Excluding fish, there are 23 vertebrate species with a provincial status of ‘Blue’ or ‘Red’ listed as occurring in the Kootenay Lake Forest District (**Appendix C**). Habitat mapped within the study area of this project likely provides requisite habitat for different life stages of 18 of these species (**Appendix C**).

No species at risk were detected in the Upper or Lower Duncan study areas during field studies in support of this report. **Appendix C** lists all species at risk possibly occurring in habitat found in both study areas. This is not a comprehensive list of all species in the Forest District but includes those likely to be using drawdown zone habitat. The Argenta Slough in the Lower Duncan River study area has the highest likelihood of providing habitat for species at risk and at least three species have been detected here. Western Painted Turtle – Intermountain Rocky Mountain population have been detected in small numbers, but reproductive success is unknown (Herbison 2011). American Bittern has also reportedly nested in this wetland, but little information was reported on this (Wright et al. 2017), and Eared Grebe (*Podiceps nigricollis*) have been observed in the open water habitat of the slough. Upland habitat adjacent to the slough may provide suitable bat roosts nearby the suitable foraging habitat of the slough for the three bat species listed (M. Kellner, pers. comm.). The invasive amphibian, American bullfrog (*Lithobates pipiens*), has not been detected in the slough but has occurred at the south end of Kootenay Lake, in the Creston Valley Wildlife Management Area and is known to be expanding its range.

Woodland Caribou (*Rangifer tarandus caribou*) (Southern Mountain ecotype) are not thought to use drawdown zone environments currently, but it is probable they traveled through this area historically between summer and winter ranges (R. Serrouya, pers. comm.). Two herds occur in the region, both considered part of the Central Selkirks herd (Wittmer et al. 2005). The Duncan herd currently consists of 7 animals, and ranges upstream of the Duncan reservoir, while the Nakusp herd ranges to the west of the reservoir and numbers 77 animals. Recent census data (2017) indicates all observations were made a considerable distance to the west of the Duncan Reservoir, along Silvercup Ridge (De Groot 2017).

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PHOTOGRAPHS

Photo 1 Early seral riparian forest

Photo 2 Mature riparian forest

Photo 3 Multi-storied open

Photo 4 Mature upland forest

Photo 5 Mature upland forest

Photo 6 Equisetum

Photo 7 Mixed grass

Photo 8 Low herbaceous

Photo 9 Scouring rush

Photo 10 Sparse vegetation (foreground)

Photo 11 Low shrub

Photo 12 Riparian mixed shrub

Photo 13 Low shrub

Photo 14 Riparian shrub (shrub habitat in background)

Photo 15 Coarse rock (foreground)

Photo 16 Fine mineral/gravel (fine material deposited along river edge and island)

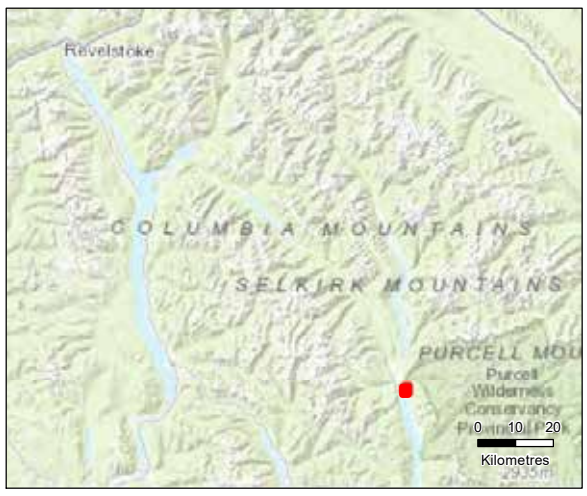
Photo 17 Woody debris

Photo 18 Wetted channel

Photo 19 Riverine wetland (shallow water and associated vegetation in foreground).

Photo 20 Cattail wetland with open water in foreground.

APPENDIX A
Habitat Mapping Figures



Legend

- cattail wetland
- coarse rock
- early-seral riparian forest
- fine mineral
- gravel
- low herbaceous
- mature riparian forest
- multi-storied open
- riparian mixed shrub
- riverine wetland
- shrub savannah
- sparse vegetation
- wetted channel
- woody debris

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Aerial Image: ESRI World Aerial
- Inset Basemap: ESRI World Topographic Map

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DDMMON-14 Duncan River
Watershed Wildlife Monitoring Report
Duncan River, BC

Habitat Figure-
Lower Duncan Argenta

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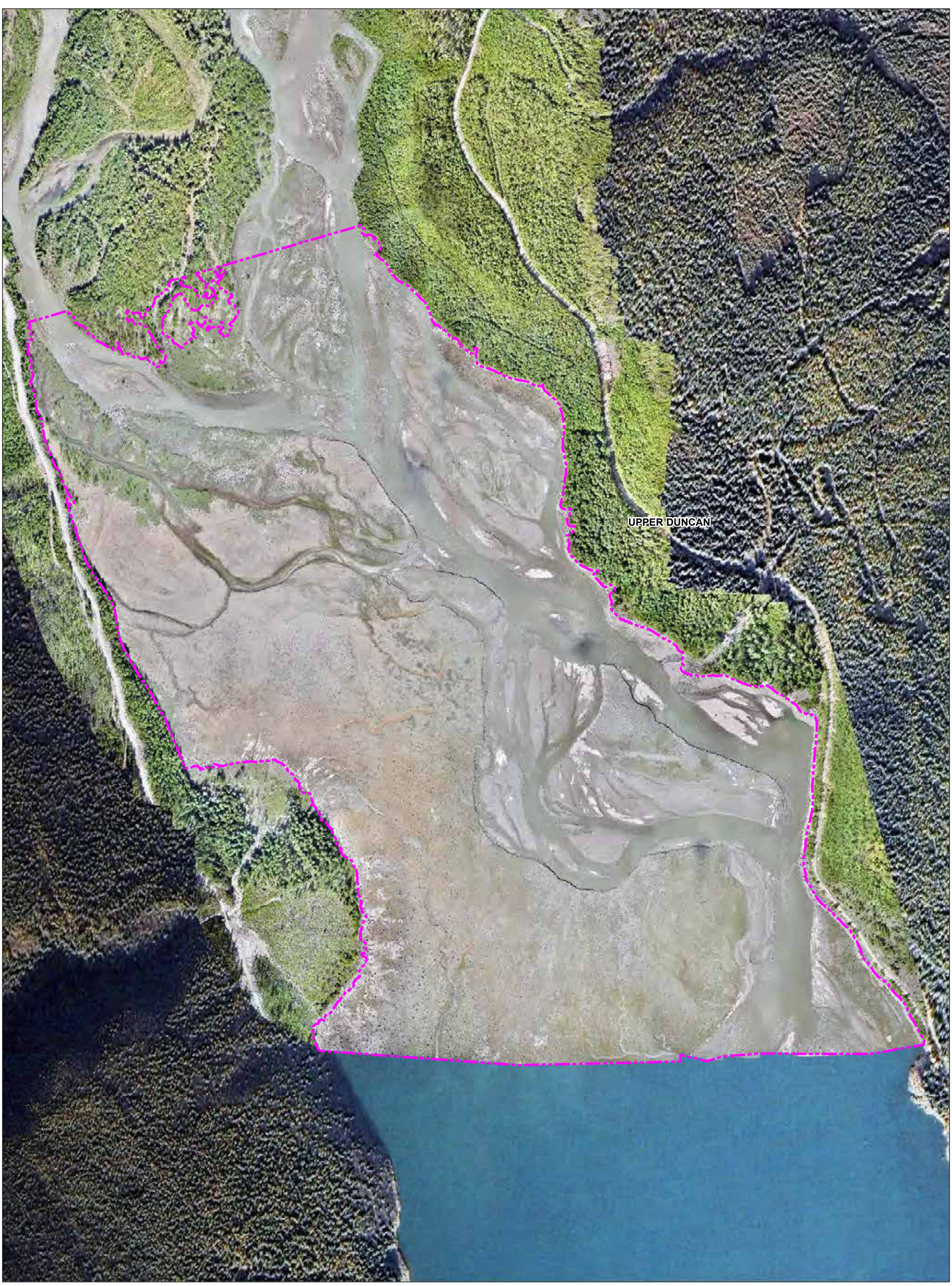

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Study Area

Sources

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Notes

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DDMMON-14 Duncan River
Watershed Wildlife Monitoring Report
Duncan River, BC

DDMMON-14 Study Areas (Upper Duncan)

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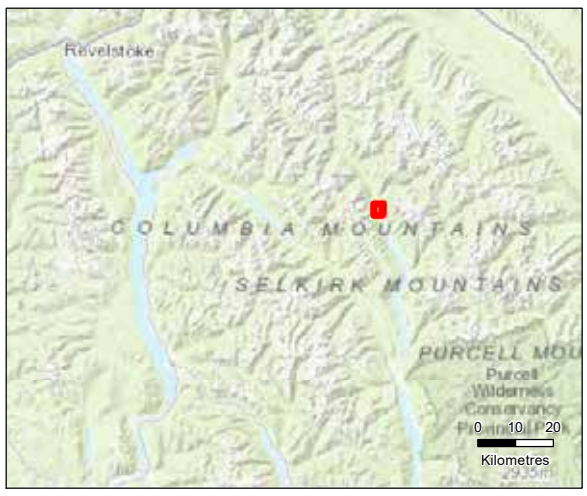

