Columbia River Project Water Use Plan

Arrow Lakes Reservoir Operations Management Plan

Reference: CLBMON-58

Kinbasket Reservoir: Monitoring of Impacts on Amphibians and Reptiles from Mica Units 5 and 6 in Kinbasket Reservoir

Study Period: 2017

Okanagan Nation Alliance, Westbank, BC

and

LGL Limited environmental research associates
Sidney, BC

November 01, 2018

EA3533

KINBASKET RESERVOIR

Monitoring Program No. CLBMON-58

Monitoring the Effects of Mica Units 5 and 6 on Amphibians and Reptiles in Kinbasket Reservoir

Final Report 2017

Prepared for

BC Hydro Generation
Water Licence Requirements
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Cover photos:

From left to right: Western Toad (*Anaxyrus boreas)* adults in amplexus, Columbia Spotted Frog egg masses (*Rana luteiventris*), Western Toad tadpoles (*Anaxyrus boreas*); © Virgil C. Hawkes, LGL Limited; and juvenile Common Gartersnake (*Thamnophis sirtalis*) © Keegan Meyers, LGL Limited

EXECUTIVE SUMMARY

CLBMON-37 and CLBMON-58. This year marked the fourth (and final) year of CLBMON-58, which is designed to support and augment a larger 10-year amphibian and reptile life history and habitat use monitoring study in the drawdown zones (DDZs) of Kinbasket and Arrow Lakes Reservoirs (i.e., CLBMON-37). CLBMON-58 is specifically intended to assess and monitor for the potential predicted impacts of the installation and operation of Units 5 and 6, (and the consequential increase of 0.6 m in maximum reservoir elevation) at Mica Dam on amphibian and reptile populations in Kinbasket Reservoir. Ten management questions (MQ) are investigated in this study; MQ 1 through 9 are the original MQ's from CLBMON-37 and MQ 10 is a management question that is specific to CLBMON-58. The primary objective of the monitoring program is to provide information on how amphibian and reptile communities at the landscape scale are affected by long-term variations in water levels, and whether changes to the reservoir's operating regime may be required to maintain or enhance these communities or the habitats in which they occur. CLBMON-37 monitoring at both reservoirs occurs every second year; in 2017, monitoring only occurred in Kinbasket Reservoir for CLBMON-58.

Biodiversity in Kinbasket. In 2017, we documented the presence of three species of amphibian, Western Toad (*Anaxyrus boreas*), Columbia Spotted Frog (*Rana luteiventris*), and Long-toed Salamander (*Ambystoma macrodactylum*). Two species of reptile, Common Garter Snake (*Thamnophis sirtalis*) and Western Terrestrial Garter Snake (*Thamnophis elegans*) were also seen in the drawdown zone of Kinbasket Reservoir. Western Toad and Columbia Spotted Frog were the most commonly encountered species.

Habitat Distributions. Western Toad and Columbia Spotted Frog were typically detected in wetlands within wool-grass–Pennsylvania buttercup, buckbean-slender sedge, Kellogg's sedge or swamp-horsetail habitats. Pond characteristics varied by species with Columbia Spotted Frog using ponds situated at a higher elevation and with a higher abundance and percent cover of aquatic macrophytes compared to Western Toad. Western Toad breeds at elevations down to 743 m above sea level (ASL) in ponds that are typically devoid of vegetation or woody debris. It appears that the water physicochemical parameters measured (dissolved oxygen, conductivity, pH, temperature) do not affect distribution, occurrence, or development of either species.

Impact of Reservoir Operations on Habitat Availability. Most amphibian detections were distributed within an elevation band of 749 to 754 m ASL. Detection rates (as a proxy for abundance) calculated for Western Toad, Columbia Spotted Frog, and Common Garter Snake, were not correlated with reservoir elevations in 2017 (correlation coefficients = -0.16, -0.23, 0.04 respectively). However, as the reservoir fills, the amount of habitat available for use by amphibians and reptiles in the drawdown zone decreases, which precludes the use of the drawdown zone by amphibians and reptiles. There is a direct effect of increasing reservoir elevations on the seasonal distribution of amphibians and reptiles in the drawdown zone. Our current understanding is, that as the reservoir fills, amphibians and reptiles continue to occupy habitats in ponds that have yet to be inundated as well as at the leading edge of the reservoir until there is either no drawdown zone left (i.e., if reservoir reaches full pool), the reservoir begins to recede, or amphibians and reptiles return to their wintering habitats.

Do Reservoir Operations affect Productivity? Of the species that use the drawdown zone for breeding, Western Toad is most exposed to impacts as this species breeds at lower elevations, and those ponds are inundated earlier in the year. The continued presence of all life stages of Western Toad and Columbia Spotted Frog in the drawdown zone in consecutive years suggests that these species are not adversely affected by reservoir operations. However, the cumulative effects of reservoir operations associated with the predicted increase of 0.6 m are not known nor do we know how non-reservoir (non DDZ) populations have varied over the same time period.

The influence of reservoir operations on the availability of habitat in the DDZ was evident; as reservoir elevations increased, the amount of available habitat decreased. Similarly, the naïve occupancy rate (i.e., the proportion of wetlands and ponds occupied per site) also decreases as reservoir elevations increase. However, the addition of 0.6 m of water to the observed annual hydrographs made no discernible difference in habitat availability and had a similar no-net effect on site occupancy. In essence, it is the variable, yet predictable management of Kinbasket reservoir that influences both habitat availability and site occupancy and the predicted increase of 0.6 m does not appear to alter the timing or extent of that influence.

Advancing the hydrograph to fill earlier is predicted to have a negative impact to amphibians and reptiles if the change is large enough. Maintaining a timing of late summer for maximum reservoir level will ensure that amphibians and reptiles using the drawdown zone, particularly those in ponds >751 m ASL, will have enough time to forage for the winter and/or develop through to metamorphosis prior to inundation.

Common Garter Snakes at Valemount Peatlands. Radio telemetry was used in 2017 to determine how Common Garter Snake use habitats in the Valemount Peatland and other upland locations. Data obtained from radiotelemetry of tagged Common Garter Snakes indicate that there are core areas of use that correspond to locations associated with high densities of amphibians (e.g., Pond 12) and that all tagged snakes overwinter in upland habitat outside of the drawdown zone.

The final status of CLBMON-58 after Year 4 (2017) with respect to the management questions and management hypotheses is summarized below. As CLBMON-58 augments CLBMON-37, 10 years of data are used to answer most questions (1 through 9) and four years of data to answer question 10.

Management Question (MQ)	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
MQ1: Which species of amphibians and reptiles occur (utilize habitat) within the drawdown zone and where do they occur?	Yes	All expected species of amphibians and reptiles have been documented from each index (study) site in all years of study.	• eDNA sampling for Western Painted Turtle and Long-toed Salamanders	• The distribution of certain species (Long-toed Salamander) is likely greater than currently understood. • The presence of Western Painted Turtle and Pacific Chorus Frog in the drawdown zone of Kinbasket Reservoir was unexpected. The occurrence and distribution of these species may be different than the chance detections
MQ2: What is the abundance, diversity, and productivity (reproduction) of amphibians and reptiles utilizing the drawdown zone and how do these vary within and between years?	Yes	10 years of site occupancy and detection rate data. Productivity estimated for some species (Western Toad and Columbia Spotted Frog by way of egg mass surveys).	• None	• The abundance of certain species (Long-toed Salamander) is likely greater than currently understood. • Productivity is difficult to measure in reptiles and most species of amphibians and those measurements were not possible in the context of the current study.
MQ3: During what portion of their life history (e.g., breeding, foraging, and over-wintering) do amphibians and reptiles utilize the drawdown zone?	Yes	10 years of site occupancy data across multiple sites and seasons used to characterize seasonal and annual use of the drawdown zone by amphibians and reptiles.	• None	• While it is assumed that Columbia Spotted Frog overwinter in ponds in the drawdown zone, this has not been confirmed.
MQ4: Which habitats do amphibians and reptiles use in the drawdown zone and what are their characteristics (e.g., pond size, water depth, water quality, vegetation, elevation band)?	Yes (when based on the 2010 DEM)	10 years of macro and micro habitat data collection used to identify habitats used and their characteristics.	• Habitat mapping is required at a scale relevant to amphibians and reptiles • Review elevation distribution relative to 2014 LiDAR dataset.	• The digital elevation model used for CLBMON-58 is based on a non-LiDAR dataset. The available LiDAR DEM should be used to reassess the elevation at which amphibians and reptiles occur and to characterize the habitats they use.
MQ5: How do reservoir operations influence or impact amphibians and reptiles directly (e.g., desiccation, inundation, predation) or indirectly through habitat changes?	Yes, but see sources of uncertainty.	10 years of data collected on the occurrence and distribution of amphibians and reptiles in the drawdown zone	• Review reservoir effects on amphibian and reptile habitat relative to 2014 LiDAR dataset.	• Variable reservoir operations. Different types of operations affect habitat availability differently. • See previous comment regarding the use of the DEM based on the 2014 LiDAR dataset.

Management Question (MQ)	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
MQ6: Can minor adjustments be made to reservoir operations to minimize the impact on amphibians and reptiles?	Uncertain	We suggest that delaying the inundation of elevations between 735 and 736 m ASL into late June would likely afford enough time for eggs to hatch into tadpoles and provide enough time for the tadpoles to grow such that the effects of inundation would be minimized. However, this has not been tested directly.	• None	• Lack of experimentation to assess how varying the time of inundation correlates to the use of the drawdown zone by amphibians and reptiles. It is not possible to manipulate when the reservoirs exceed a given elevation or for how long.
MQ7: Can physical works projects be designed to mitigate adverse impacts on amphibians and reptiles resulting from reservoir operations?	Yes (for Kinbasket)	Evidence of use of wetlands cleared of wood debris in Kinbasket Reservoir. Supports notion that physical works can mitigate for some of the adverse impacts. Mitigation is limited in terms of location, spatial extent, and scale.	• Additional assessments of physical works in Kinbasket.	• Kinbasket Reservoir was not filled completely in 2016. As such, the ponds that were cleared of wood debris and the mounds that were created were not inundated so the integrity of the mounds following inundation has not been tested.
MQ8: Does revegetating the drawdown zone affect the availability and use of habitat by amphibians and reptiles?	No (for Kinbasket)	N/A	• N/A	• Given the non-specific nature of the re-vegetation work that has occurred, this MQ is not applicable to this study. Wetland-related plants would need to be planted to benefit amphibians and reptiles.
MQ9: Do physical works projects implemented during the course of this monitoring program increase amphibian and reptile abundance, diversity, or productivity?	Kinbasket: Partial for Productivity; no for abundance and diversity.	Same as MQ7	• Additional assessments of physical works in Kinbasket.	• Limited scope of physical works in Kinbasket. Results to date are site-specific (i.e., can't infer results to entire reservoir).

Management Question (MQ)	Able to Address MQ?	Scope: Current supporting results	Scope: Suggested modifications to methods where applicable	Sources of Uncertainty
MQ10: Do increased reservoir levels in Kinbasket Reservoir during the summer months resulting from the installation of Mica 5 and 6 negatively impact amphibian populations in the drawdown zone through increased larval mortality or delayed development?	Yes	Maximum reservoir elevations documented between 1978 and 2017 indicate that the average full pool date is August 25. At this time amphibians should be migrating out of the breeding ponds. This suggests that increasing reservoir elevations by 60 cm in the summer months should not directly impact amphibians. A comparison of habitat availability using actual reservoir elevations + 60 cm suggests no change to habitat availability resulting from the installation of Mica units 5 and 6.	• Reassess using the 2014 LiDAR-derived DEM.	• The potential effects of Mica Units 5 and 6 on vegetation in the drawdown zone are being assessed under CLBMON-57. Once that study is complete, any impacts to wetland-associated plants should be considered in the context of changes to amphibian habitat. At present, the potential impacts of Mica units 5 and 5 on amphibian habitat is based solely on changes to habitat availability. • It is not clear if surcharge can be used as proxy for increasing the reservoir by 60 cm in the summer months. • There could be effects that remain unaccounted for if Kinbasket Reservoir reaches full pool more regularly as a result of the additional 60 cm of water. • See previous comment regarding the use of the DEM based on the 2014 LiDAR dataset.

Key Words: amphibian, reptile, life history, habitat use, reservoir elevation, drawdown zone, Kinbasket Reservoir, Mica

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1.0 INTRODUCTION

Dams regulate the flow regime in most of the world's large river systems, and the flooding resulting from dam construction and water storage creates a complex disturbance that can modify entire ecosystems (Nilsson and Berggren 2004; Eskew et al. 2012). These impacts are not restricted to the direct flooding and loss of riparian and wetland habitats upstream of dams, but also extend downstream of dams through disturbance of annual flooding regimes needed to maintain the health of floodplain environments (MacKenzie and Shaw 2000; Nilsson and Berggren 2004; Kupferberg et al. 2011; Eskew et al. 2012). To date, most studies of the effects of impoundment have focused primarily on the instream and riparian effects on fish and wildlife downstream of dams (e.g., Burt and Munde 1986; Hayes and Jennings 1986; Kupferberg 1996; Ligon et al. 1995; Lind et al. 1996; Wright and Guimond 2003; Nilsson et al. 2005; García et al. 2011). The need to understand the operational aspects of reservoir effects upstream of dams on wildlife and their habitat remains high (Brandão and Araújo 2008; Eskew et al. 2012), and that is the focus of this study.

Most major rivers in British Columbia have been dammed, and such hydroelectric developments have had numerous negative impacts on wetland ecosystems throughout the province (Hawkes 2005). This is particularly true for the Columbia River in southeastern B.C., which has been extensively altered by dams built for flood control and hydroelectric power production in both Canada and the United States. There are 14 dams on the Columbia River, three of which are in B.C. (Mica, Revelstoke, and Hugh Keenleyside); the remainder are in the U.S.

Kinbasket Reservoir was created when the Columbia River was impounded by Mica Dam in 1973. Mica Dam was built under the Columbia River Treaty to provide water storage for power generation and flood control. The creation of Kinbasket Reservoir flooded ~42,650 ha resulting in the loss or alteration of eight broad habitat types (lakes: 2,343 ha; rivers: 4,897 ha; streams: 192 ha; shallow ponds: 555 ha; gravel bars: 236 ha; wetlands: 5,863 ha; floodplain [riparian]: 15,527 ha; and upland forest: 13,036 ha; Utzig and Schmidt 2011).

During the Columbia River Water Use Planning process (WUP), the Consultative Committee expressed concerns about potential impacts of the operations of the Kinbasket and Arrow Lakes Reservoirs on wildlife and vegetation, including amphibians and reptiles. However, a lack of information on the abundance, distribution, life history and habitat use of these animals made it difficult to assess the impact of current operations and operating alternatives on them.

In 2008, BC Hydro initiated a long-term monitoring program spanning 10 years (CLBMON-37) to assess the life history and habitat use of amphibian and reptile populations in the Arrow Lakes and Kinbasket Reservoirs of the Columbia Basin. Monitoring populations of amphibians and reptiles in the drawdown zone will provide the necessary information to address management questions related to (1) their life history and habitat use, (2) the effects of reservoir operations on those populations, and (3) the potential to mitigate those impacts by using physical works (as per CLBMON-37).

In addition to the uncertainties raised during the Columbia River WUP process, the Mica 5/6 Core Committee raised concerns about the potential impacts of the installation of Units 5 and 6 at Mica Dam on amphibian and reptile populations in Kinbasket Reservoir.