Legend

- coarse rock
- early-seral riparian forest
- equisetum
- fine mineral
- low shrub
- riparian shrub
- riverine wetland
- scouring rush
- shrub savannah
- sparse vegetation
- wetted channel
- woody debris

Notes

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- Inset Basemap: ESRI World Topographic Map

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DDMMON-14 Duncan River
Watershed Wildlife Monitoring Report
Duncan River, BC

Habitat Figure-
Upper Duncan Reservoir

989446-01	Production Date: Oct 16, 2019	Appendix A2

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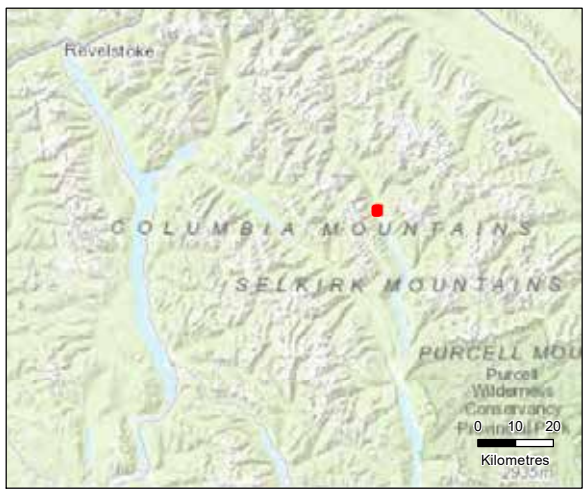

EARLY-SERAL RIPARIAN FOREST
WOODY DEBRIS
RIPARIAN SHRUB
COARSE ROCK
SPARSE VEGETATION
SCOURING RUSH
FINE MINERAL
LOW SHRUB
WETTED CHANNEL
EQUISETUM
SHRUB SAVANNAH
MIXED GRASS
RIVERINE WETLAND

Legend

- coarse rock
- early-seral riparian forest
- equisetum
- fine mineral
- low shrub
- riparian shrub
- riverine wetland
- scouring rush
- shrub savannah
- sparse vegetation
- wetted channel
- woody debris

Notes

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Sources

- Inset Basemap: ESRI World Topographic Map

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Metres

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Page Size: 11" x 17"

DDMMON-14 Duncan River
Watershed Wildlife Monitoring Report
Duncan River, BC

Habitat Figure-
Upper Duncan Reservoir - Habitat

989446-01	Production Date: Oct 16, 2019	Appendix A3

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Hemmera An Ausenco Company

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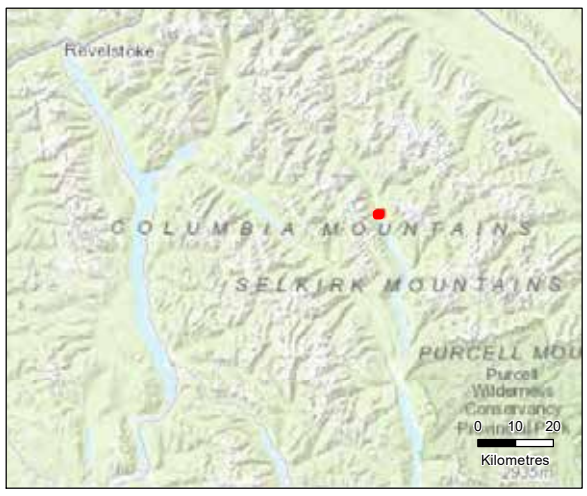

FINE MINERAL
FINE MINERAL
FINE MINERAL
FINE MINERAL
RIVERINE WETLAND
COARSE ROCK
FINE MINERAL
EQUISETUM
EQUISETUM
WETTED CHANNEL
FINE MINERAL
FINE MINERAL
FINE MINERAL
FINE MINERAL
FINE MINERAL
FINE MINERAL
SPARSE VEGETATION
EQUISETUM
SPARSE VEGETATION
EQUISETUM
WETTED CHANNEL
EQUISETUM

Legend

- coarse rock
- equisetum
- fine mineral
- riverine wetland
- scouring rush
- sparse vegetation
- wetted channel
- woody debris

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 11N

Page Size: 11" x 17"

DDMMON-14 Duncan River
Watershed Wildlife Monitoring Report
Duncan River, BC

Habitat Figure-
Upper Duncan Reservoir - Eqisetum

989446-01	Production Date: Oct 16, 2019	Appendix A4

Nupqu DEVELOPMENT CORPORATION

Hemmera An Ausenco Company

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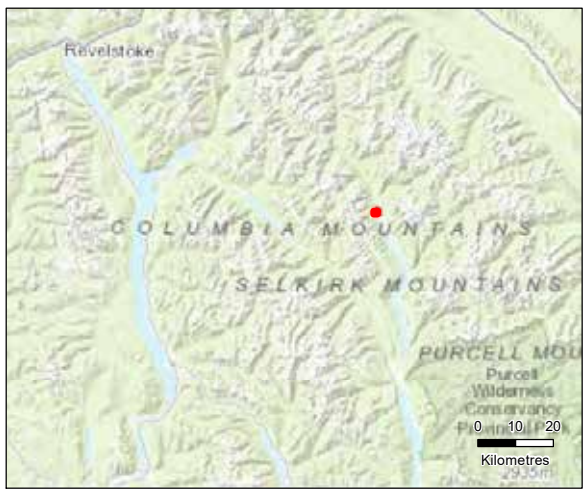

MIXED GRASS
SHRUB SAVANNAH
SCOURING RUSH
NG RUSH
EQUISETUM
FINE MINERAL
SCOURING RUSH
EQUISETUM
SCOURING RUSH
RIVERINE WETLAND
SCOURING RUSH
EQUISETUM
MIXED GRASS
MIXED GRASS
EQUISETUM
MIXED GRASS
RIVERINE WETLAND
EQUISETUM
EQUISETUM
SPARSE VEGETATION
MIXED GRASS
WOODY DEBRIS
SPARSE VEGETATION
WETTED CHANNEL
EQUISETUM
WOODY DEBRIS
MIXED GRASS

Legend

- equisetum
- fine mineral
- riparian shrub
- riverine wetland
- scouring rush
- shrub savannah
- sparse vegetation
- wetted channel
- woody debris

Notes

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Sources

- Inset Basemap: ESRI World Topographic Map

N

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0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 11N

Page Size: 11" x 17"

DDMMON-14 Duncan River
Watershed Wildlife Monitoring Report
Duncan River, BC

Habitat Figure-
Upper Duncan Reservoir - Wetland

989446-01	Production Date: Oct 16, 2019	Appendix A5

Nupqu DEVELOPMENT CORPORATION

Hemmera An Ausenco Company

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EXTENT 4

EXTENT 3

EXTENT 1

EXTENT 2

Legend

- cattail wetland
- coarse rock
- developed
- early-seral riparian forest
- fine mineral
- gravel
- low herbaceous
- mature riparian forest
- mature upland forest
- multi-storied open
- riparian mixed shrub
- riparian shrub
- riverine wetland
- shrub savannah
- sparse vegetation
- wetted channel
- woody debris

Notes

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Sources

- Aerial Image: ESRI World Aerial
- Inset Basemap: ESRI World Topographic Map

N

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Metres

NAD 1983 UTM Zone 11N

Page Size: 11" x 17"