Mica Dam was originally designed to hold six generating units; however only four were installed at the time of construction in 1973. The installation of the 5th and 6th units commenced in 2011 with a planned operational date of 2014 (unit 5) and 2015 (unit 6). To optimize reservoir storage for power generation associated with the new units, it was predicted that reservoir levels would increase by 0.6 m during the summer months, which could affect larvae survival of amphibian populations that use wetland habitats in the upper elevations of the reservoir.

The Mica 5/6 Core Committee recommended that additional monitoring (CLBMON-58) be conducted to augment the existing Columbia Water Licence Requirements (WLR) study (CLBMON-37) on amphibian and reptiles. This was to be done to assess whether the incremental increase in summer water levels affect amphibian or reptile populations using habitats in the drawdown zone of Kinbasket Reservoir. Funding for CLBMON-58 provided for an additional four years of biennial data collection in Kinbasket Reservoir to supplement the CLBMON-37 monitoring. There is one Management Question (MQ10) that is specifically associated with CLBMON-58.

This final annual report for CLBMON-58 summarizes the findings of Year 4 (2017) monitoring surveys for BC Hydro's Monitoring Program CLBMON-58: *Monitoring the Impacts of Mica Units 5 and 6 on Amphibians and Reptiles in Kinbasket Reservoir*. Data collected in 2013, 2015, and 2017 are used to assess whether any trends are apparent in the data. A final comprehensive report for the combined CLBMON-58 and CLBMON-37 projects will be written in 2018.

1.1 Study Species

Monitoring associated with CLBMON-58 is intended to address the impacts of the installation of units 5 and 6 at Mica Dam on amphibian populations using habitats in and adjacent to the drawdown zone (DDZ) of Kinbasket Reservoir. Because amphibians occupy both aquatic and terrestrial habitats during different parts of their life cycle, their response is likely to be very different from other taxa (e.g., fish, mammals, and birds). Amphibians have long been considered as model organisms to study the effects of human-induced habitat change on ecosystems (Hopkins 2007). Several characteristics of their life history make them particularly well-suited to studies of ecological processes as well as anthropogenic changes to the natural world.

Of the 16 species of amphibians and reptiles that occur in the Columbia Basin, at least three species of amphibian [Western Toad (*Anaxyrus boreas*), Columbia Spotted Frog (*Rana luteiventris*), and Long-toed Salamander (*Ambystoma macrodactylum*)] and three species of reptile [Common Garter Snake (*Thamnophis sirtalis*), Western Terrestrial Garter Snake (*T. elegans*) and Western Painted Turtle (*Chrysemys picta*)] have been documented within the drawdown zone of the Kinbasket Reservoir (Table 1-1).

One species of amphibian is considered to be at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC): the Western Toad is currently (November 2012) listed as Special Concern. The Intermountain–Rocky Mountain Population of the Western Painted Turtle is blue-listed in British Columbia and is a SARA Schedule 1 species of Special Concern.

Table 1-1: Provincial and federal status of species of amphibians and reptiles that occur in the Columbia Basin. Species names in bold are known to occur in the drawdown zone of Kinbasket Reservoir.

Group and Species	Species Code	Status†	
		CDC	SARA listed*
Amphibian			
Columbia Spotted Frog (*Rana luteiventris*)	**RALU**	Y	
Wood Frog (*Lithobates sylvatica*)	LISY	Y	
Pacific Chorus Frog (Pseudacris regilla)	PSRE	Y	
Western Toad (*Anaxyrus boreas*)	**ANBO**	Y	SC
Long-toed Salamander (*Ambystoma macrodactylum*)	**AMMA**	Y	
Reptile			
Western Terrestrial Garter Snake (*Thamnophis elegans*)	**THEL**	Y	
Common Garter Snake (*Thamnophis sirtalis*)	**THSI**	Y	
Western Painted Turtle (*Chrysemys picta*)	**CHPI**	B	SC

†Status: CDC = British Columbia Conservation Data Centre: B = blue-listed; Y = yellow-listed; *SARA-listed = COSEWIC/SARA Schedule: SC = Special Concern

2.0 STUDY OBJECTIVES

In 2008, BC Hydro initiated a long-term monitoring program (CLBMON-37) to assess the life history and habitat use of amphibian and reptile populations in the Arrow Lakes and Kinbasket Reservoirs of the Columbia Basin. Monitoring populations of amphibians and reptiles in the drawdown zone will provide the necessary information to address management questions related to (1) their life history and habitat use, (2) the effects of reservoir operations on those populations, and (3) the potential to mitigate those impacts by using physical works (as per CLBMON-37). Monitoring efforts specific to Kinbasket Reservoir (as per CLBMON-58) will enable an assessment of the impacts of Mica Units 5 and 6 on amphibians using habitats in the drawdown zone of Kinbasket Reservoir. Table 2-1 summarizes the annual implementation schedule for CLMBON-37 and CLBMON-58 in Kinbasket Reservoir only.

Table 2-1: Monitoring years for CLBMON-37 and CLBMON-58 in Kinbasket Reservoir (2007 to 2017). The current year is indicated in bold.

Year	CLBMON-58	CLBMON-37	Reference
2008		Year 1	Hawkes and Tuttle 2009
2009		Year 2	Hawkes and Tuttle 2010a
2010		Year 3	Hawkes et al. 2011
2011	Year 1		Hawkes and Tuttle 2012
2012		Year 4	Hawkes and Tuttle 2013a, b
2013	Year 2		Hawkes and Wood 2014
2014		Year 5	Hawkes et al. 2015
2015	Year 3		Hawkes and Tuttle 2016
2016		Year 6	Hawkes et al. 2017
2017	**Year 4**		**Annual report**
2018	Year 5	Year 7	Final comprehensive report

2.1 Management Questions and Hypotheses

In 2008, BC Hydro developed nine management questions (MQs) to determine the impacts of reservoir operations on amphibians and reptiles that use habitats in the drawdown zones of Kinbasket and Arrow Lakes Reservoirs (as per CLBMON-37). In 2011, a tenth management question asked how the installation of Mica Units 5 and 6 would affect amphibian populations in the drawdown zone of Kinbasket Reservoir; this was added to accommodate the CLBMON-58 objective. The ten MQs are grouped into four broad themes:

CLBMON-37/58 – Theme 1: Life History and Habitat Use

MQ1: Which species of amphibians and reptiles occur (utilize habitat) within the drawdown zone and where do they occur?

MQ2: What is the abundance, diversity, and productivity (reproduction) of amphibians and reptiles utilizing the drawdown zone and how do these vary within and between years?

MQ3: During what portion of their life history (e.g., breeding, foraging, and over-wintering) do amphibians and reptiles utilize the drawdown zone?

MQ4: Which habitats do amphibians and reptiles use in the drawdown zone and what are their characteristics (e.g., pond size, water depth, water quality, vegetation, elevation band)?

CLBMON-37/58 – Theme 2: Reservoir Operations and Habitat Change

MQ5: How do reservoir operations influence or impact amphibians and reptiles directly (e.g., desiccation, inundation, predation) or indirectly through habitat changes?

MQ6: Can minor adjustments be made to reservoir operations to minimize the impact on amphibians and reptiles?

CLBMON-37/58 – Theme 3: Physical Works

MQ7: Can physical works projects be designed to mitigate adverse impacts on amphibians and reptiles resulting from reservoir operations?

MQ8: Does revegetating the drawdown zone affect the availability and use of habitat by amphibians and reptiles?

MQ9: Do physical works projects implemented during the course of this monitoring program increase amphibian and reptile abundance, diversity, or productivity?

CLBMON-58 – Theme 4: Effects of Mica Units 5 and 6

MQ10: Do increased reservoir levels in Kinbasket Reservoir during the summer months resulting from the installation of Mica 5 and 6 negatively impact amphibian populations in the drawdown zone through increased larval mortality or delayed development?

Hypotheses were developed to address the four themes of management questions. Hypothesis H_1 was modified to include the effect of Units 5 and 6 on amphibians that use habitats in the drawdown zone of Kinbasket Reservoir:

H_1 Annual and seasonal variation in water levels in Kinbasket Reservoir (due to reservoir operations), the implementation of soft operational constraints, and the effects of Units 5 and 6 in Mica Dam on Kinbasket

Reservoir, do not directly or indirectly impact reptile and amphibian populations.

H_{1A} Reservoir operations do not result in a decreased abundance of amphibians or reptiles in the drawdown zone.

H_{1B} Reservoir operations do not increase the stage specific (e.g., larval, juvenile, or adult) mortality rates of amphibians or reptiles in the drawdown zone.

H_{1C} Reservoir operations do not result in decreased site occupancy of amphibians or reptiles in the drawdown zone.

H_{1D} Reservoir operations do not result in decreased productivity of amphibians or reptiles in the drawdown zone.

H_{1E} Reservoir operations do not reduce the availability and quality of breeding habitat, foraging habitat and over-wintering habitat for amphibians or reptiles in the drawdown zone.

H_2 The physical works projects and revegetation efforts do not increase the utilization of habitats by amphibians or reptiles in the drawdown zone.

H_{2A} Revegetation and physical works do not increase species diversity or seasonal (spring/summer/fall) abundance of amphibians or reptiles in the drawdown zone.

H_{2B} Revegetation and physical works do not increase amphibian or reptile productivity in the drawdown zone.

H_{2C} Revegetation does not increase the amount or improve habitat for amphibians and reptiles in the drawdown zone.

These questions and hypotheses will be tested directly by this monitoring program, which is aimed at determining the habitat use/associations and distribution of amphibians and reptiles in the drawdown of Kinbasket Reservoir relative to reservoir operational regimes, including changing water levels (Table 2-2). The monitoring program is also designed to address whether the proposed physical works and/or revegetation programs will enhance habitat suitability for amphibians and reptiles in the drawdown zone.

Table 2-2: Hypotheses addressed by each theme for CLBMON-58. A √ indicates a relationship between the theme and hypothesis

Theme	Hypotheses									
	H_1	H_{1A}	H_{1B}	H_{1C}	H_{1D}	H_{1E}	H_2	H_{2A}	H_{2B}	H_{2C}
Life History and Habitat Use	√	√	√	√	√	√				
Reservoir Operations and Habitat Change	√	√	√	√	√	√				
Physical Works							√	√	√	√
Effects of Mica Units 5 and 6	√	√	√	√	√	√				

3.0 STUDY AREA

3.1 Physiography

The Columbia Basin in southeastern British Columbia is bordered by the Rocky, Selkirk, Columbia, and Monashee Mountains. The headwaters of the Columbia

River begin at Columbia Lake in the Rocky Mountain Trench, and the river flows northwest along the trench for about 250 km before it empties into Kinbasket Reservoir behind Mica Dam (BC Hydro 2007). From Mica Dam, the river continues southward for about 130 km to Revelstoke Dam. The river then flows almost immediately into Arrow Lakes Reservoir behind Hugh Keenleyside Dam. The entire drainage area upstream of Hugh Keenleyside Dam is approximately 36,500 km^2.

The Columbia Basin is characterized by steep valley side slopes and short tributary streams that flow into Columbia River from all directions. The Columbia River valley floor elevation extends from approximately 800 m near Columbia Lake to 420 m near Castlegar. Approximately 40 per cent of the drainage area within the Columbia Basin is above 2,000 m elevation. Permanent snowfields and glaciers predominate in the northern high mountain areas above 2,500 m elevation. About 10 per cent of the Columbia River drainage area above Mica Dam exceeds this elevation.

3.2 Climatology

Precipitation in the basin is produced by the flow of moist, low-pressure weather systems that move eastward through the region from the Pacific Ocean. More than two-thirds of the precipitation in the basin falls as winter snow. Snow packs often accumulate above 2,000 m elevation through the month of May and continue to contribute runoff long after the snow pack has melted at lower elevations. Summer snowmelt is reinforced by rain from frontal storm systems and local convective storms. Runoff begins to increase in April or May and usually peaks in June to early July, when approximately 45 per cent of the runoff occurs. The mean annual local inflow for the Mica, Revelstoke and Hugh Keenleyside projects is 577 m^3/s, 236 m^3/s, and 355 m^3/s, respectively (BC Hydro 2007). Air temperatures across the basin tend to be more uniform than is precipitation. The summer climate is usually warm and dry, with the average daily maximum temperature for June and July ranging from 20 to 32°C.

3.3 Kinbasket Reservoir

Located in southeastern B.C., Kinbasket Reservoir is surrounded by the Rocky and Monashee Mountain ranges and is approximately 216 km long. The Mica hydroelectric dam located 135 km north of Revelstoke, B.C., spans the Columbia River and impounds Kinbasket Reservoir. The original Mica powerhouse, completed in 1973, has a generating capacity of 1,805 megawatt (MW), and Kinbasket Reservoir has a licensed storage volume of 12 million-acre feet (MAF; BC Hydro 2007). The addition of the new turbines at Mica Dam will increase the generating capacity of Kinbasket Reservoir by roughly 1,000 MW (BC Hydro, 2007). The normal operating range of the reservoir is between 707.41 m and 754.38 m elevation but can be operated to 754.68 m above sea level (ASL) with approval from the Comptroller of Water Rights. The biogeoclimatic (BEC) zones that occur in the lower elevations of Kinbasket Reservoir are the Interior Cedar-Hemlock (ICH) zone and the Sub-Boreal Spruce (SBS) zone (Figure 3-1).

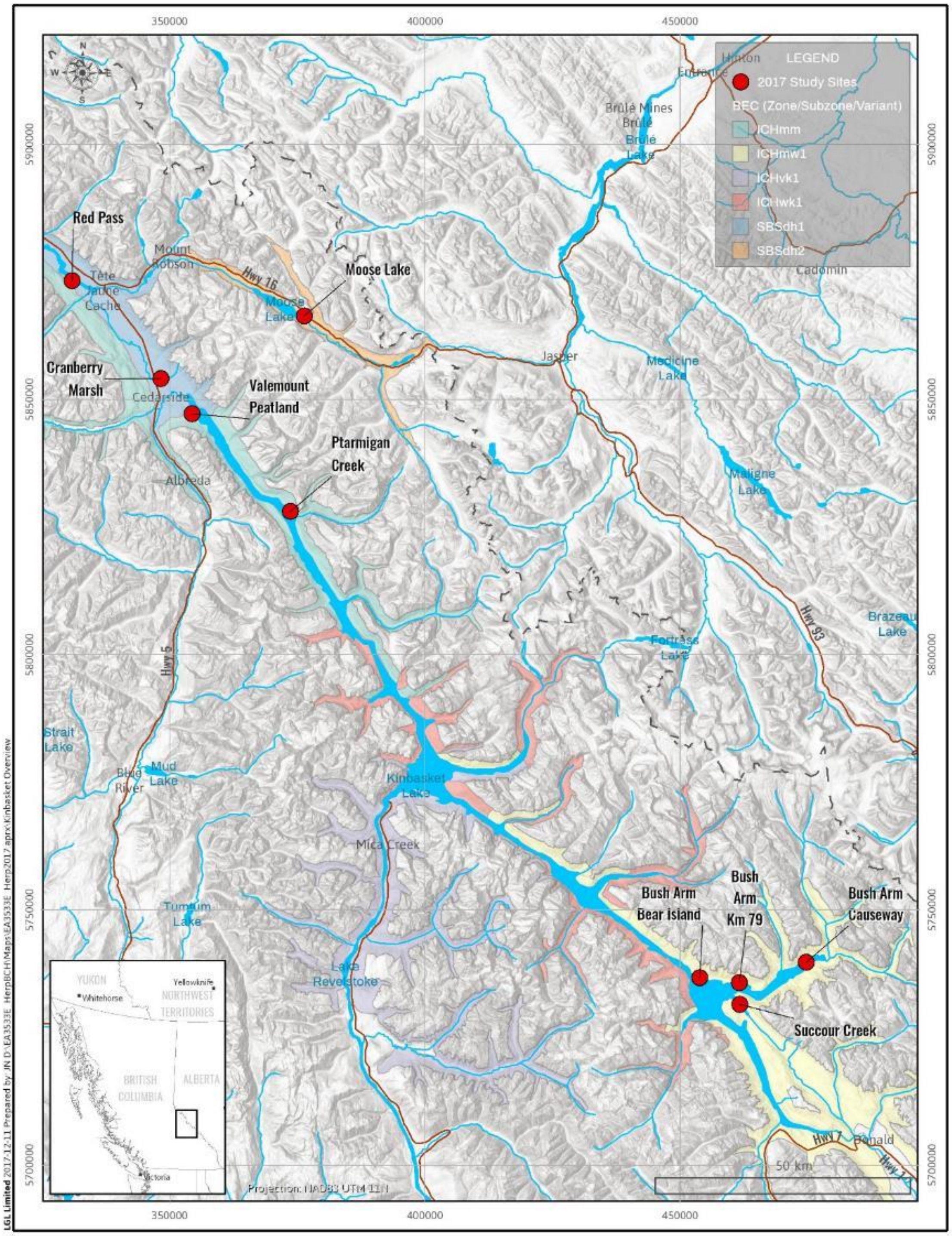

Figure 3-1: Location of Kinbasket Reservoir in British Columbia and locations sampled for CLBMON-58 in 2017. Naming of study sites follows Hawkes et al. (2007)

Kinbasket Reservoir fills in the spring and is typically full by the mid- to late-summer (Figure 3-2). Although there is some year to year variation, the general pattern is consistent.

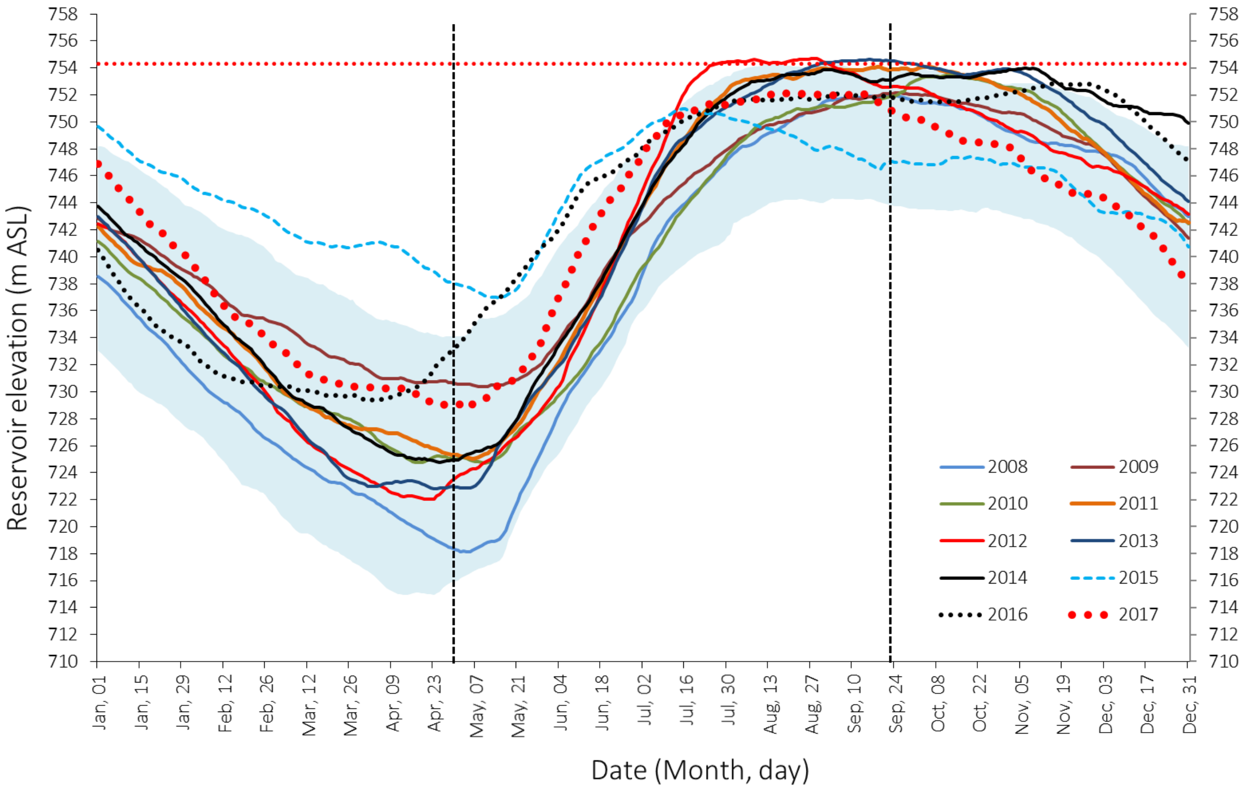

Figure 3-2: **Kinbasket Reservoir hydrograph for the period 2008 through 2017**. The shaded area represents the 10th and 90th percentile for the period 1976 to 2017; the dashed horizontal red line is the normal operating maximum. Vertical dashed lines indicated start and end dates of sampling in 2017

3.3.1 Study Locations

Specific sites in the drawdown zone of Kinbasket Reservoir are sampled under CLBMON-58. These areas were selected because of the presence of wetlands and ponds in the drawdown zone and the use of those sites by reptiles and amphibians (e.g., breeding). DDZ sites studied include habitats at the east end of Bush Arm (i.e., the Bush Arm Causeway), areas on the north side of Bush Arm including habitats at KM79 (i.e., ~79.5 km along Bush forest service road) and KM88 (i.e., the mouth of Bush Arm, Bear Island), Succour Creek near the mouth of Bush Arm, and sites in Canoe Reach in the Valemount Peatland and at Ptarmigan Creek (Figure 3-1; see Appendix 10-1 for maps of each study site). Sites sampled that occur outside of the DDZ included Red Pass, Cranberry Marsh, Moose Lake and a small perched wetland at KM79. A total 0f 164 ponds were sampled in the drawdown zone in 2017 (Table 3-1).

Table 3-1: Number, area (ha), and elevation (m ASL) of ponds sampled for amphibians in the drawdown zone of Kinbasket Reservoir in 2017.

		Area (ha)				Elevation (m ASL)		
Site	Ponds	Total	Min	Max	Mean	Min	Max	Mean
Bear Island	73	2.02	0.001	0.49	0.03	734.30	754.57	744.46
Causeway	23	2.31	0.002	0.97	0.10	751.27	753.04	752.11
KM79	21	0.97	0.004	0.32	0.05	744.10	751.66	746.71
Ptarmigan Creek	1	0.94	0.945	0.94	0.94	748.45	748.45	748.45
Valemount Peatland	46	4.73	0.007	0.83	0.10	750.01	755.94	751.82
Total	**164**	**10.97**						

4.0 METHODS

4.1 Field Schedule

In 2017, field sampling was conducted between late April and August to coincide with the active period of amphibians and reptiles. Field sampling in Canoe Reach was more extensive due to a graduate student and field technician continuing a radiotelemetry study on snakes (*Thamnophis sirtalis*) in the Valemount Peatland. Sampling in the peatland occurred every few days from April 26 to September 28. Field sampling in Bush Arm occurred between April 29-30, May 1-3, May 24-25, June 9- 11, June 22-23, July 18-19, and August 16-17. The 2017 field sampling schedule followed a similar timeline as that implemented in other years of this study to facilitate data comparison between years. Predicted reservoir levels obtained from BC Hydro were incorporated into field scheduling to determine how much of the DDZ would be available for sampling.

4.2 Data Collection

4.2.1 General Survey Data

A variety of techniques were used to survey amphibians (visual encounter surveys [VES]) and reptiles (VES, radiotelemetry [snakes only]) in the DDZ of Kinbasket Reservoir in 2017. Total survey time per person was recorded to calculate catch per unit effort time (i.e., detection rate) for each survey site, field session and species. Surveys for egg masses, tadpoles and larvae were conducted in the spring at various wetland sites but are a subset survey type of VES and are reported with those results. To assess species-by-site relationships, we pooled all life stages to identify sites where the detection of a given species was the highest regardless of age class. Aggregations of tadpoles (or metamorphs) were treated as a single detection per location or pond, so as not to skew numbers.

Study sites (listed above) were general locations which were searched for animals (depending on the reservoir elevation during the field sampling session) from the reservoir water's edge to the outside edge of the DDZ reservoir habitat (max elevation of reservoir – typically forested habitat or road). These DDZ areas include wetlands and ponds as well as terrestrial areas where amphibians and reptiles may occur. Previously mapped ponds and wetlands were surveyed in the Valemount Peatland, at Ptarmigan Creek, and throughout Bush Arm (KM88, Causeway, and KM79) to determine amphibian occupancy and use. All amphibian and reptile observations and captures, including incidental observations, were georeferenced to associate each observation with a given wetland or pond, elevation, and vegetation community (as defined in Hawkes et al. 2007).

Air temperature and precipitation were obtained from Environment Canada's Mica Dam weather station (11U: UTM_E: 391261 UTM_N: 5766272; 579.10 m ASL) to evaluate the influence of weather conditions on species detectability and measures of relative abundance.

4.2.2 Morphometric Data

The Resources Inventory Standards Committee (RISC) protocols for sampling and handling of amphibians and reptiles (RISC 1998a, b) were followed. All captured animals were weighed and measured (snout-vent and snout-urostyle lengths, tail lengths), and sex was determined when possible. Most captured animals were photographed, and UTM coordinates were obtained for each observation. Larval amphibians were staged according to the Gosner (1960) or Harrison (1969) indexing standards. For a more detailed description of the methods used to sample amphibians and reptiles in 2017, refer to the other CLBMON-37 reports (Hawkes and Tuttle 2009) and revised monitoring program sampling protocols (Hawkes and Tuttle 2012).

4.2.3 Pond Habitat and Breeding Amphibian Data

To assess the relationship between reservoir operations and amphibian habitat availability we first mapped all ponds to determine the location, total area (hectares) and elevation of each pond within the drawdown zone. When reservoir levels were low (which usually corresponded with the month of May), all mapped ponds were visited to determine (1) availability (presence or absence in each field session prior to inundation), (2) amphibian (or reptile) presence, and (3) amphibian breeding activity. Breeding activity was documented for each species by estimating counts of egg masses, larval aggregations, and breeding adults (e.g., numbers of pairs in amplexus and adult males and females).

One of the critical life history stages for amphibians that use drawdown zone ponds is the larval stage because tadpoles/larvae are unable to move out of ponds until metamorphosis is complete. To evaluate how amphibian species are affected by reservoir operations (i.e., how inundation of ponds by the reservoir influences amphibians), we monitored breeding occurrences, larval development (e.g., Gosner staging) and timing of metamorphosis (where possible) in Canoe Reach and Bush Arm.

4.2.4 Changes to habitat availability and Mica units 5 and 6

The installation of Mica units 5 and 6 is predicted to result in a 0.6 m increase in reservoir elevations during the summer months in three out of 10 years. Changes in amphibian habitat availably resulting from this predicted increase were visually assessed by plotting the observed elevation of amphibians relative to the observed annual hydrograph and to the observed annual hydrograph + 0.6 m. The plots were reviewed to determine if an additional 0.6 m would reduce the amount of habitat available to amphibians, particularly during the breeding and larval development periods.

The years in which reservoir elevations will increase by 0.6 m are unknown. It is also not likely that any changes associated with reservoir operations following the installation of Mica units 5 and 6 will be easily attributable to the installation of those units. As such, the effects of the installation of Mica units 5 and 6 is considered in the context of reservoir effects. If, by adding 0.6 m to observed annual hydrographs, there is a reduction or removal of amphibian breeding habitat in the drawdown zone of Kinbasket Reservoir, a negative impact on amphibian populations in the drawdown zone will be assumed.

4.2.5 Habitat Data

Habitat data were collected in a standardized manner at all locations where amphibians were observed as well as at locations where they were not. Habitat data collected included characteristics at both the macro and micro scales. The vegetation community types (from CLBMON-10) in which species were observed was determined by relating the species observation location to the vegetation polygon on a GIS map. For a detailed description of the methods used to sample habitat (micro and macro) in 2017, refer to the other CLBMON-37 reports (Hawkes and Tuttle 2009) and revised monitoring program sampling protocols (Hawkes and Tuttle 2010b).

Water chemistry point data (dissolved oxygen in mg/L, conductivity in µs, temperature in °C, and pH) were collected at all pond and reservoir sampling locations at each study site. An YSI 85 multi-function metre was used to measure dissolved oxygen, conductivity, and temperature. An Oakten waterproof pH Tester 30 was used to obtain pH data. Data for pond physiocochemistry were summarized as averages (+/- SD) of point data.

In 2017, three dissolved oxygen (PME MiniDOT) dataloggers were installed in select wetlands (KM88, KM79, Bush Arm Causeway) to collect continuous data (dissolved oxygen and water temperature). The dataloggers were installed between 30 cm and 50 cm below the water's surface in depths of 65 to 80 cm. The units were affixed to steel rebar (125 cm in length) using a pipe clamp and the rebar was fitted with an orange plastic safety cap for easy relocation. The dataloggers were programmed to record data every 10 minutes and data were downloaded using the manufacture's software (PME miniDOT software). Dataloggers were deployed in May and data were collected in October, spanning 142 to 156 days.

Temporal habitat availability (i.e., the time of year when habitats are available and how long they are available) is likely to have a greater effect on amphibian and reptile populations than spatial habitat availability (i.e., the size of the habitat that may be used). This is particularly true for pond-breeding amphibians. This is based on an assessment of the distribution of amphibians and reptiles observed since 2008 and on our understanding of where important amphibian and reptile habitats occur in the drawdown zone of Kinbasket Reservoir. Temporal habitat availability was assessed based on the duration of the active season (i.e., the number of days between April 1 and September 30) during which the drawdown zone was available to amphibians and reptiles. This was accomplished by correlating reservoir elevation (in 1 m increments) to the number of days between April 1 and September 30 (n = 183) that each 1 m elevation band was exposed and therefore available for use.

4.2.6 Radiotelemetry

Radiotelemetry of Common Garter Snake continued in 2017 in the Valemount Peatland. Radio telemetry transmitters (Model SB-2, 5.0 g, Holohil Systems Ltd.) with whip antennas (approximately 15 cm) were surgically implanted in female common garter snakes and transmitters weighed no more than 5 per cent of the mass of each snake (Millspaugh and Marzluff 2001; Jepsen et al. 2003). Surgical procedures followed Reinert and Cundall (1982). Snakes were released at the site of capture and located the day following release to confirm that they were behaving normally (i.e., moving adequately with appropriate thermoregulatory and defensive behaviours without any signs of pain or stress).

Telemetry sessions for snakes were conducted every few days between May and September 2017. The location of each animal on each visit was determined either visually, by getting to the closest assumed location without seeing the animal, or via triangulation. All snakes fitted with transmitters were tracked until they remained in the same location for approximately one week, signalling that they had selected a site to overwinter.