DDMMON-14 Duncan River
Watershed Wildlife Monitoring Report
Duncan River, BC

Habitat Figure -
Lower Duncan Habitat Change Overview

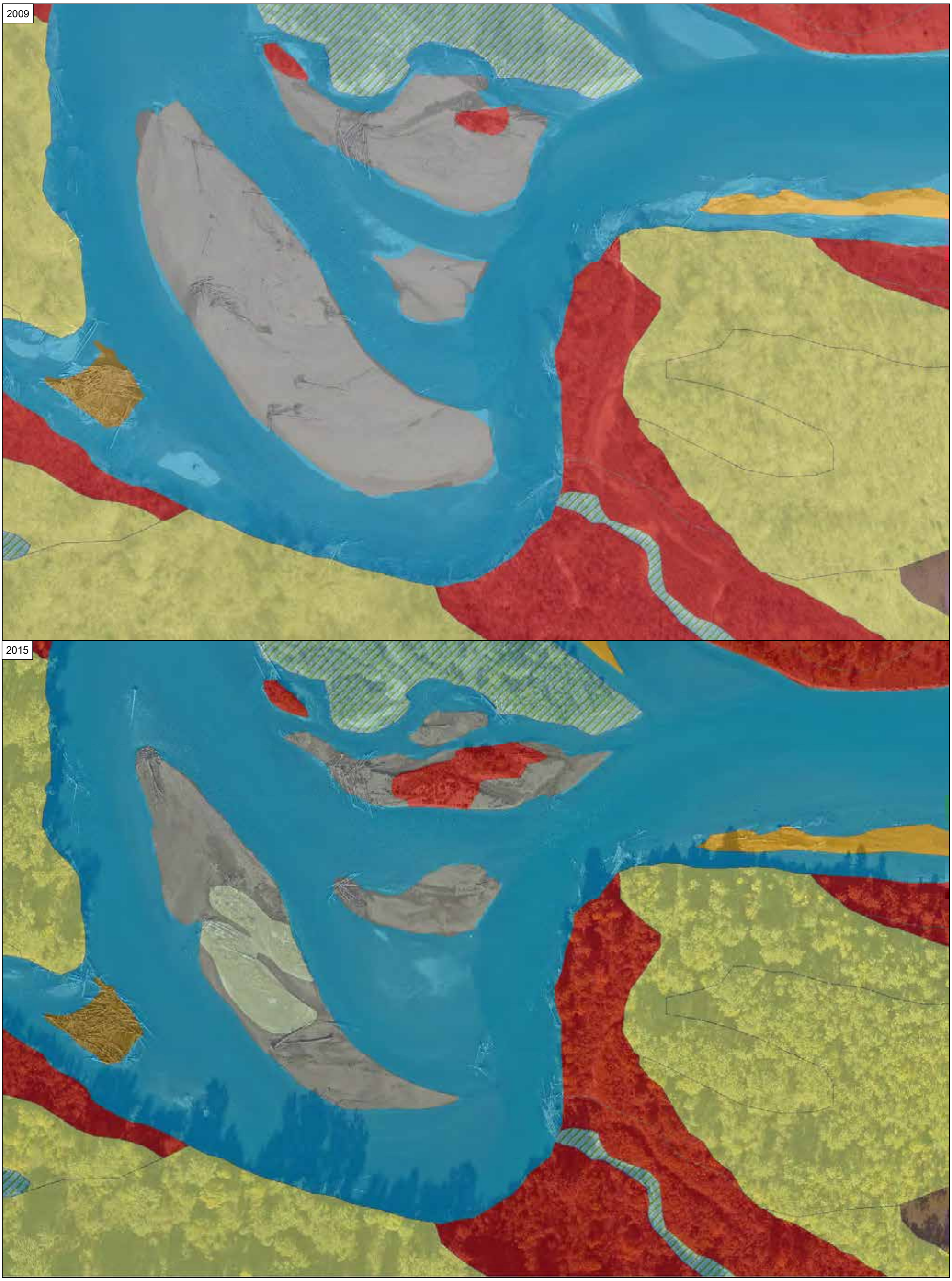
989446-01	Production Date: Oct 16, 2019	Appendix A6

Nupqu DEVELOPMENT CORPORATION

Hemmera An Ausenco Company

Path: S:\Geomatics\Projects\989446\01\mxd\AppA6_989446-01_HabitatLD_191016.mxd

2009



2015

Legend

- fine mineral
- gravel
- mature riparian forest
- multi-storied open
- riparian mixed shrub
- riverine wetland
- wetted channel
- woody debris

Notes

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Sources

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Metres

NAD 1983 UTM Zone 11N

Page Size: 11" x 17"

DDMMON-14 Duncan River
Watershed Wild life Monitoring Report
Duncan River, BC

Habitat Figure -
Lower Duncan Habitat Change - Extent 2

989446-01	Production Date: Oct 16, 2019	Appendix A7

Nupqu DEVELOPMENT CORPORATION

Hemmera An Ausenco Company

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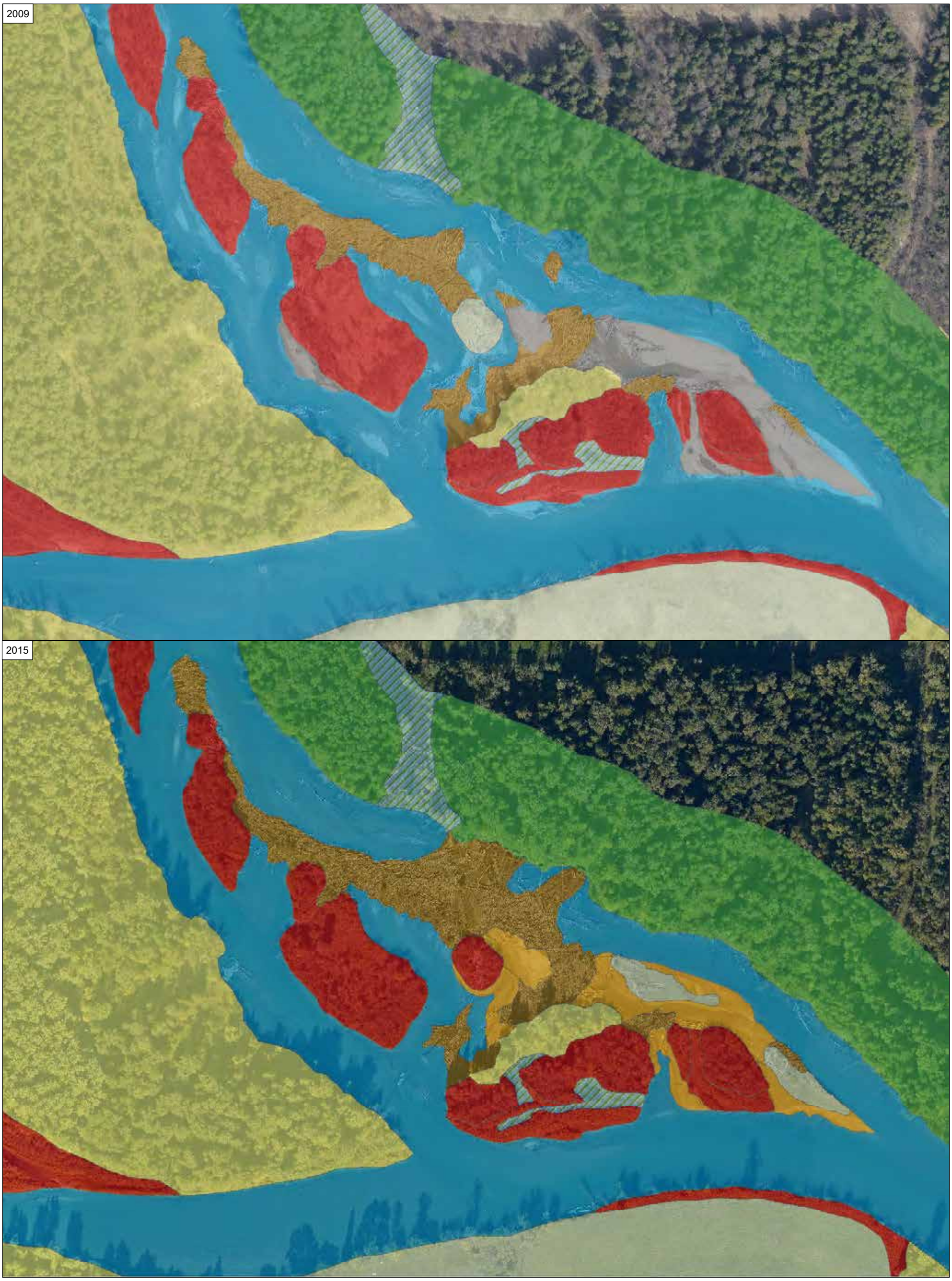
2009



2015

Legend

- gravel
- low herbaceous
- mature riparian forest
- mature upland forest
- riparian mixed shrub
- riverine wetland
- wetted channel
- woody debris

Notes

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Sources

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Metres

NAD 1983 UTM Zone 11N

Page Size: 11" x 17"

DDMMON-14 Duncan River
Watershed Wild life Monitoring Report
Duncan River, BC

Habitat Figure -
Lower Duncan Habitat Change - Extent 3

989446-01	Production Date: Oct 16, 2019	Appendix A8

Nupqu DEVELOPMENT CORPORATION

Hemmera An Ausenco Company

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Legend

- gravel
- low herbaceous
- mature riparian forest
- mature upland forest
- riparian mixed shrub
- riverine wetland
- sparse vegetation
- wetted channel
- woody debris

Notes

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Sources

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Metres

NAD 1983 UTM Zone 11N

Page Size: 11" x 17"

DDMMON-14 Duncan River
Watershed Wild life Monitoring Report
Duncan River, BC

Habitat Figure -
Lower Duncan Habitat Change - Extent 4

989446-01	Production Date: Oct 16, 2019	Appendix A9

Nupqu DEVELOPMENT CORPORATION

Hemmera An Ausenco Company

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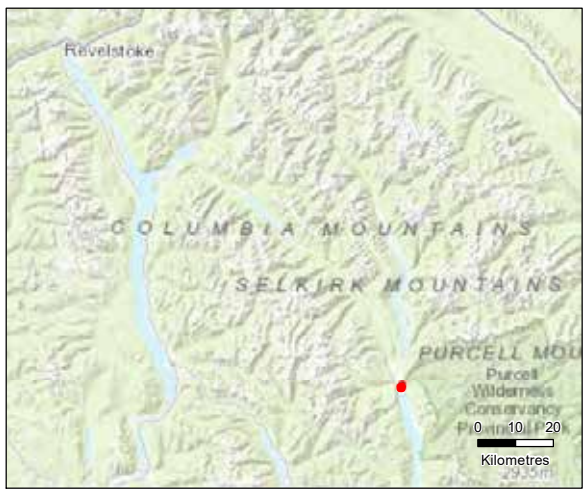