4.3 Data Analysis

4.3.1 Species Detections

Monitoring amphibians can lead to biased population estimates and inaccurate interpretations of habitat relationships when imperfect detections of the species are not considered (Bailey et al. 2004; Mackenzie et al. 2006). Site occupancy modelling and probabilistic sampling are methods that help overcome this deficiency (Hansen et al. 2012). Site occupancy modeling will be completed following the final year of CLBMON-37 (in 2018). For now, we report on the occurrence and distribution of amphibians relative to study location based on the detection of any life stage of each species at a survey area and pond. By visiting survey sites multiple times, we maximized our chances of detection; however, we are not reporting this naïve occupancy metric as it is likely an underestimate of true occupancy rates (Mackenzie et al. 2006).

4.3.2 Habitat Availability

Habitat availability was assessed through graphical presentation of total area available (i.e., habitats that have not been inundated yet) relative to use (breeding, foraging, and overwintering occurrences). Pearson's correlation coefficients were used to describe the associations between total available habitat, reservoir elevation and time of year (month) and linear regression was used to assess the relationships between reservoir elevation and the amount of foraging habitat available to amphibians and reptiles.

4.3.3 Habitat Associations

Habitat associations were assessed for Western Toad, Columbia Spotted Frog and Common Garter Snake through graphical presentation of the distribution of pooled life stages of each species detection by vegetation community. To account for annual differences in sampling effort, presence data (e.g., catch per unit effort) were used and standardized by species totals within each year. Amphibian observations made between 741 m and 754 m ASL were evaluated relative to vegetation community mapping completed under CLBMON-10 (Hawkes et al. 2016).

5.0 RESULTS

5.1 Environmental Data

Weather conditions (air temperature, precipitation) known to affect the surface activity of amphibians are shown in Figure 5-1.

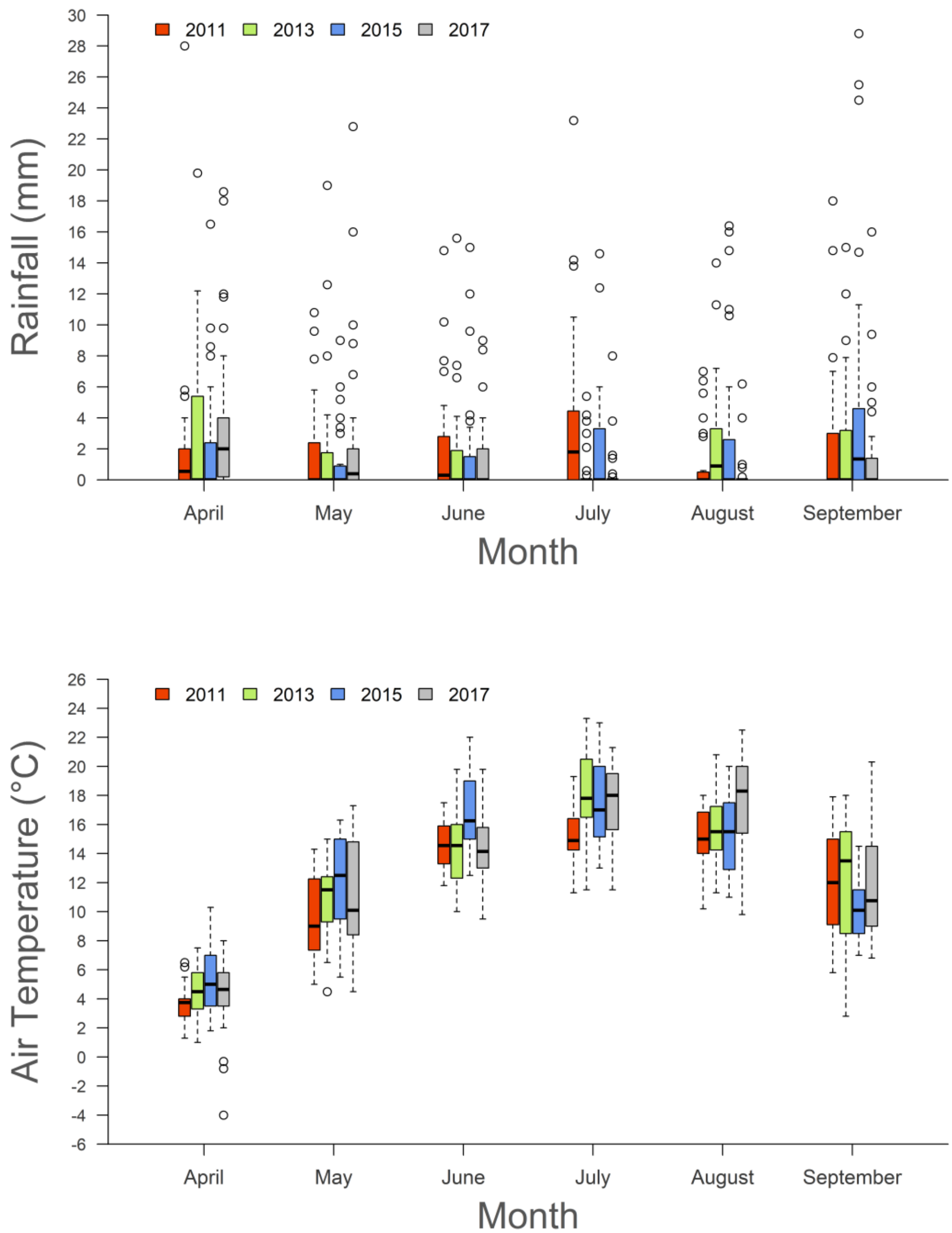

Figure 5-1: Daily precipitation (mm, above) and temperature (°C, below) for April through September 2011, 2013, 2015, and 2017 as measured at Mica Dam. Data source: Environment Canada (http://climate.weather.gc.ca/index_e.html)

5.2 Water Physicochemical Data

Point data [Conductivity (µS/cm), Dissolved Oxygen (mg/L), pH, and Temperature (°C)] are summarized for all amphibian observations (Table 5-1).

Table 5-1: Summary of water physicochemistry data collected for amphibian observations in the drawdown zone of Kinbasket Reservoir in 2017. Average and standard deviation values are provided. These are point data point data, Total # refers to the number of ponds sampled and the number of sampled obtained per pond (could be the same pond but at a different time of the year)

	Total #		Conductivity		Dissolved Oxygen		pH		Temperature	
Pond Type	**Ponds**	**Samples**	$\bar{x}$	**SD**	$\bar{x}$	**SD**	$\bar{x}$	**SD**	$\bar{x}$	**SD**
Artificial Pond	1	1	285.5	99.0	8.4	0.7	7.7	0.4	16.1	1.1
Beaver Pond	4	5	146.2	115.1	7.4	5.5	7.5	0.7	13.2	4.9
Open DDZ Pond	15	30	117.1	42.4	8.6	2.3	7.9	0.6	14.7	4.6
Peatland Pond	35	90	71.2	34.5	8.5	5.8	7.2	0.4	17.3	4.1
Wetland	5	7	140.4	37.6	8.7	2.0	7.5	0.3	13.2	3.3
Total	**138**	**138**	**92.1**	**56.1**	**8.5**	**5.0**	**7.4**	**0.5**	**16.3**	**4.4**

Data obtained from ponds in the drawdown zone indicate that water temperature profiles vary throughout the year, with a rapid rise in temperature in June and July and slow decline in temperature into the winter months. The amphibian breeding period of May through mid-July is associated with the greatest temperature variation measured for some ponds in the drawdown zone (data for KM88 shown in Figure 5-2), but the maximum temperatures recorded are well within recorded tolerances for the pond-breeding amphibians that occur in the drawdown zone of Kinbasket Reservoir (Feder and Burggren 1992).

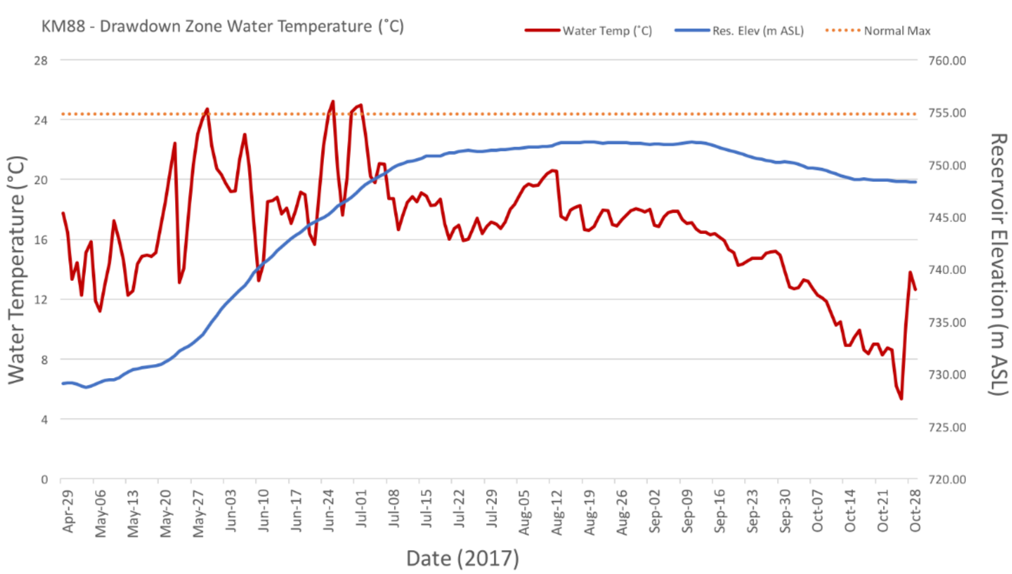

Figure 5-2: Average temperature profiles obtained from three Hobo Onset tidbit temperature dataloggers deployed at KM88 Bush Arm, in the drawdown zone of Kinbasket Reservoir in 2017 (data from May to October 2017 shown)

Maximum elevation for Kinbasket Reservoir was 752.1 m ASL in 2017, and therefore not all ponds in the drawdown zone were inundated. A data logger installed in a pond at Bush Arm KM79 recorded a large difference between pre- and post-inundation conditions for dissolved oxygen (Figure 5-3; Figure 5-4).

However, the difference in water temperature was less pronounced following inundation. For ponds that did not get inundated in 2017 (e.g., reclaimed wetland at Bush Arm Causeway), water temperatures remained stable before dropping in August, possibly due to increased runoff from the Bush River. Dissolved oxygen levels were stable and did not drop below 6 mg/L.

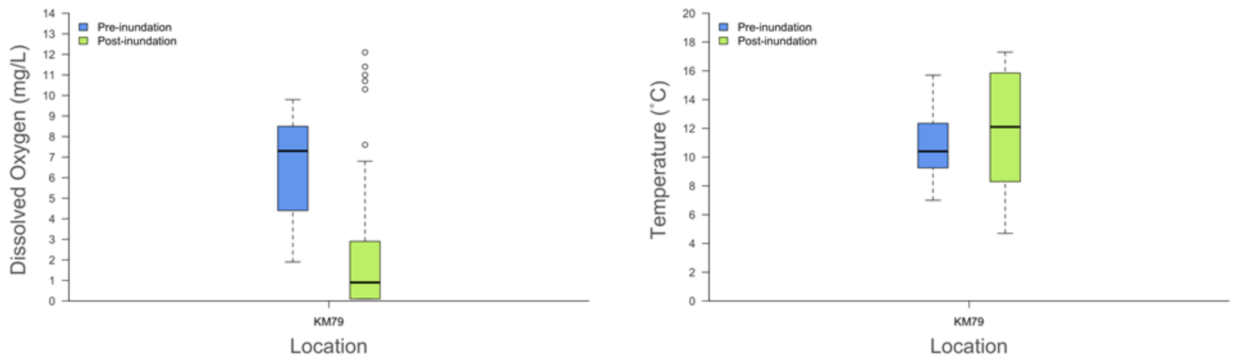

Figure 5-3: Differences in dissolved oxygen (DO; mg/L) and water temperature (°C) before and after reservoir inundation at KM79 in the drawdown zone of Kinbasket Reservoir in 2017

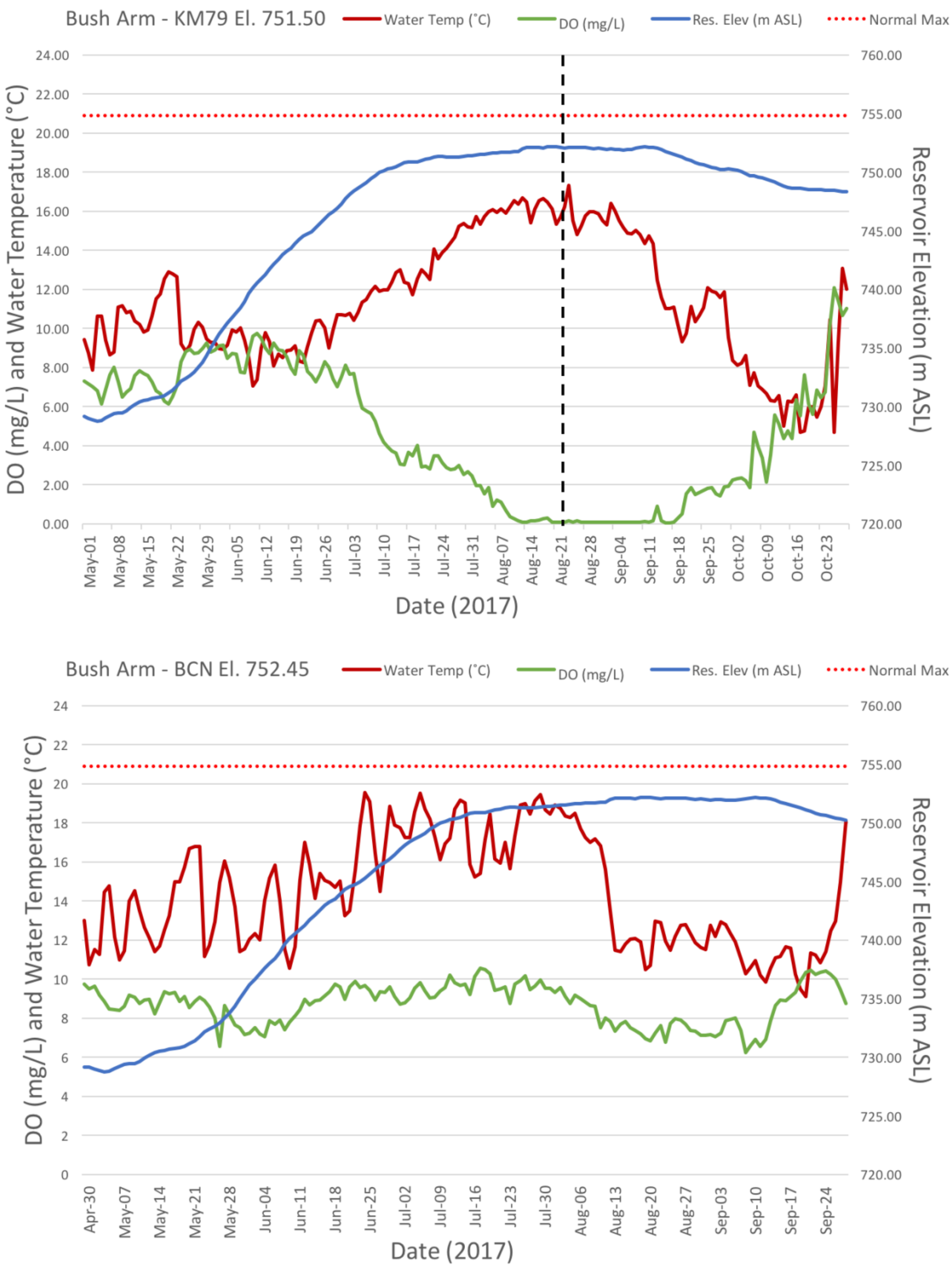

Figure 5-4: Daily variation in dissolved oxygen (DO; mg/L) and water temperature (°C) relative to reservoir elevation (m ASL) for wetlands at two locations in the drawdown zone of Kinbasket Reservoir for 2017. The dashed vertical line in the top panel represents the date of inundation. The dashed horizontal red line is the normal operating maximum. Data loggers were set at a depth of 30 cm below the surface when first installed. BCN = Bush Arm Causeway North (lower)

5.3 Species Occurrence and Distribution

5.3.1 Site Occupancy

At the landscape level, four species of amphibians and three reptiles were observed in the DDZ of Kinbasket Reservoir in 2017 (Table 5-2). Two sites supported all three species of amphibians in 2017: Valemount Peatland and Bush Arm Causeway. Western Toad and Columbia Spotted Frog occupied most of the sites surveyed in all years and accounted for most of the observations. Of the two gartersnake species documented, Common Garter Snake is more widely distributed than the Western Terrestrial Garter Snake with the former documented each year in most survey locations. A Western Terrestrial Garter Snake was observed at Bush Arm KM88 for the first time since 2011 and a new record in the drawdown zone at Bush Arm KM79 was also documented. There were no Western Painted Turtle or Pacific Chorus Frog observations in Kinbasket Reservoir in 2017. Mapped occurrences of all species observed in 2017 are included in Appendix 10-1Appendix 10-1.