Legend

- gravel
- low herbaceous
- mature riparian forest
- riparian mixed shrub
- riverine wetland
- wetted channel

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 11N

Page Size: 11" x 17"

DDMMON-14 Duncan River
Watershed Wildlife Monitoring Report
Duncan River, BC

Habitat Figure-
Lower Duncan-2015

989446-01	Production Date: Oct 16, 2019	Appendix A10

Nupqu DEVELOPMENT CORPORATION

Hemmera
An Ausenco Company

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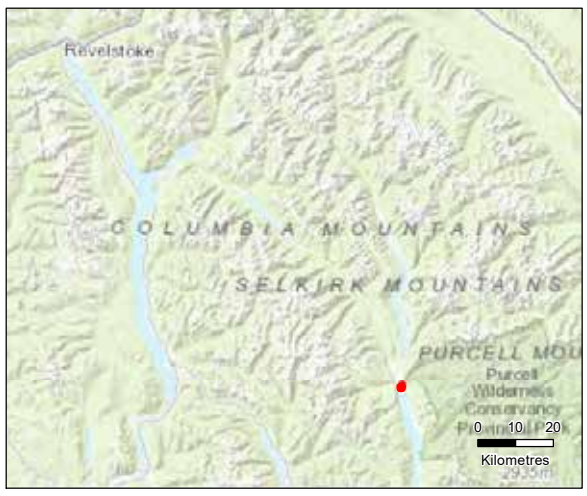

Legend

- gravel
- low herbaceous
- mature riparian forest
- riparian mixed shrub
- riverine wetland
- wetted channel

Notes

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Sources

- Inset Basemap: ESRI World Topographic Map

N

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0 10 20 30 40 50

Metres

NAD 1983 UTM Zone 11N

Page Size: 11" x 17"

DDMMON-14 Duncan River
Watershed Wildlife Monitoring Report
Duncan River, BC

Habitat Figure-
Lower Duncan-2009

989446-01	Production Date: Oct 16, 2019	Appendix A11

Nupqu DEVELOPMENT CORPORATION

Hemmera An Ausenco Company

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APPENDIX B
Timeline of DDMMON-14 activities

Table B-1. Timeline of DDMMON-14 activities

Year	Progress
2009	• Year 1 of DDMMON-14
2011	• Year 2 DDMMON-14
2012	• Reporting on original Management Questions
2014	• Project delayed
2017	• DDMMON-14 Terms of Reference Revised. Management Questions were rewritten.
2018	• Habitat mapping and field surveys to identify vegetation categories and wildlife values of the upper and Lower Duncan study areas.

APPENDIX C

Species at risk known or suspected of occurring in the DDMMON-14 study areas

Table C-1. Species at risk known or suspected of occurring the DDMMON-14 study areas

Common Name	Scientific name	SARA Schedule 1 status	Provincial status	COSEWIC status	Likelihood of occurrence	Habitat Categories
Great Blue Heron	*Ardea herodias herodias*	-	Blue	-	high	riverine wetland, wetted channel, cattail wetland, mature upland forest
American Bittern	*Botaurus lentiginosus*	-	Blue	-	moderate	cattail wetland
Eared Grebe	*Podiceps nigricollis*	-	Blue	-	high	cattail wetland
Painted Turtle	*Chrysemys picta*	Threatened	Blue	Special Concern	high	riverine wetland, cattail wetland
Olive-sided Flycatcher	*Contopus cooperi*	Threatened	Blue	Special Concern	high	mature upland forest
Yellow-breasted Chat	*Icteria virens*	Endangered	Red	Endangered	low	riparian mixed shrub
Northern Leopard Frog	*Lithobates pipiens*	Endangered	Red	Endangered	low	cattail wetland, riverine wetland
Grizzly bear	*Ursus arctos*	Special Concern	Blue	Special Concern	high	all
Bobolink	*Dolichonyx oryzivorus*	Threatened	Blue	Threatened	moderate	developed areas
Rusty Blackbird	*Euphagus carolinus*	Special Concern	Blue	Special Concern	low	riverine wetland
Wolverine	*Gulo gulo*	Special Concern	Blue	Special Concern	low	mature upland forest
Barn Swallow	*Hirundo rustica*	Threatened	Blue	Threatened	high	developed
Western Screech Owl	*Megascops kennicottii macfarlanei*	Threatened	Blue	Threatened	low	mature riparian forest
Lewis's Woodpecker	*Melanerpes lewis*	Threatened	Blue	Threatened	low	low herbaceous
Western Toad	*Anaxyrus boreas*	Special Concern	Blue	Special Concern	high	all
Townsend’s Big-eared Bat	*Corynorhinus townsendii*	-	Blue	Endangered	moderate	mature upland forest, developed
Northern Myotis	*Myotis septentrionalis*	Endangered	Blue	-	low	mature upland forest, mature riparian forest, developed
Little brown myotis	*Myotis lucifugus lucifugus*	Endangered	Yellow	Endangered	high	mature upland forest, mature riparian forest, developed

Table C-2. Qualitative habitat ratings for assessing suitability for species at risk, as per (Wright et al. 2017)

Likelihood of occurrence	Definition
Low	Known to occur in the dkl, habitat suitability in the study areas is sub-optimal or limited.
Moderate	Known to occur in the study areas, habitat suitability is sub-optimal, or limited.
High	Known to occur, or highly suitable habitat exists.

APPENDIX D

Wildlife species detected during ground-truthing, June 2018

Table D-1. Wildlife species detected during ground-truthing, June 2018.

Habitat Category	Species Detected	Latin Name	Study Area
cattail wetland	Canada Goose	*Branta canadensis*	Aves
	Common Yellowthroat	*Geothlypis trichas*	Aves
	Red-winged Blackbird	*Agelaius phoeniceus*	Aves
	Song Sparrow	*Melospiza melodia*	Aves
	Yellow Warbler	*Setophaga petechia*	Aves
equisetum	American Robin	*Turdus migratorius*	Aves
	Lincoln's Sparrow	*Melospiza lincolnii*	Aves
	Mountain Bluebird	*Sialia currucoides*	Aves
	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	Aves
	Savannah Sparrow	*Passerculus sandwichensis*	Aves
	Tree Swallow	*Tachycineta bicolor*	Aves
	Violet-green Swallow	*Tachycineta thalassina*	Aves
	Elk	*Cervus canadensis nelsoni*	Mammalia
	Western Toad	*Anaxyrus boreas*	Amphibia
fine mineral	Canada Goose	*Branta canadensis*	Aves
	Killdeer	*Charadrius vociferus*	Aves
	Spotted Sandpiper	*Actitis macularius*	Aves
	Western Toad	*Anaxyrus boreas*	Amphibia
gravel	Killdeer	*Charadrius vociferus*	Aves
low herbaceous	American Robin	*Turdus migratorius*	Aves
	Canada Goose	*Branta canadensis*	Aves
	Common Yellowthroat	*Geothlypis trichas*	Aves
	Killdeer	*Charadrius vociferus*	Aves
	Mallard	*Anas platyrhynchos*	Aves
	Song Sparrow	*Melospiza melodia*	Aves
	Spotted Sandpiper	*Actitis macularius*	Aves
	Western Meadowlark	*Sturnella neglecta*	Aves
	Yellow Warbler	*Setophaga petechia*	Aves
	Elk	*Cervus canadensis nelsoni*	Mammalia
low shrub	Chipping Sparrow	*Spizella passerina*	Aves
	Common Yellowthroat	*Geothlypis trichas*	Aves
	Lincoln's Sparrow	*Melospiza lincolnii*	Aves
	Savannah Sparrow	*Passerculus sandwichensis*	Aves
	Spotted Sandpiper	*Actitis macularius*	Aves
	Yellow Warbler	*Setophaga petechia*	Aves
	Elk	*Cervus canadensis nelsoni*	Mammalia

Habitat Category	Species Detected	Latin Name	Study Area
early seral riparian forest	Common Yellowthroat	*Geothlypis trichas*	Aves
	Yellow Warbler	*Setophaga petechia*	Aves
mature riparian forest	American Redstart	*Setophaga ruticilla*	Aves
	American Robin	*Turdus migratorius*	Aves
	Black-capped Chickadee	*Poecile atricapillus*	Aves
	Bullock's Oriole	*Icterus bullockii*	Aves
	Cedar Waxwing	*Bombycilla cedrorum*	Aves
	Common Yellowthroat	*Geothlypis trichas*	Aves
	Dark-eyed Junco	*Junco hyemalis*	Aves
	Eastern Kingbird	*Tyrannus*	Aves
	Golden-crowned Kinglet	*Regulus satrapa*	Aves
	Gray Catbird	*Dumetella carolinensis*	Aves
	Hammond's Flycatcher	*Empidonax hammondii*	Aves
	Least Flycatcher	*Empidonax minimus*	Aves
	MacGillivray's Warbler	*Oporornis tolmiei*	Aves
	Northern Flicker	*Colaptes auratus*	Aves
	Northern Waterthrush	*Parkesia noveboracensis*	Aves
	Pacific Wren	*Troglodytes pacificus*	Aves
	Pileated Woodpecker	*Dryocopus pileatus*	Aves
	Red-eyed Vireo	*Vireo olivaceus*	Aves
	Ruffed Grouse	*Bonasa umbellus*	Aves
	Song Sparrow	*Melospiza melodia*	Aves
	Swainson's Thrush	*Catharus ustulatus*	Aves
	Traill's Flycatcher	*Empidonax alnorum/traillii*	Aves
	Tree Swallow	*Tachycineta bicolor*	Aves
	Veery	*Catharus fuscescens*	Aves
	Violet-green Swallow	*Tachycineta thalassina*	Aves
	Warbling Vireo	*Vireo gilvus*	Aves
	Western Tanager	*Piranga ludoviciana*	Aves
	Western Wood-PeWee	*Contopus sordidulus*	Aves
	Yellow Warbler	*Setophaga petechia*	Aves
	Black bear	*Ursus americanus*	Mammalia
	Elk	*Cervus canadensis nelsoni*	Mammalia
riparian mixed shrub	American Redstart	*Setophaga ruticilla*	Aves
	American Robin	*Turdus migratorius*	Aves
	Black-capped Chickadee	*Poecile atricapillus*	Aves
	Cedar Waxwing	*Bombycilla cedrorum*	Aves
	Common Yellowthroat	*Geothlypis trichas*	Aves
	Least Flycatcher	*Empidonax minimus*	Aves
	MacGillivray's Warbler	*Oporornis tolmiei*	Aves

Habitat Category	Species Detected	Latin Name	Study Area
	Mallard	*Anas platyrhynchos*	Aves
	Northern Waterthrush	*Parkesia noveboracensis*	Aves
	Red-eyed Vireo	*Vireo olivaceus*	Aves
	Song Sparrow	*Melospiza melodia*	Aves
	Spotted Sandpiper	*Actitis macularius*	Aves
	Traill's Flycatcher	*Empidonax alnorum/traillii*	Aves
	Tree Swallow	*Tachycineta bicolor*	Aves
	Violet-green Swallow	*Tachycineta thalassina*	Aves
	Warbling Vireo	*Vireo gilvus*	Aves
	Wilson's Warbler	*Wilsonia pusilla*	Aves
	Yellow Warbler	*Setophaga petechia*	Aves
	Black bear	*Ursus americanus*	Mammalia
	Elk	*Cervus canadensis nelsoni*	Mammalia
riparian shrub	Common Yellowthroat	*Geothlypis trichas*	Aves
	Gray Catbird	*Dumetella carolinensis*	Aves
	Yellow Warbler	*Setophaga petechia*	Aves
riparian wetland	American Redstart	*Setophaga ruticilla*	Aves
	Canada Goose	*Branta canadensis*	Aves
	Cedar Waxwing	*Bombycilla cedrorum*	Aves
	Common Yellowthroat	*Geothlypis trichas*	Aves
	MacGillivray's Warbler	*Oporornis tolmiei*	Aves
	Mallard	*Anas platyrhynchos*	Aves
	Northern Waterthrush	*Parkesia noveboracensis*	Aves
	Red-eyed Vireo	*Vireo olivaceus*	Aves
	Red-winged Blackbird	*Agelaius phoeniceus*	Aves
	Song Sparrow	*Melospiza melodia*	Aves
	Sora	*Porzana carolina*	Aves
	Spotted Sandpiper	*Actitis macularius*	Aves
	Swainson's Thrush	*Catharus ustulatus*	Aves
	Violet-green Swallow	*Tachycineta thalassina*	Aves
	Yellow Warbler	*Setophaga petechia*	Aves
	Western Toad	*Anaxyrus boreas*	Amphibia
scouring rush	Canada Goose	*Branta canadensis*	Aves
	Lincoln's Sparrow	*Melospiza lincolnii*	Aves
	Savannah Sparrow	*Passerculus sandwichensis*	Aves
	Spotted Sandpiper	*Actitis macularius*	Aves
	Elk	*Cervus canadensis nelsoni*	Mammalia
	Western Toad	*Anaxyrus boreas*	Amphibia

Habitat Category	Species Detected	Latin Name	Study Area
shrub savannah	Cedar Waxwing	*Bombycilla cedrorum*	Aves
	Song Sparrow	*Melospiza melodia*	Aves
	Yellow Warbler	*Setophaga petechia*	Aves
	Elk	*Cervus canadensis nelsoni*	Mammalia
sparse vegetation	American Robin	*Turdus migratorius*	Aves
	Cedar Waxwing	*Bombycilla cedrorum*	Aves
	Yellow Warbler	*Setophaga petechia*	Aves
	Elk	*Cervus canadensis nelsoni*	Mammalia
mature upland forest	American Redstart	*Setophaga ruticilla*	Aves
	Cedar Waxwing	*Bombycilla cedrorum*	Aves
	Dark-eyed Junco	*Junco hyemalis*	Aves
	Golden-crowned Kinglet	*Regulus satrapa*	Aves
	Hammond's Flycatcher	*Empidonax hammondii*	Aves
	MacGillivray's Warbler	*Oporornis tolmiei*	Aves
	Magnolia Warbler	*Setophaga magnolia*	Aves
	Northern Waterthrush	*Parkesia noveboracensis*	Aves
	Pacific Wren	*Troglodytes pacificus*	Aves
	Pileated Woodpecker	*Dryocopus pileatus*	Aves
	Red-breasted Nuthatch	*Sitta canadensis*	Aves
	Red-eyed Vireo	*Vireo olivaceus*	Aves
	Swainson's Thrush	*Catharus ustulatus*	Aves
	Veery	*Catharus fuscescens*	Aves
	Warbling Vireo	*Vireo gilvus*	Aves
	Western Wood-Pewee	*Contopus sordidulus*	Aves
	Wilson's Warbler	*Wilsonia pusilla*	Aves
	Black bear	*Ursus americanus*	Mammalia
	Elk	*Cervus canadensis nelsoni*	Mammalia
wetted channel	Canada Goose	*Branta canadensis*	Aves
	Spotted Sandpiper	*Actitis macularius*	Aves

Table D-2. Wildlife species by study area, June 2018.

Common Name	Latin Name	Study Area Detected
Canada Goose	*Branta canadensis*	Both
Common Yellowthroat	*Geothlypis trichas*	Both
Red-winged Blackbird	*Agelaius phoeniceus*	Lower Duncan
Song Sparrow	*Melospiza melodia*	Lower Duncan
Yellow Warbler	*Setophaga petechia*	Both
American Robin	*Turdus migratorius*	Both
Lincoln's Sparrow	*Melospiza lincolnii*	Upper Duncan
Mountain Bluebird	*Sialia currucoides*	Upper Duncan
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	Lower Duncan
Savannah Sparrow	*Passerculus sandwichensis*	Both
Tree Swallow	*Tachycineta bicolor*	Lower Duncan
Violet-green Swallow	*Tachycineta thalassina*	Lower Duncan
Elk	*Cervus canadensis nelsoni*	Upper Duncan
Western Toad	*Anaxyrus boreas*	Upper Duncan
Killdeer	*Charadrius vociferus*	Lower Duncan
Spotted Sandpiper	*Actitis macularius*	Both
Mallard	*Anas platyrhynchos*	Both
Western Meadowlark	*Sturnella neglecta*	Lower Duncan
Chipping Sparrow	*Spizella passerina*	Upper Duncan
American Redstart	*Setophaga ruticilla*	Lower Duncan
Black-capped Chickadee	*Poecile atricapillus*	Lower Duncan
Bullock's Oriole	*Icterus bullockii*	Lower Duncan
Cedar Waxwing	*Bombycilla cedrorum*	Both
Dark-eyed Junco	*Junco hyemalis*	Lower Duncan
Eastern Kingbird	*Tyrannus tyrannus*	Lower Duncan
Golden-crowned Kinglet	*Regulus satrapa*	Lower Duncan
Gray Catbird	*Dumetella carolinensis*	Upper Duncan
Hammond's Flycatcher	*Empidonax hammondii*	Lower Duncan
Least Flycatcher	*Empidonax minimus*	Lower Duncan
MacGillivray's Warbler	*Oporornis tolmiei*	Lower Duncan
Northern Flicker	*Colaptes auratus*	Lower Duncan
Northern Waterthrush	*Parkesia noveboracensis*	Lower Duncan
Pacific Wren	*Troglodytes pacificus*	Both
Pileated Woodpecker	*Dryocopus pileatus*	Lower Duncan
Red-eyed Vireo	*Vireo olivaceus*	Lower Duncan
Ruffed Grouse	*Bonasa umbellus*	Lower Duncan
Swainson's Thrush	*Catharus ustulatus*	Both
Traill's Flycatcher	*Empidonax alnorum/traillii*	Upper Duncan
Veery	*Catharus fuscescens*	Lower Duncan

Common Name	Latin Name	Study Area Detected
Warbling Vireo	*Vireo gilvus*	Both
Western Tanager	*Piranga ludoviciana*	Lower Duncan
Western Wood-PeWee	*Contopus sordidulus*	Lower Duncan
Black bear	*Ursus Americanus*	Lower Duncan
Wilson's Warbler	*Wilsonia pusilla*	Lower Duncan
Sora	*Porzana carolina*	Lower Duncan
Magnolia Warbler	*Dendroica magnolia*	Lower Duncan
Red-breasted Nuthatch	*Sitta canadensis*	Lower Duncan

APPENDIX E

Probability of inundation of habitat by date for each habitat class in the Upper Duncan study area.