Table 5-2: Presence of amphibians and reptiles observed in the drawdown zone of Kinbasket Reservoir for 2013, 2015, and 2017 by survey site (shaded cells). A-AMMA = Long-toed Salamander, A-ANBO = Western Toad, A-PSRE = Pacific Chorus Frog (pink shaded = possible observation), A-RALU = Columbia Spotted Frog, R-CHPI = Painted Turtle, R-THEL = Western Terrestrial Garter Snake, R-THSI = Common Garter Snake

	A-AMMA			A-ANBO			A-PSRE			A-RALU			R-CHPI			R-THEL			R-THSI			No. Species		
Survey Sites	**13**	**15**	**17**	**13**	**15**	**17**	**13**	**15**	**17**	**13**	**15**	**17**	**13**	**15**	**17**	**13**	**15**	**17**	**13**	**15**	**17**	**13**	**15**	**17**
Bush Arm KM88				■	■	■				■	■	■		■				■		■	■	2	4	4
Bush Arm Causeway	■	■	■	■	■	■				■	■	■					■		■	■	■	4	5	4
Bush Arm KM79 (DDZ)				■	■	■				■	■	■						■	■		■	3	2	4
Bush Arm KM79 (UPL)				■	■	■				■	■	■									■	2	2	3
Ptarmigan Creek	■			■	■	■				■	■	■							■	■	■	4	3	3
Succour Creek																	■	■				0	1	1
Valemount Peatland	■	■	■	■	■	■		▨		■	■	■							■	■	■	4	5	4
Total Sites Occupied	**3**	**2**	**2**	**6**	**6**	**6**	**0**	**1**	**0**	**6**	**6**	**6**	**0**	**1**	**0**	**0**	**2**	**3**	**4**	**4**	**6**	**6**	**7**	**7**

5.3.2 Detection Rate

Between April and August, we spent over 750 hours surveying monitoring sites within the DDZ of Kinbasket Reservoir, during which we observed more than 599,851 individuals across multiple life stages of all species (Table 5-3). The perched wetland at Bush Arm KM79 (UPL) and Bush Arm Causeway had the most consistently high rates of detections. Western Toad and Columbia Spotted Frog were the species with the highest detection rates.

Table 5-3: Total survey time (hours) and species detections by survey location for Kinbasket Reservoir in 2017. Blanks indicate the species was not detected. A-AMMA = Long-toed Salamander, A-ANBO = Western Toad, A-RALU = Columbia Spotted Frog, R-THEL = Western Terrestrial Garter Snake, R-THSI = Common Garter Snake. CPUE (catch per unit effort) = the number of observations per site and per species divided by the survey time

Survey Location	Effort (hrs)	A-AMMA	A-ANBO	A-RALU	R-THEL	R-THSI	Total	CPUE
Bush Arm KM88	22.0		14	17	1	2	34	**1.542**
Bush Arm Causeway	48.0	6	257	22		8	293	**6.104**
Bush Arm KM79 (DDZ)	26.3		13	60	1	2	76	**2.888**
Bush Arm KM79 (UPL)	5.3		141	24		1	166	**31.109**
Ptarmigan Creek	77.0		100	2		20	122	**1.585**
Succour Creek	0.3				1		1	**3.355**
Valemount Peatland	578.9	1	134	203		57	395	**0.682**
Total: Effort (hrs); #obs	**757.8**	**7**	**659**	**328**	**3**	**90**	**1087**	**1.434**
CPUE (#obs/hr)		**0.009**	**0.870**	**0.433**	**0.004**	**0.119**	**1.434**	

We examined the detection rates by species for six survey areas in Kinbasket Reservoir (Figure 5-5). Western Toad and Columbia Spotted Frog were detected at all sites, with Western Toad having a higher overall detection rate at Bush Arm Causeway, KM79 upland perched wetland, Bush Arm KM 88, and Ptarmigan Creek. During the breeding season at KM79 upland perched wetland, we observed many Western Toad adults in amplexus in a single survey. The high number of detections over a short survey period resulted in an increased detection rate for that site. KM79 upland perched wetland is a known breeding location for Western Toad and Columbia Spotted Frog and it is not uncommon to have a high density of individuals during the early summer months, with the latter species consistently found there between April and September. Aside from KM 79 upland perched wetland, Bush Arm Causeway had the overall highest detection rates for Western Toad, while Bush Arm KM88 and KM79 had the highest detection rates of Columbia Spotted Frog. Western Terrestrial Garter Snake had the overall lowest detection rates and were only found at sites located in Bush Arm. Common Garter Snakes also had low detection rates compared to the other species, although they were detected at all sites in 2017. Long-toed Salamander were found in Valemount Peatland and Bush Arm Causeway, but their overall detection rates remained low.

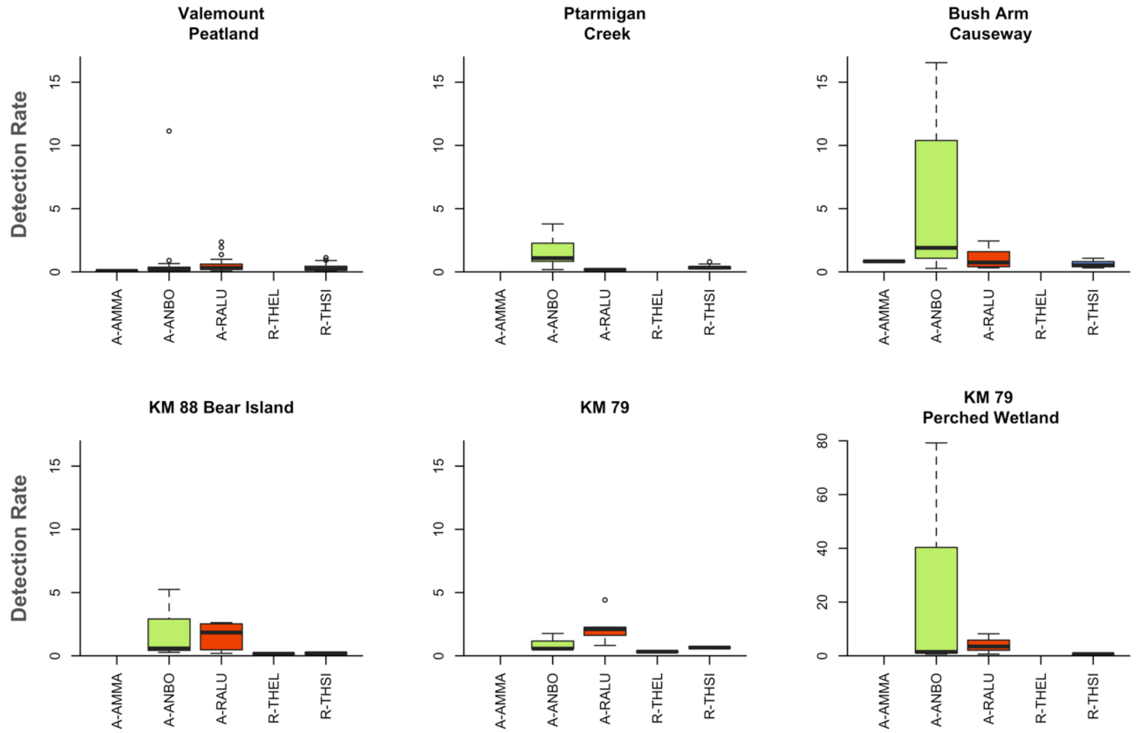

Figure 5-5: Detection rate for amphibian and reptile species in Kinbasket Reservoir in 2017. Detection rate = the number of times a species was detected (all life stages pooled)/the total time spent searching at a study site. Scale of y-axes differ due to high detection rate at KM79 Perched Wetland. A-AMMA = Long-toed Salamander, A-ANBO = Western Toad, A-RALU = Columbia Spotted Frog, R-THEL = Western Terrestrial Garter Snake, R-THSI = Common Garter Snake

5.3.3 Elevation

Amphibians and reptiles were found across a wide range of elevations in Kinbasket Reservoir in 2017 (Figure 5-6). Most observations (all life stages combined) were between 749 and 754 m ASL, a trend that was also observed in 2013 and 2015 (Figure 5-7). Western Toad spanned the widest range of elevations, while observations of Long-toed Salamander and Western Terrestrial Garter Snake spanned the narrowest range; however, detectability issues between the species or ontogenetic variation likely affect these relationships. The relationship between amphibian and reptile distributions in the drawdown zone is likely a function of habitat availability.

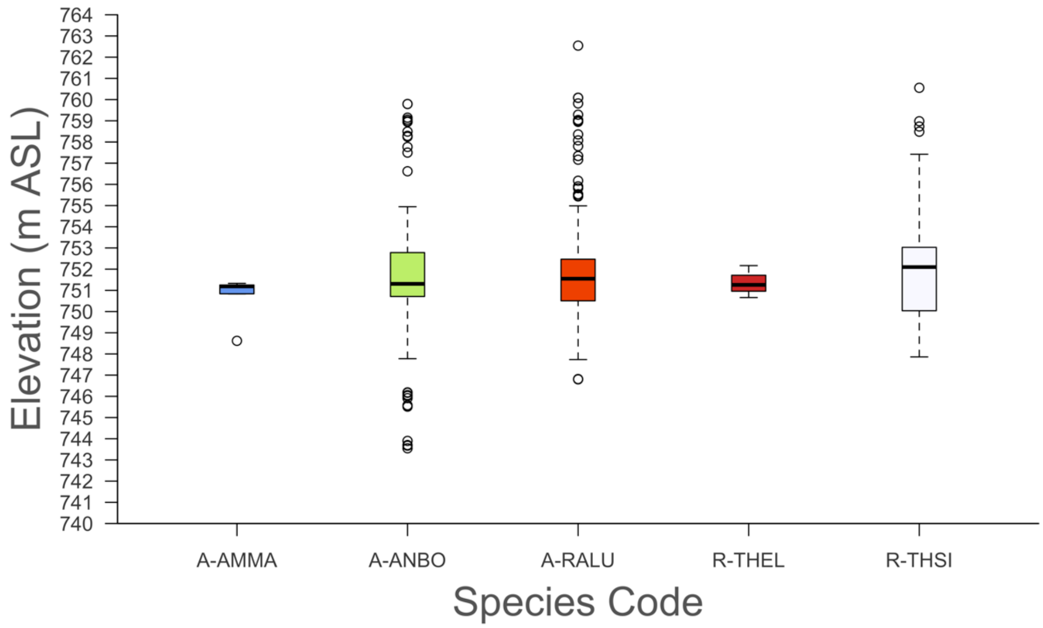

Figure 5-6: Elevation distribution of amphibians and reptiles (number of observations, all life stages combined) documented in and adjacent to the drawdown zone of Kinbasket Reservoir in 2017. A-AMMA = Long-toed Salamander, A-ANBO = Western Toad, A-RALU = Columbia Spotted Frog, R-THEL = Western Terrestrial Garter Snake, R-THSI = Common Garter Snake

Western Toad and Columbia Spotted Frog were distributed across an elevation range of 743 to 763 m ASL. The largest aggregations of both species were observed between ~748 and 755 m ASL, which is related to the distribution of wetlands in the drawdown zone (see Section 6.11.6). In 2017, salamanders were recorded in ponds around ~751 m ASL; however, one observation of a dead adult in early spring in the drawdown zone at Valemount Peatland was recorded (~748 m ASL). The distribution of snakes in Kinbasket Reservoir overlapped that of amphibians in most cases: Common Garter Snake were typically found between 748 and 757 m ASL; Western Terrestrial Garter Snakes were found within a narrower range of elevation around 751 m ASL.

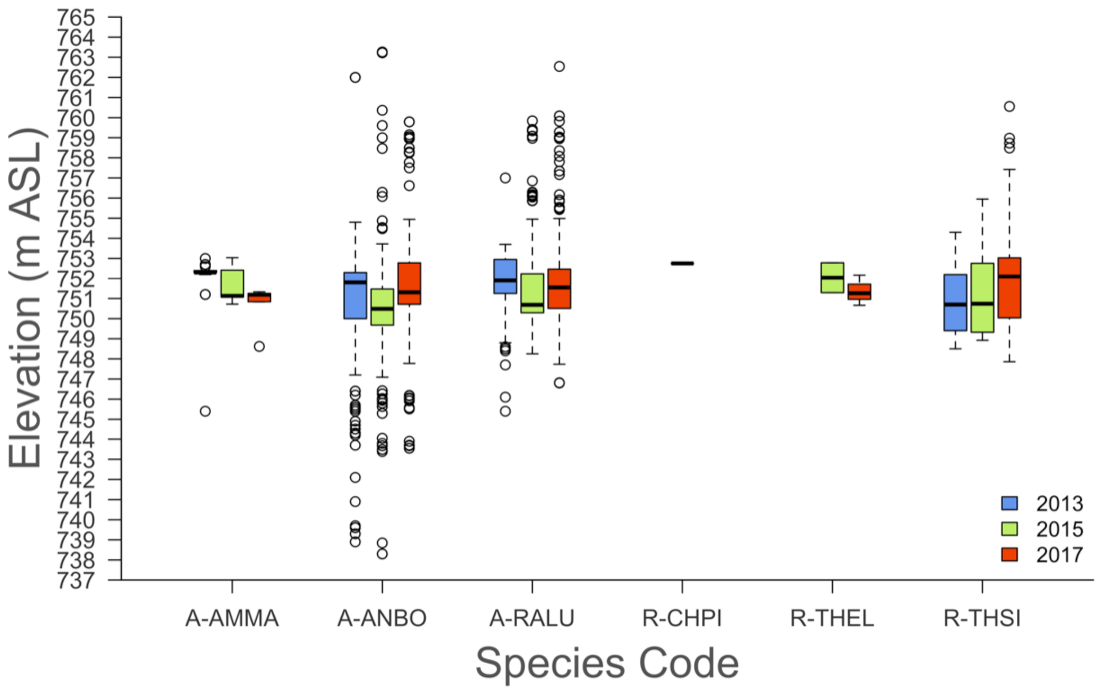

Figure 5-7: Elevation distribution of amphibians and reptiles (number of observations, all life stages combined) documented in and adjacent to the drawdown zone of Kinbasket Reservoir in 2013, 2015, and 2017. A-AMMA = Long-toed Salamander, A-ANBO = Western Toad, A-RALU = Columbia Spotted Frog, R-CHPI = Painted Turtle, R-THEL = Western Terrestrial Garter Snake, R-THSI = Common Garter Snake

5.3.4 Pond and Wetland Habitat in the Drawdown Zone

One hundred and sixty-four ponds ranging from 0.001 ha to 0.97 ha have been delineated across the years in and adjacent to the drawdown zone of Kinbasket Reservoir. Most ponds (n=149) mapped were < 0.15 ha. Pond habitat occurs between 734 and 756 m ASL and most of the amphibian and reptile observations made in 2017 occurred between 744 and 754 m ASL (Figure 5-8).