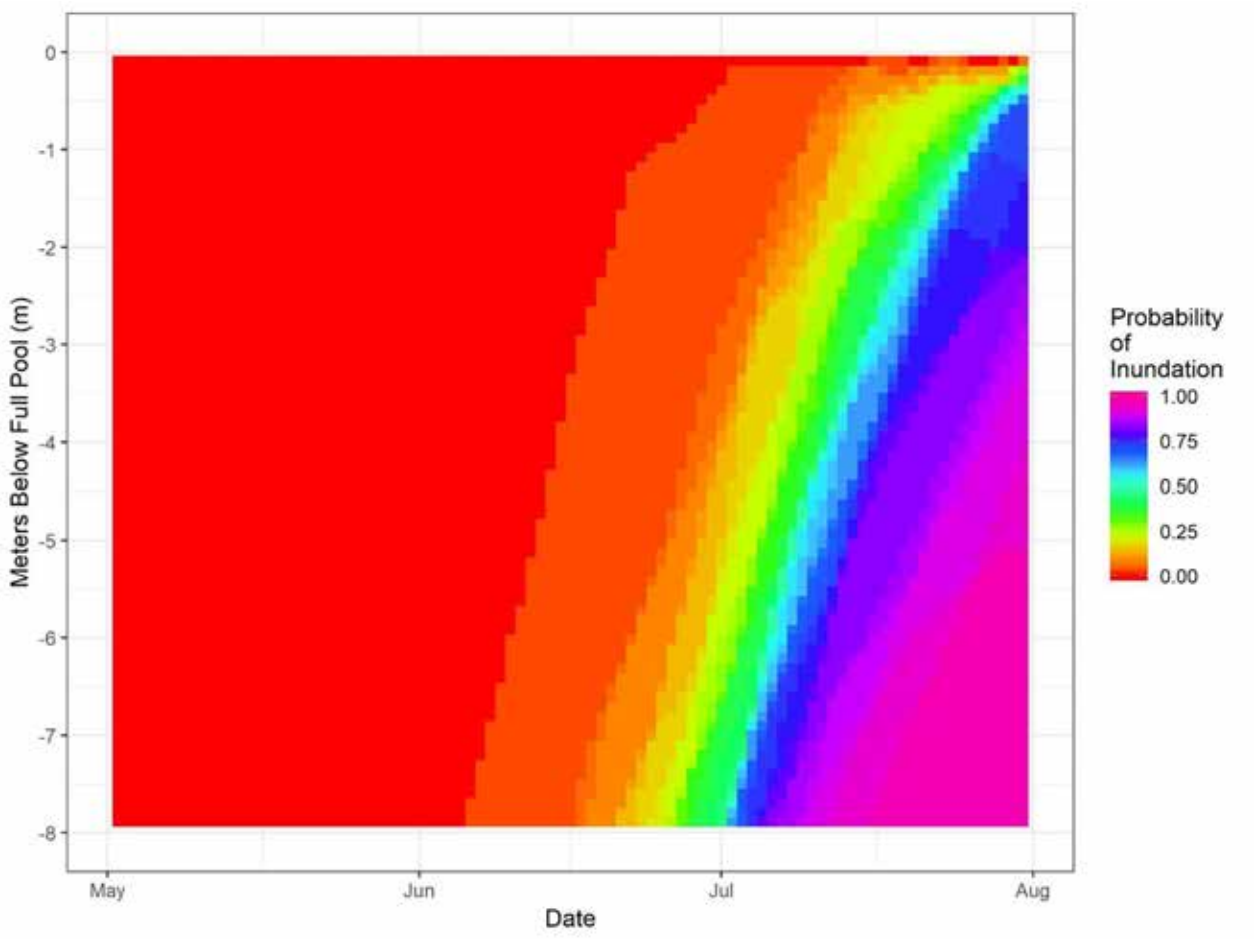

Figure 14: Probability of inundation by date of habitat mapped as 'Equisetum' in the Upper Duncan Reservoir.

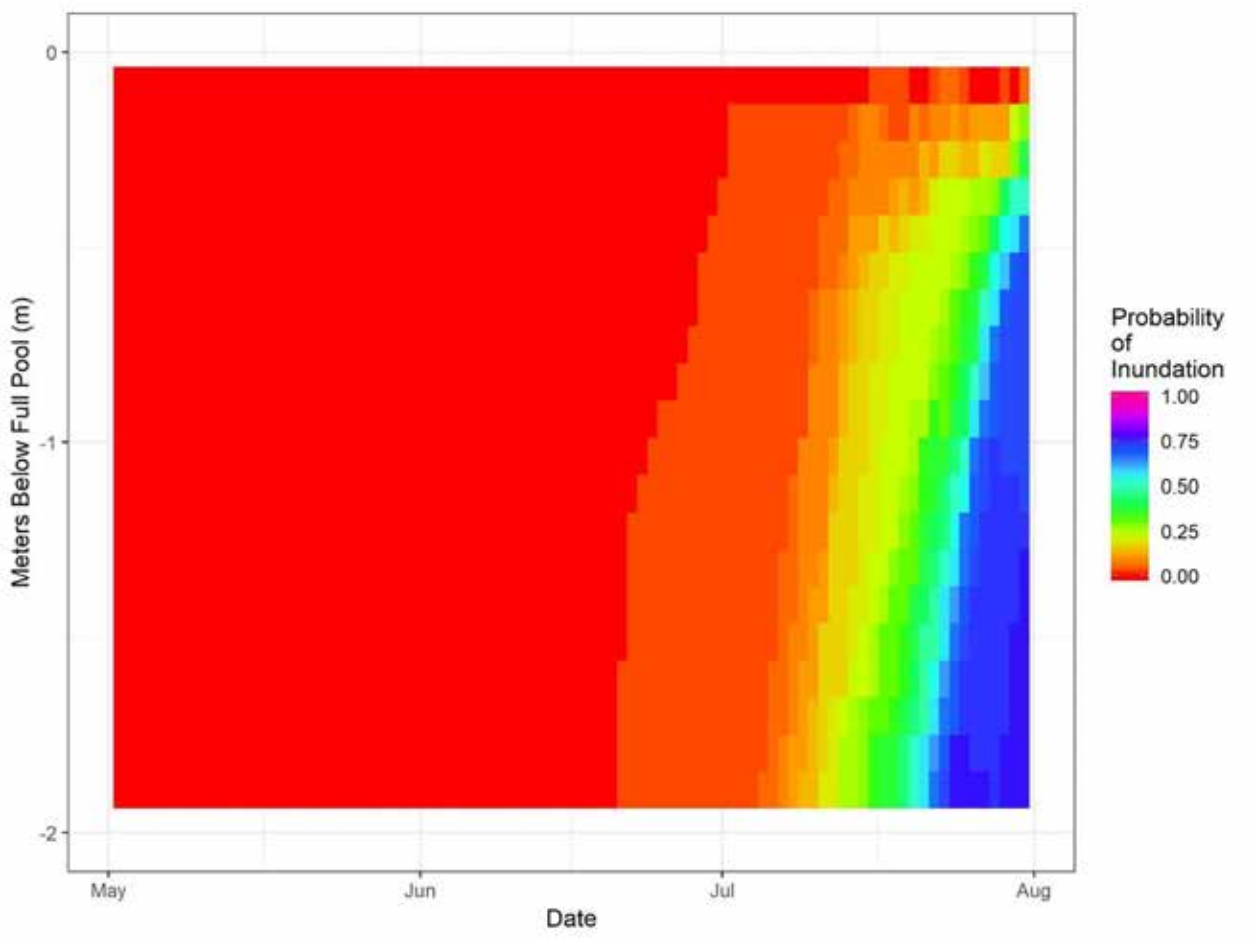

Figure 15: Probability of inundation by date of habitat mapped as 'Early-seral Riparian Forest', 'Low Shrub' and 'Riparian Shrub' in the Upper Duncan Reservoir.

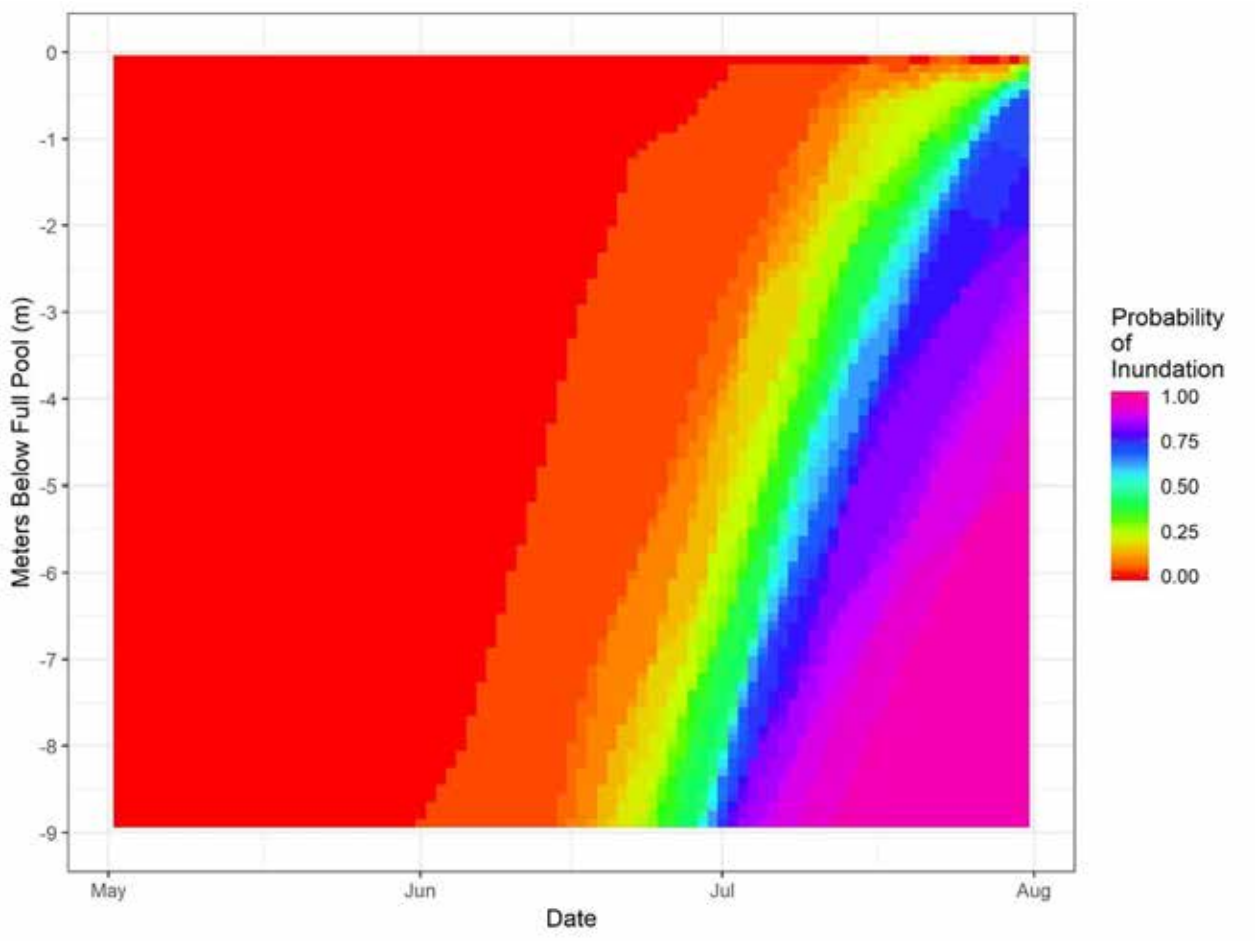

Figure 16: Probability of inundation by date of habitat mapped as 'Fine Material' in the Upper Duncan Reservoir.

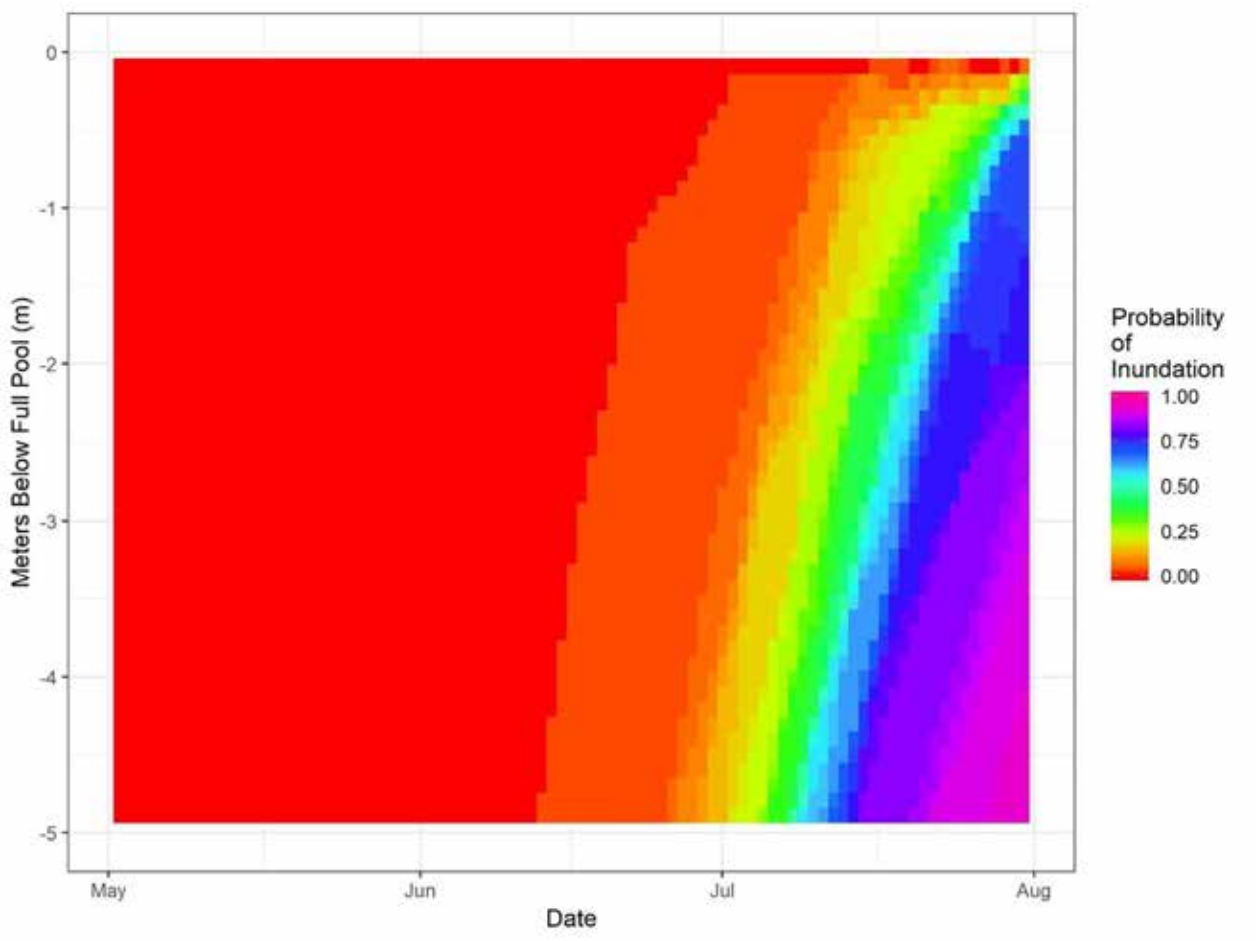

Figure 17: Probability of inundation by date of habitat mapped as 'Riverine Wetland' and 'Mixed Grass' in the Upper Duncan Reservoir.