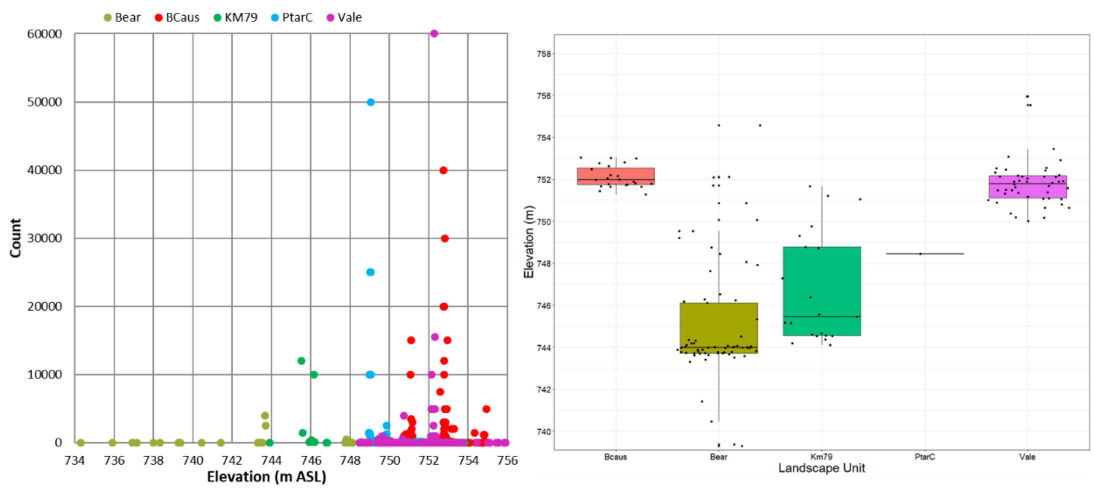

Figure 5-8: Elevation distribution of amphibians and reptiles detected in 2017 (all species pooled including larval life stages; left) and elevation distribution of mapped ponds (right) in the drawdown zone of Kinbasket Reservoir by landscape unit. Bcaus = Bush Arm Causeway, Bear = Bear Island; Km79 = 79 km along Bush Forest Service Road, PtarC = Ptarmigan Creek; Vale = Valemount Peatland

5.3.5 Vegetation Community Associations

Habitat use by Western Toad and Columbia Spotted Frog was compared to the vegetation community mapping that was completed for CLBMON-10 (Figure 5-9). Overall, Western Toad are generalists in terms of their habitat use, and detections were made across multiple habitat types, whereas Columbia Spotted Frog were found most often in the wetter wool-grass–Pennsylvania buttercup (WB) habitats. Vegetation communities in which amphibians were found were distributed between ~740 m and 754 m ASL (Figure 5-9).

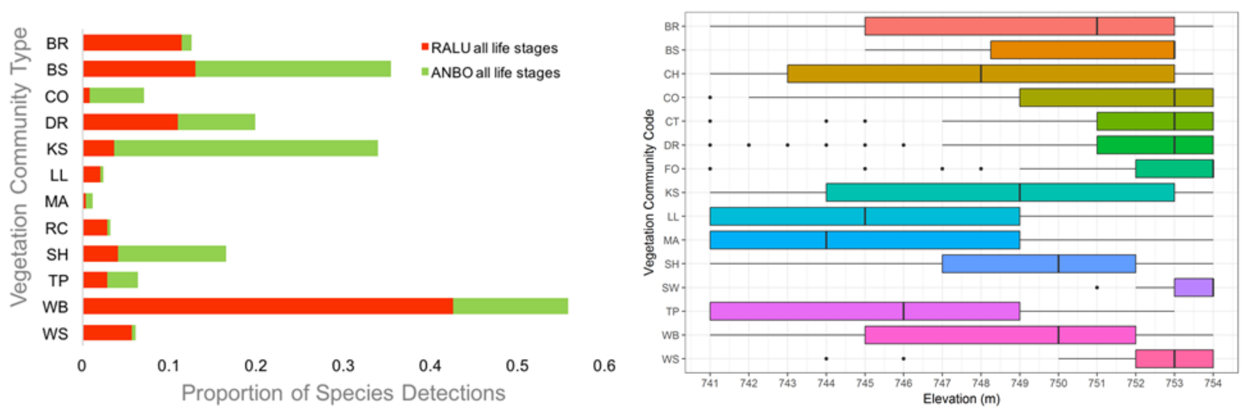

Figure 5-9: Distribution of Western Toad and Columbia Spotted Frog (all life stages grouped) by Vegetation Community Type/Code in the drawdown zone of Kinbasket Reservoir in 2017 (left panel) and elevation distribution of the same Vegetation Community Code (right panel). ANBO = Western Toad, RALU = Columbia Spotted Frog; BR = bluejoint reedgrass, BS = buckbean-slender sedge, CH = common horsetail, CO = clover–oxeye daisy, DR = driftwood, FO = forest, KS = Kellogg's sedge, LL = lady's thumb-lamb's quarter, MA = marsh cudweed–annual hairgrass, SH = swamp horsetail, SW = shrub willow, TP = toadrush-pond water starwort, WB = wool-grass–Pennsylvania buttercup, WS = willow–sedge. See Hawkes et al. (2013) for descriptions of each habitat type

The vegetation communities with the most detections for Western Toad and Columbia Spotted Frog (WB and KS) were situated between ~744 and 753 m ASL (Figure 5-9). A large proportion of all ponds mapped in the drawdown zone (48.4 per cent; 5.5 ha) occurred in these two vegetation communities (WB: 29.9 per cent; 3.4 ha; KS: 10.7 per cent; 1.2 ha), so the presence of amphibians in these communities is not surprising. Few observations occurred in the toadrush-pond water starwort (TP) community despite >10 per cent of all ponds occurring there. The lack of observations is likely because the TP community typically occurs at lower elevations than the other four communities (Figure 5-9).

The general use of habitats in the drawdown zone by both amphibian species suggests that even if vegetation communities change over time, the patterns of amphibian use of the drawdown zone are likely to persist. This is because species distributions are more likely a reflection of suitable breeding habitat (i.e., pond areas) and determinants of habitat quality (i.e., suitable habitat for purposes other than breeding) rather than vegetation community alone. In general, amphibians tend to use breeding ponds that are small, shallow, and warm. Columbia Spotted Frog tend to breed in more specific habitats, such as in wet habitats associated with the WB vegetation community (Figure 5-10). In contrast, Western Toad tends to use a wide range of elevations and was most often observed breeding in ponds in the swamp-horsetail vegetation community (SH). Ponds used by Western Toad for breeding were typically devoid of vegetation.

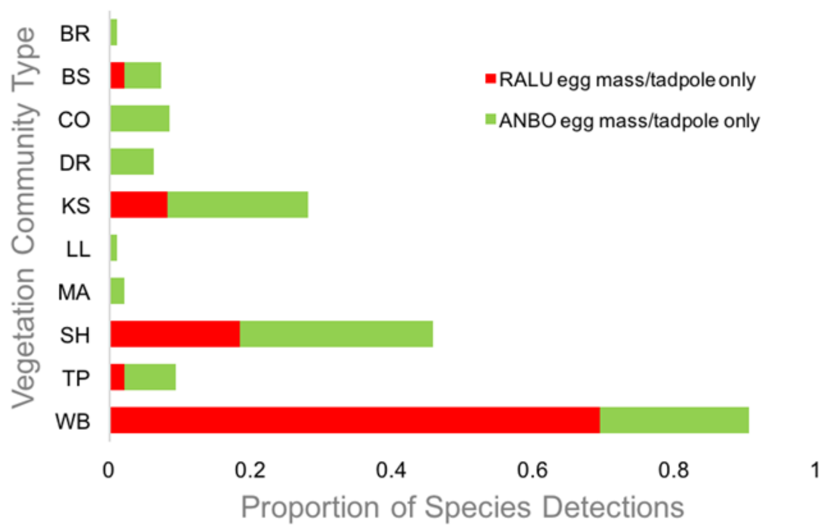

Figure 5-10: Distribution of Western Toad and Columbia Spotted Frog (egg masses and tadpoles only) by vegetation community class in the drawdown zone of Kinbasket Reservoir in 2017. ANBO = Western Toad, RALU = Columbia Spotted Frog; BR = bluejoint reedgrass, BS = buckbean-slender sedge, CO = clover–oxeye daisy, DR = driftwood, KS = Kellogg's sedge, LL = lady's thumb-lamb's quarter, MA = marsh cudweed–annual hairgrass, SH = swamp horsetail, TP = toadrush-pond water starwort, WB = wool-grass–Pennsylvania buttercup. See Hawkes et al. (2013) for descriptions of each habitat type

5.3.6 Radiotelemetry

In 2017, 15 Common Garter Snake (all females) were captured and fitted with radio transmitters in the Valemount Peatland. Snakes ranged in size from 472 mm to

771 mm SVL and 34 to 229 g. Animals were tagged and tracked between May 2nd and August 27th, both in the drawdown zone and into upland habitat where all snakes overwintered. Specific results for 2015, 2016 and 2017 will be provided in the 2018 report after completion of the Master's study.

6.0 DISCUSSION

The relationship between habitats occurring in the drawdown zone of hydroelectric reservoirs and their use by amphibians and reptiles has not been well-studied (but see Swan et al. 2015). While suitable habitat may exist in the drawdown zone of these reservoirs, reservoir operations can affect the suitability and availability of those habitats within and between years. In Kinbasket Reservoir, the relationship between reservoir operations and the distribution and occurrence of amphibians and reptiles has been studied since 2008. Beginning in 2011, a more intensive study on amphibian survivorship was implemented to understand what the implications of increasing reservoir elevations by 0.6 m during the summer months might be. The predicted increase is related to the installation of units 5 and 6 at Mica Dam, which was completed in 2015.

Reservoir operations do affect the availability and suitability of habitats in the drawdown zone, with large reductions in total available habitat (due to inundation) occurring on an annual basis. Despite a seasonal reduction in total available habitat because of increasing reservoir elevations and the associated changes in some water physicochemical parameters, amphibian and reptile populations are persisting in the drawdown zone of Kinbasket Reservoir. This is likely due to the timing of breeding in the spring and the timing of inundation of breeding habitats which happens late enough in the year to permit larval development. Because of this, the predicted increases in reservoir elevation of 0.6 m during the summer months associated with the installation and operation of units 5 and 6 at Mica Dam is unlikely to negatively impact pond-breeding amphibian populations or their predators (garter snakes) directly. However, there are likely to be direct effects on amphibian habitat resulting mainly from the vertical and horizontal movement and depositions of large rafts of wood debris if Kinbasket Reservoir is filled more frequently because of the predicted increase.

To better assess the within and between season use of the drawdown zone by amphibians and reptiles, a radiotelemetry study for northern Kinbasket Reservoir was piloted in 2014 (Western Toad and Common Garter Snake) and continued in 2015 through 2017 (snakes only). The results to date indicate that Common Garter Snake use the drawdown zone for spring and summer foraging, with all tagged individuals retreating to upland habitat for overwintering. Although we have not documented over-wintering locations used by Western Toad, we presume they occur in upland habitats, consistent with other studies (e.g., Bull 2006). More data are required to characterize the seasonal habitat (especially winter) use for other species (Columbia Spotted Frog, Long-toed Salamander).

6.1 MQ1: Which species of amphibians and reptiles occur (utilize habitat) within the drawdown zone and where do they occur?

Five expected species have been documented using the drawdown zone and adjacent upland habitat of Kinbasket Reservoir (Table 5-2). Two additional unexpected observations were made in 2015: one Pacific Chorus Frog (auditory only) was documented in the Valemount Peatland and one Western Painted Turtle was observed at Bush Arm KM88. More detections of these species at these sites are required to confirm occupancy (i.e., turtle could have been an introduction by human release), as a single detection in one year does not provide conclusive evidence that a species (or population of that species) occurs there. The most commonly occurring species in Kinbasket Reservoir are Western Toad, Columbia Spotted Frog and Common Garter Snake. These three species are widespread across B.C. (Matsuda et al. 2006) and are locally abundant at most of the monitoring locations. The most productive sites in Kinbasket Reservoir are Bush Arm KM79 marshes, Bush Arm Causeway, Valemount Peatland and Ptarmigan Creek.

6.2 MQ2: What is the abundance, diversity, and productivity (reproduction) of amphibians and reptiles utilizing the drawdown zone and how do these vary within and between years?

6.2.1 Amphibian Abundance, Diversity and Productivity

Amphibian abundances (detection rates) vary from year to year and in general, there are more detections in the spring than in the summer or early fall. Spring surveys coincide with the peak of the breeding season when most adults are migrating to and from breeding ponds and are therefore more conspicuous. This trend was apparent in all years and in particular, for Western Toad. It is unknown if the seasonal variation observed in the drawdown zone is similar to the seasonal variation associated with non-reservoir populations of toads and frogs. For example, inundation of breeding ponds (i.e., cooler water temperatures) could affect the timing of metamorphosis (and therefore presence of tadpoles) differently than in ponds above the reservoir's influence.

Amphibian species diversity has not varied substantively by year, ranging from 0.34 to 0.41, which is related primarily to the total number of detections made each year combined with within season differences that contribute to inconstant detectability. Although diversity has not varied, detection rates have (see previous section), which is not surprising. Amphibian populations naturally exhibit large degrees of variation with the number detected a function of current environmental conditions, overwinter survival, and predation pressure (Hansen et al. 2012). Some species (e.g., Long-toed Salamander) are often difficult to locate because they have an early breeding period and are inconspicuous during the remainder of the year (Wilkinson and Hanus 2002). Although Long-toed Salamander have been documented from only a few locations, they are likely distributed throughout Kinbasket Reservoir and adjacent upland habitats, particularly in areas with suitable breeding habitat. Auditory surveys and additional visual encounter surveys will have to be conducted to confirm presence of Pacific Chorus Frog in the Valemount Peatland or elsewhere in the reservoir.