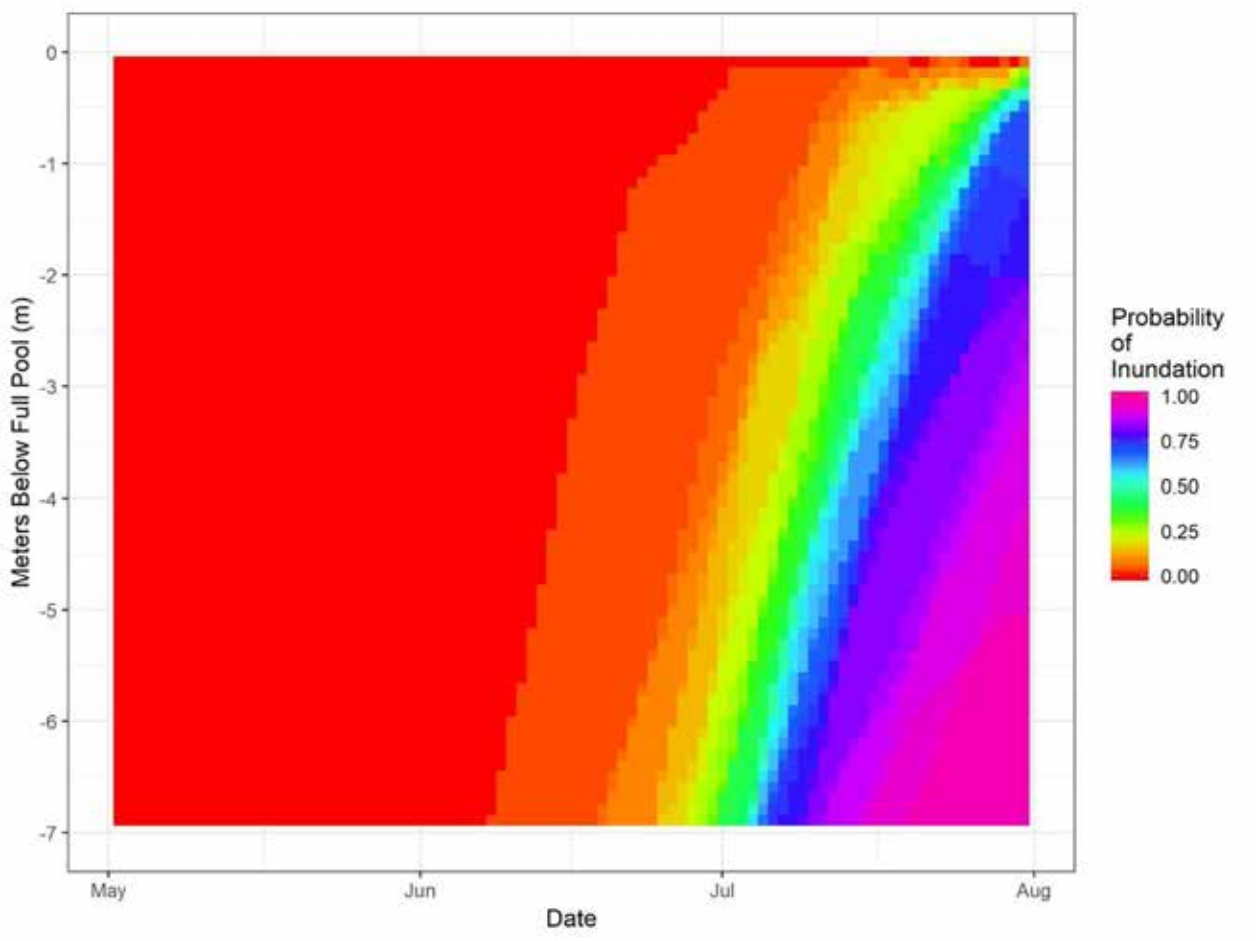

Figure 18: Probability of inundation by date of habitat mapped as 'Scouring Rush' in the Upper Duncan Reservoir.

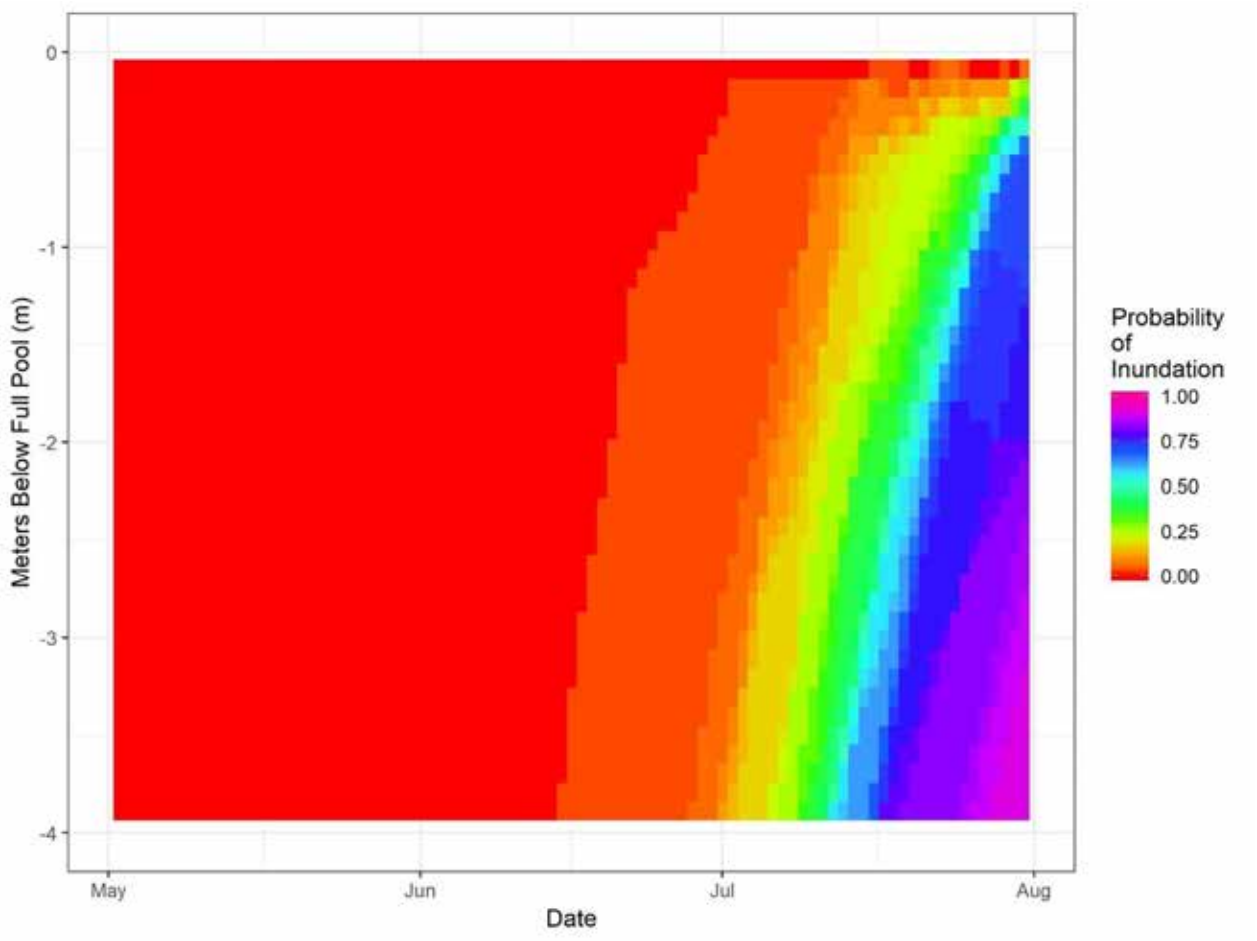

Figure 19: Probability of inundation by date of habitat mapped as 'Sparse Vegetation' in the Upper Duncan Reservoir.

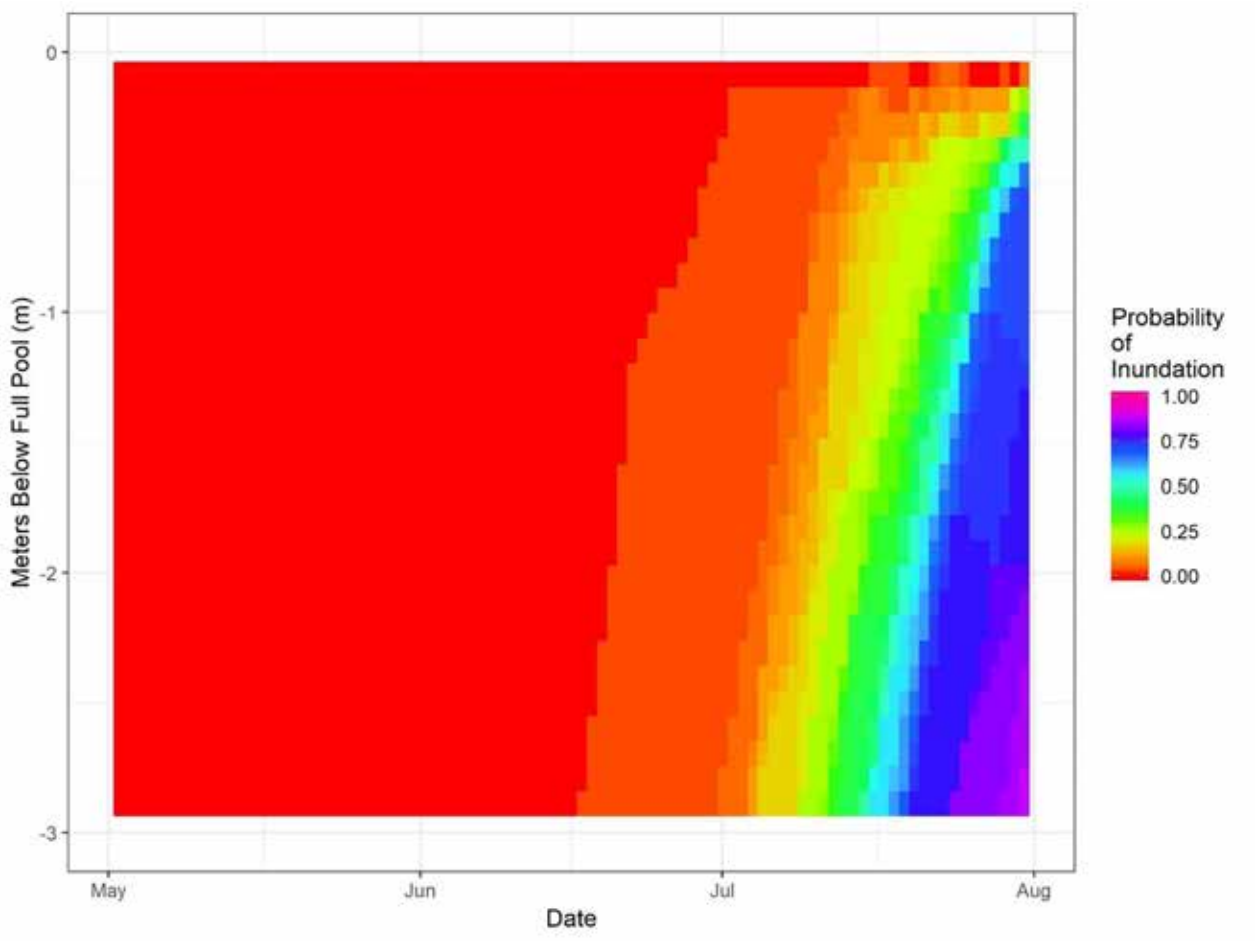

Figure 20: Probability of inundation by date of the primary wetland in the Upper Duncan Reservoir.