Amphibian productivity: We currently know which amphibian species (Western Toad, Columbia Spotted Frog, and Long-toed Salamander) use the DDZ for reproduction (inferring productivity), and data collected for two species (Western Toad and Columbia Spotted Frog) indicate that all life stages of this species (i.e., eggs, tadpoles, toadlets, and adults) use habitats in the drawdown zone. Qualitatively, it appears that the productivity of both Western Toad and Columbia Spotted Frog is consistent between years, as egg masses and adults have been repeatedly detected at the same pond locations each year (e.g., Ptarmigan Creek, various locations in the Valemount Peatland, and KM79). Further, in the absence of a suitable control or baseline data from ponds outside of the drawdown zone of Kinbasket Reservoir, we cannot know for certain how productivity is affected by reservoir operations. Species-specific and individual fecundity has not been assessed and is therefore not discussed.

6.2.2 Reptile Abundance, Diversity and Productivity

Reptile abundances (detection rates) vary annually and seasonally; however, small samples sizes limit our ability to discuss within-season trends.

Reptile species diversity is typically low ranging from 0 (i.e., a single species) to .09 [indicative of three species with few detections per species (<60)]. One species, Common Garter Snake, has been observed annually using habitats in the drawdown zone (especially at Ptarmigan Creek and in the Valemount Peatland). Western Terrestrial Garter Snake have not been observed as frequently in the drawdown zone but are known to occur in the upland habitats immediately adjacent to the drawdown zone. In 2015, an observation of a single adult Western Painted Turtle was made at KM88 (near the mouth of Bush Arm, the first observation of this species in the drawdown zone of Kinbasket Reservoir); however it is not known if (1) more than one turtle is present at this or other sites, or (2) what the origin of this individual is (i.e., we don't know if there is a resident/native population of turtles in Kinbasket Reservoir). No turtles were observed in 2016 or 2017.

Reptile productivity is not readily assessed under CLBMON-58, largely because reptile productivity is not directly linked to the presence or absence of water. There are no records for Painted Turtle nest sites for Kinbasket Reservoir, but searches will occur in 2018 at KM88, where the turtle was spotted in 2015. Reproduction for garter snakes likely occurs near overwintering sites (Garstka et al. 1982; Kromher 2004) which are outside of the DDZ. However, because of the value of DDZ habitats to pond-breeding amphibians, which snakes use as a primary food resource, reservoir operations could impact reptile populations. While it is relatively easy to measure direct productivity in captured female snakes (e.g., counting eggs internally in gravid females), it does not follow that females are necessarily using the DDZ in the same way foraging snakes are, since females generally do not feed as frequently during pregnancy (Tuttle and Gregory 2009). Assessing reptile productivity requires intensive studies using radiotelemetry and is well-suited to a graduate program (Tuttle and Gregory 2014). The results from the radiotelemetry study conducted in Kinbasket Reservoir in 2016 and 2017 will help to answer this question (will be included in 2018 reports).

6.3 MQ3: During what portion of their life history (e.g., breeding, foraging, and over-wintering) do amphibians and reptiles utilize the drawdown zone?

Our current understanding of the use of the drawdown zone by amphibians and reptiles is that frogs and toads use the DDZ to fulfill most of their life history stages (e.g., breeding and foraging), while other species (e.g., Long-toed Salamander, garter snakes) appear to use the DDZ to fulfill specific life stages. We do not have enough data for Long-toed Salamander, Western Painted Turtle, Pacific Chorus Frog, or on both species of garter snake to determine how they are using the DDZ. Long-toed Salamander are not always easy to detect, so their perceived lower levels of use of the DDZ (e.g., mainly restricted to egg mass observations) may be related to their cryptic nature and not necessarily to their absence from the DDZ.

Use of the drawdown zone for overwintering is considered unlikely for most species; Columbia Spotted Frog and possibly Painted Turtle may overwinter in ponds in the drawdown zone. Water bodies that are deep enough that they do not freeze on the bottom are required for overwintering frog adults, juveniles and possibly larvae (Bull and Hayes 2002; Bull 2005). Freezing depth has not been assessed for ponds in the drawdown zone of Kinbasket Reservoir.

6.4 MQ4: Which habitats do reptiles and amphibians use in the drawdown zone and what are their characteristics (e.g., pond size, water depth, water quality, vegetation, elevation band)?

Many species of amphibians that occur in and adjacent to the drawdown zone depend on aquatic habitats to fulfill their life requisites (Duellman and Trueb 1986; Duellman 2007; Wells 2007); several regions of the Kinbasket Reservoir drawdown zone contain aquatic habitat features, which are used by several amphibian species for reproduction. Snakes, on the other hand, use habitats in the drawdown zone mainly for foraging because amphibians are their primary prey. Turtles, similar to the population in Revelstoke Reach, likely use the drawdown for most life requisites; however, with only a single observation at this point, this species is left out of the discussion.

The species of amphibians using the drawdown zone of Kinbasket Reservoir are all pond-breeders. In the spring, these species migrate to ponds, breed, lay eggs, and then move into their spring and summer foraging habitat. Small, isolated wetlands can be critical to the persistence of amphibians that possess complex life cycles (Hopkins 2007). These habitat features are common in certain regions of the drawdown zone of Kinbasket Reservoir and are affected on an annual basis to varying degrees depending on the elevation at which they are situated and on reservoir operations. At present we have delineated pond and non-pond habitat for the drawdown zone and assessed how biotic and abiotic pond qualities are related to amphibian use and vary with respect to reservoir operations (Hawkes and Tuttle 2012).

Pond depth has not been assessed for all ponds delineated, but amphibian observations occurred in water ranging from two to 20 cm and most observations were made within 100 cm of the shore line. Ponds delineated in the drawdown zone were typically vegetated with species such as *Potamogeton pusillus* (small pondweed), *Nuphar polysepala* (Rocky Mountain Pond-lily), *Sparganium angustifolium* (Narrow-leaved Bur-reed), *Myriophyllum spp.* (Eurasian Water-Milfoil/Siberian Water Milfoil), and *Equisetum fluviatile* (Swamp Horsetail). Ponds occurring at elevations < ~739 m ASL were typically unvegetated and can be characterized as shallow ponds with fine mud and organic sediment comprising the bottom substrate. These ponds were used only by Western Toad.

We correlated species presence with vegetation communities mapped in the drawdown zone (using vegetation communities classified under CLBMON-10) and measured the water chemistry of ponds with and without amphibians. Most species were found in the wetland-associated habitat types (wool-grass–Pennsylvania buttercup, Kellogg's sedge, buckbean-slender sedge, and swamp-horsetail; see Section 5.3.5). Western Toad use a wider range of elevations (743–754 m ASL) than Columbia Spotted Frog (747–756 m ASL).

Western Toad and Columbia Spotted Frog presence in breeding ponds was dependent on vegetation community, pond size, and elevation to varying degrees (see Section 5.3.4); however, in general, both species used a wide range of pond sizes and tend to occupy most available habitat. In general, amphibians tend to use breeding ponds that are small, shallow, and warm. These ponds typically have high levels of dissolved oxygen. Columbia Spotted Frog tends to be found at higher elevations, in wet habitats associated with the wool-grass–Pennsylvania buttercup vegetation community. In contrast, Western Toad tends to use a wide range of elevations and is most often present in swamp horse-tail vegetation community. Ponds used by Western Toad for breeding were typically devoid of vegetation.

6.5 MQ5: How do reservoir operations influence or impact amphibians and reptiles directly (e.g., desiccation, inundation, predation) or indirectly through habitat changes?

Direct impacts of reservoir operations on amphibians and reptiles have not been observed in the drawdown zone of Kinbasket Reservoir. We have observed desiccation at breeding ponds, but this is likely related to natural causes (e.g., rapid pond drying rate, absence of rain, etc.), and not to reservoir operations; the inundation of the drawdown zone would have the opposite effect. Egg string and egg mass stranding have been observed at various locations in the drawdown zone and is usually associated with decreasing hydroperiod at oviposition sites, which can be a major cause of death to developing embryos. This phenomenon is not unique to drawdown zones (e.g., Marco and Blaustein 1998). Local environmental conditions can influence the hydroperiod of breeding ponds and are likely confounding any potential reservoir effects that may be linked to egg mass stranding. The normal operating regime of Kinbasket Reservoir is to fill in the spring between April and June (Figure 3-2) and because this coincides with the egg-laying period for amphibians, it is unlikely that reservoir-caused desiccation is an issue.

Water physicochemical parameters measured in ponds in the drawdown zone suggest little evidence of an effect of dissolved oxygen, pH, water temperature, or conductivity on amphibian use or development (see Section 5.2). Of these parameters, water temperature can influence tadpole development to some degree (Crowder et al. 1998; Ultsch et al. 1999). However, the effects of reservoir inundation on water temperature and subsequent tadpole development are equivocal with no apparent direct effect on amphibians using the drawdown zone of Kinbasket Reservoir. The ability to directly measure the potential effects of changing physicochemical parameters on amphibians is confounded by reservoir operations, which vary annually.

Reservoir operations do impact habitat through changes in availability of breeding and foraging habitat of amphibians and reptiles using the drawdown zone, both directly and indirectly (Figure 6-7). Habitat availability varies by month and year relative to reservoir operations and is a function of reservoir elevation (see Section 6.11.6). The number of amphibian and reptile observations often decreased as reservoir elevations increased. The seasonal changes in habitat availability affect the distribution of amphibians and the additive effects of annual displacement are currently unknown. Although inundation affects habitat availability directly, we have consistently observed only minor changes in water physicochemical parameters over the years and all life stages of both anuran species were observed in 2017. Because amphibians are persisting in the drawdown zone, we can speculate that the annual reduction of habitat availability does not dramatically affect local amphibian populations; however, we do not know if the populations are supressed relative to populations in non-reservoir habitats.

A review of data presented in Hawkes and Gibeau (2017) suggests that although the distribution and extent of vegetation communities defined in the drawdown zone of Kinbasket Reservoir have varied over time, there is no indication that this variation has resulted in large-scale changes to habitats used by amphibians and reptiles. A recent assessment of the effects of inundation on vegetation in the drawdown zone of Kinbasket Reservoir was conducted in the fall of 2015. Preliminary results suggest that the vegetation will benefit from some level of inundation. Too much inundation, or none, results in reduced plant vigour and increased mortality. The extent to which inundation affects wetland productivity is the focus of another study (CLBMON-61) and data from that study could be used to better understand the relationships between amphibian habitat productivity and reservoir operations.

6.6 MQ6: Can minor adjustments be made to reservoir operations to minimize the impact on amphibians and reptiles?

The data collected to date suggest that current reservoir operations reduce the amount of habitat available for use by amphibians and reptiles, which varies both seasonally and annually. The direct effects of reservoir operations on amphibian and reptiles are related to temporal and spatial displacement from shallow wetland habitats, which are in short supply in the drawdown zone of Kinbasket Reservoir. Although we have a considerable amount of data regarding the occurrence and distribution of Western Toad and Columbia Spotted Frog that suggests these species are persisting in the drawdown zone, we do not currently have enough occurrence or abundance data to provide an assessment for any other species using the drawdown zone.

The limited amount of breeding habitat available in the drawdown zone should be considered relative to reservoir operations. Some ponds at lower elevations in Bush Arm are used by Western Toad for breeding (e.g., breeding ponds at KM88). These ponds are situated between 735 and 744 m ASL, and although they comprise a small number of ponds, they could be considered for protection to minimize impacts to toads. By protection, we suggest that delaying the inundation of elevations between 735 and 736 m ASL into late June would likely afford enough time for eggs to hatch into tadpoles and provide enough time for the tadpoles to grow such that the effects of inundation would be minimized.

The variable way Kinbasket Reservoir is managed creates somewhat of a conundrum with respect to this management question. In general, the operation of Kinbasket Reservoir from 2011 to 2017 does not appear to have had a direct effect on amphibians and reptiles using the drawdown zone. However, because reservoir operation changes from year to year, it is difficult to identify any one management regimen to change. A management strategy to avoid involves rapidly filling the reservoir in the spring when amphibians are breeding in ponds in the drawdown zone. Doing so would likely affect the annual fecundity of all species of pond-breeding amphibians. See also Section 6.10.

6.7 MQ7: Can physical works projects be designed to mitigate adverse impacts on amphibians and reptiles resulting from reservoir operations?

The answer to this question is currently "yes". The removal of wood debris from wetlands, which was done as part of a physical works project in Kinbasket Reservoir improved the suitability of those wetlands for amphibians. Although not measured, the improvement of wetland suitability in the drawdown zone Kinbasket Reservoir is expected to benefit reptiles through increased food viability. There are others areas in the drawdown zone of Kinbasket reservoir (e.g., Pond 12 in the Valemount Peatland and additional areas at the Causeway) that would benefit from wood debris removal to enhance wetland habitat suitability. The use of physical works to mitigate adverse impacts on amphibians and reptiles resulting from reservoir operations will be limited in scale as only certain portions of the drawdown zone can be manipulated to improve habitat suitability. The long-term efficacy of physical works to continue to provide suitable habitat for amphibians and reptiles relative to normal reservoir operations (including filling to the normal operational maximum) requires study.

6.8 MQ8: Does revegetating the drawdown zone affect the availability and use of habitat by amphibians and reptiles?

For Kinbasket the answer is "no", revegetating the drawdown zone does not affect the availability and use of habitat by wildlife. Portions of the DDZ of Kinbasket Reservoir were revegetated using a variety of techniques, including live staking, seeding, seedlings and fertilizers (CLBWORKS-1). The revegetation program did not include improvements to amphibian and reptile habitat suitability as a primary objective. As of 2016, most of the revegetation treatments applied in the drawdown zone of Kinbasket Reservoir have failed (Hawkes and Miller 2016). The one area showing signs of success (Bear Island) was not revegetated to benefit amphibians and reptiles and the longer-term survival of those plants has yet to be determined.

6.9 MQ9: Do physical works projects implemented during the course of this monitoring program increase the abundance of amphibians and reptiles abundance, diversity, or productivity?

The physical works implemented in Kinbasket Reservoir in 2015 have resulted in Western Toad using previously unavailable wetlands for breeding. As such, there is evidence to support an increase in productivity for certain species via the removal of wood debris from wetlands. There is no expectation that the diversity of amphibians or reptiles will change as a result of physical works in Kinbasket Reservoir and abundance may increase in previously unused habitats, but it is unknown if this increase will result in a net change in abundance over time.

6.10 MQ10: Do increased reservoir levels in Kinbasket Reservoir during the summer months resulting from the installation of Mica 5 and 6 negatively impact amphibian populations in the drawdown zone through increased larval mortality or delayed development?

Consistent with previous years our data do not support a qualitative assessment of increased larval mortality rates or delayed development for either Western Toad or Columbia Spotted Frog. For example, we know that all life stages of Western Toad and Columbia Spotted Frog use the drawdown zone at different times during the active season (April through September). In all years of study we have observed all life stages of toads and frogs from the same locations in the drawdown zone (e.g., Valemount Peatland, KM88, Bush Arm Causeway, and Ptarmigan Creek). Metamorph toadlets have also been documented emerging from the same drawdown zone locations in multiple years, which provides an indication of how this species uses (and possibly relies upon) habitats within the drawdown zone to fulfill its life requisites. Certain species, like Columbia Spotted Frog and Long-toed Salamander are abundant, but some life stages are seldom seen. For example, transforming froglets are rarely observed, as are Long-toed Salamander (all life stages), which is a function of survey timing and the cryptic nature of these species. In certain locations, Columbia Spotted Frog egg masses provide the best evidence of use.

Mortality rates are difficult to assess, which is related to our inability to track individual egg masses over time because of changes in reservoir elevations, which precludes tracking egg strings or egg masses at different elevations from the time of deposition to metamorphosis. As such, stage-specific (i.e., hatching rates or proportion of tadpoles that metamorphose) mortality rates are unlikely to be accurately measured or reported during this study.

Based on reservoir operations between 2011 and 2017, an increase in reservoir elevation of 0.6 m is unlikely to have a large effect on amphibian and reptile populations that use the drawdown zone of Kinbasket Reservoir. This conclusion is somewhat confounded by the fact that Kinbasket Reservoir is managed differently each year. For example, reservoir management in 2011 followed a typical pattern with low levels in the spring and filling into late summer and early fall. In 2012 and 2013, the reservoir was surcharged (i.e., filled beyond the normal maximum), managed with a typical pattern in 2014, 2016 and 2017, and maintained a lower than average levels in 2015 (Figure 3-2).

Of the various reservoir management regimes reviewed, surcharge may represent the worst-case scenario with respect to reservoir management. A review of historical reservoir data indicates that Kinbasket Reservoir was surcharged seven times between 1978 and 2017. Adding 0.6 m to each year of historical data (to simulate the addition of units 5 and 6 at Mica Dam) increases the frequency of surcharge to 36.8 per cent, or 14 of 39 years (1978 to 2017; Figure 6-1). However, the anticipated increase in reservoir surcharging is not likely to directly affect amphibian populations, but indirect effects are likely. Important habitats will be impacted, particularly those ponds situated above 751 m ASL (which represents ~64 per cent of all ponds mapped in the drawdown zone). Impacts will be mainly related to changes in habitat suitability caused by wood deposition and changes to aquatic and riparian vegetation communities that could affect the primary productivity of wetlands (see Table 6-1). The effects of these changes are not likely to result in immediate effects to habitat quality and are likely to be studied directly by CLBMON-61. Data from that program should be examined to determine how wetland productivity is affected by reservoir operations and as a result of the installation of units 5 and 6 at Mica Dam.

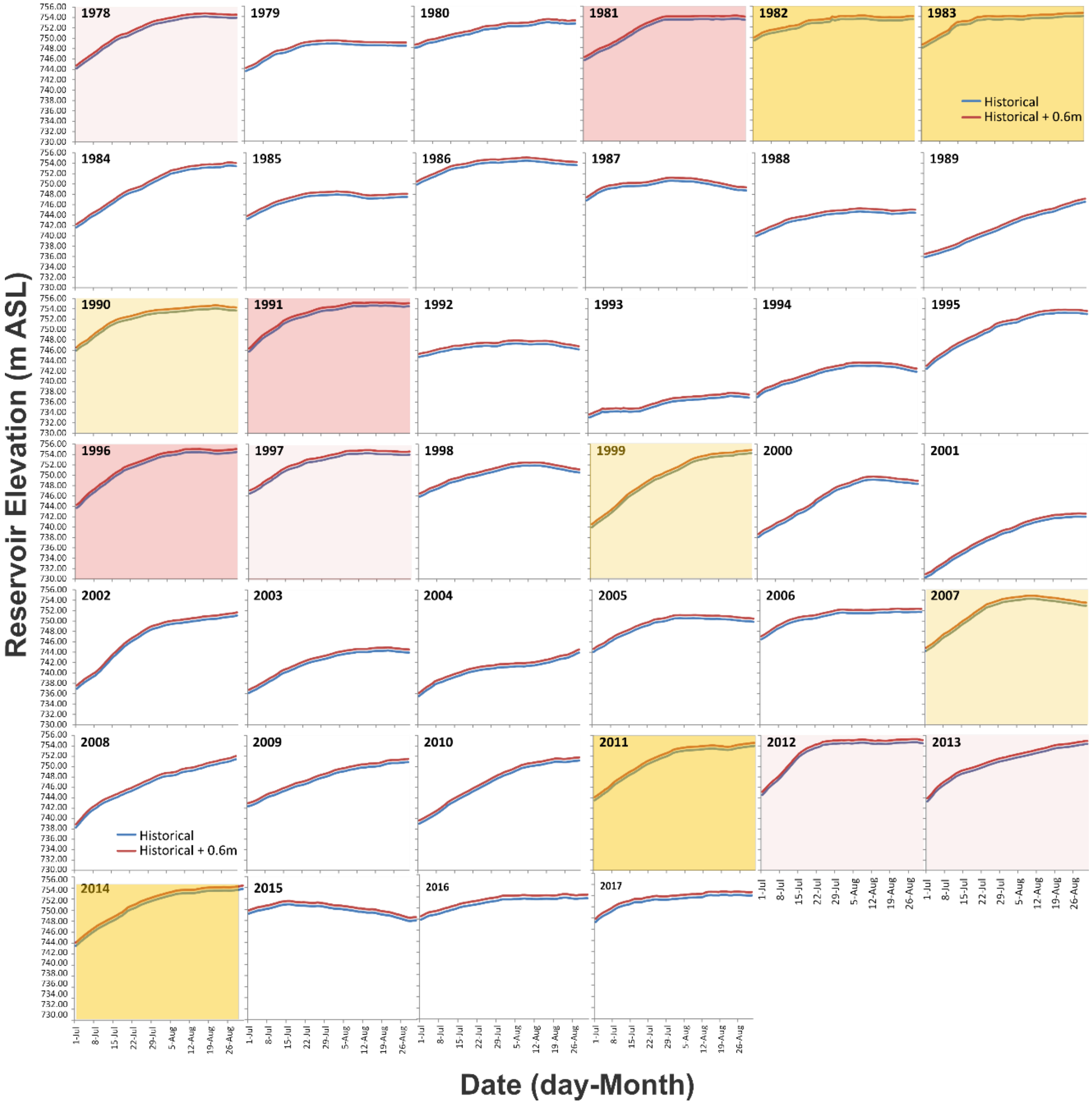

Figure 6-1: Historical reservoir elevations measured in July and August 1978 to 2017, with and without 60 cm added to simulate the addition of units 5 and 6 at Mica Dam. Red shading indicates the years Kinbasket was filled to elevations > 754.38 m ASL (i.e., surcharged). Yellow shading indicates the additional years when Kinbasket would have been surcharged if the reservoir was filled 60 cm more than the historical maximums

Effects on amphibians resulting from surcharge need to be considered not only relative to maximum reservoir elevations, but relative to the date at which maximum reservoir elevations were achieved. Between 1978 and 2017, the date at which maximal elevations were achieved was earliest in 1987 (August 2) and latest is 2014 (November 9). Between 1987 and 2017 the average date of full pool was August 25. In years when Kinbasket was surcharged, the earliest date the reservoir reached full pool was August 2 (2007) and the latest was October 2 (1997) with an average fill date of September 1. By this time (i.e., August 25 or

September 1), amphibian eggs have hatched, and free-swimming tadpoles are either beginning to metamorphose or have fully transformed to froglets and toadlets. This further suggests that reservoir elevations and the current timing of full pool are not likely to directly impact amphibian populations using habitats in the drawdown zone of Kinbasket Reservoir.

If the timing of full pool or surcharge changed relative to historical data, and in particular if reservoir filling occurred earlier in the summer (i.e., July) there could be impacts to various life stages of amphibians using the drawdown zone including changes to egg and larval development, increased predatory pressure, and potential changes to habitat suitability resulting from wood debris transport or changes to vegetation and physicochemical attributes (Table 6-1). Given that reservoir elevations are predicted to increase in the summer months, achieving full pool in July is not recommended and maximum reservoir elevations should be targeted for the current average date of August 25. This will ensure that amphibians using the drawdown zone, particularly those in ponds >751 m ASL, will have enough time to develop prior to inundation.

Table 6-1: Examples of potential worst-case-scenario effects on amphibians resulting from Kinbasket Reservoir elevations exceeding the normal maximum operating elevation by 0.6 m

Potential Impact	Effect on Amphibians	Life Stage
Increased rates of erosion	• Increased turbidity leading to reduced water quality, which could affect larval food resources and larval development • Increased sediment deposition leading to a reduction in water depth, pond area, water temperature, and overall pond suitability (as it relates to breeding)	• Egg masses • Larvae
Changes in vegetation composition and structure at upper elevations	• Reduced habitat suitability near the periphery of breeding habitats (e.g., reduced cover), which could increase rates of predation	• Adults • Sub-adults • Juveniles • Metamorphs
Changes in coarse woody debris conditions near or outside of the DDZ	• Changes to microhabitat conditions (e.g., reduced cover). Indirect effects to foraging opportunities dues to effects on insect communities	• Adults • Sub-adults • Juveniles • Metamorphs
Changes to aquatic characteristics (e.g., DO, conductivity, temperature, pH, etc.) in ponds near the periphery of the DDZ (or those that are not inundated under normal operating conditions	• Potential effects to egg and larval development. • Potential effects to overall suitability of the pond for breeding leading to pond-abandonment	• All life stages
Changes to the biological communities of ponds (e.g., introduction of fish, changes in semi-aquatic and aquatic macrophytes)	• Potential for increased predation risk by fish on amphibian eggs and larvae • Potential changes to available food resources required by developing amphibians	• Egg masses • Larvae

As previously mentioned, garter snake species are unlikely to be directly affected by increased reservoir elevations resulting from the installation of units 5 and 6 at Mica Dam but could be indirectly affected if the abundance of primary food resources changes significantly (e.g., decrease in amphibians). Garter snakes are typically quite plastic in their use of habitat and therefore likely move in response to changes in habitat, food sources, basking locations, etc. What is unknown is how energetically expensive these additional movements may be to snakes that have to follow amphibian food sources around the drawdown zone. Radiotelemetry studies conducted in 2016 and 2017 have identified the locations of reptile overwintering sites, all of which occur outside the drawdown zone of Kinbasket Reservoir.

Our current assessment of the potential effects associated with the installation of Mica units 5 and 6 (Figure 6-3) suggest that an increase of up to 0.6 m relative to current reservoir operating regimes may not adversely affect amphibian larval development. However, if reservoir elevations in Kinbasket Reservoir differ and inundation occurs early in the developmental cycle of amphibians (i.e., during the egg stage or very early in the larval development stage) there could be developmental-related effects such as delayed development or mortality. Similarly, if reservoir elevations are low in the spring and snowpack or rainfall are also low, some ponds in the drawdown zone may not fill, reducing breeding opportunities for pond-breeding amphibians in some years. This may not represent a long-term risk but given climate change and changes to precipitation coupled with predictions for longer, drier, and warmer summers (e.g., Payne et al. 2004), reservoir operations need to be considered in the context of a changing climate and the potential effects on water resources. However, because of the uncertainty associated with most climate change models and the predicted effects on water resources (Christensen and Christensen 2007; Saha 2015), a detailed assessment is required to understand how seasonal changes in precipitation might influence wetlands in the drawdown zone of Kinbasket Reservoir.

6.11 Hypotheses Testing

6.11.1 H1: Annual and seasonal variation in water levels in Kinbasket Reservoir (due to reservoir operations), the implementation of soft operational constraints, and the effects of Units 5 and 6 in Mica Dam on Kinbasket Reservoir, do not directly or indirectly impact reptile and amphibian populations

Effects of Mica 5/6

Empirical data collected prior to Mica Units 5 and 6 operation might not provide an ideal representation of typical four-unit operations. During this time, the operation of Kinbasket Reservoir was operated differently than in previous years (Figure 3-2). Specifically, Kinbasket Reservoir was filled (surcharged) beyond the normal operating maximum in 2012 and 2013, an operation that had not been implemented since 1997 (Figure 6-2).This information is used to facilitate a qualitative assessment of the effects that the installation of units 5 and 6 might have on amphibians using the drawdown zone of Kinbasket Reservoir.

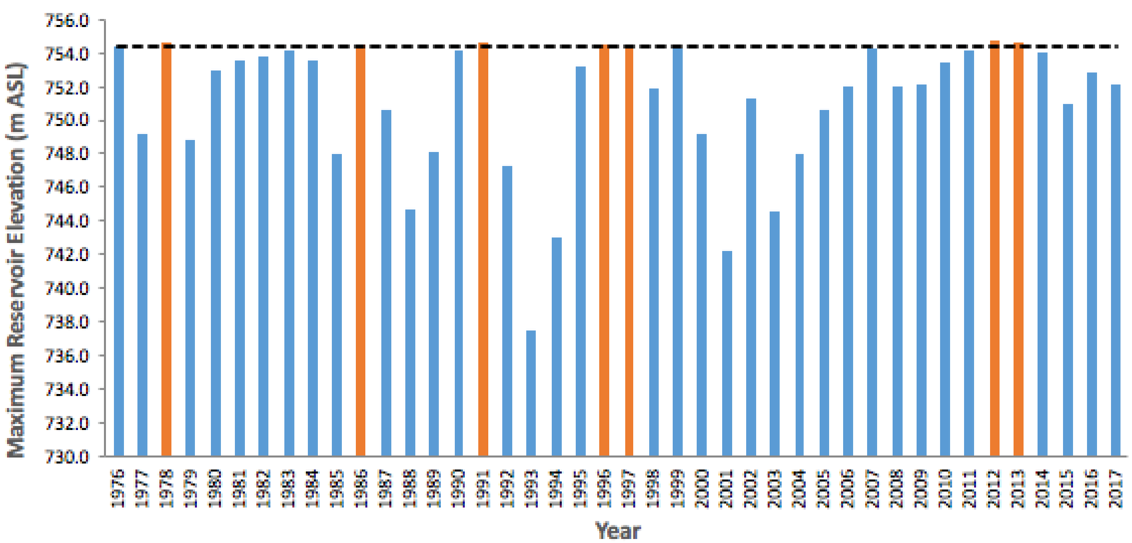

Figure 6-2: Maximum reservoir elevations (metres above sea level, m ASL) achieved in Kinbasket Reservoir, 1976 to 2017. Red bars indicate years when Kinbasket Reservoir was operated beyond the normal operating maximum (black dashed line)

The additional generating capacity associated with the installation of Units 5 and 6 at Mica Creek is predicted to change the reservoir operation towards increase reservoir elevations by 0.6 m during the summer months, which coincides with the period of larval amphibian development. The current operating regime of Kinbasket Reservoir includes a drawdown in the late winter followed by rapid filling in the spring and early summer, with full pool normally attained by late July or August (Figure 3-2). This pattern is repeated annually with some year-to-year variation. Specifically, reservoir fill maxima were higher and occurred earlier from 2011 to 2014, than in all previous monitoring years (i.e., 2008 to 2010; Figure 3-2). With the exception of 2015, where the reservoir operated at a lower than normal maximum height, the potential of direct impacts to amphibians and loss of suitable habitats (see Section 6.11.6) has increased relative to 2008 and the previous decade (Figure 6-2; Figure 6-3).

A lack of observations of the direct effects of reservoir operations on the development, survival, and mortality of amphibians in the drawdown zone of Kinbasket Reservoir precludes a quantitative answer of this management question (i.e., without in situ or lab experiments it is difficult to quantify this relationship). For example, observations of delayed development resulting from temperature changes (reductions) correlated to reservoir filling would be required. Similarly, without observations of mortality events, such as many dead tadpoles at the leading edge of the reservoir as it fills, it is not possible to quantify the direct effect of reservoir operations on amphibians. An assessment of increased predation of tadpoles by fish (via gut analysis) concurrent with reservoir filling could also provide a metric of reservoir-related effects on amphibians. Further, without detailed knowledge of overwintering sites, metamorph habitat use and overwinter survival, we cannot comment on any quantitative effects that the installation of Mica Units 5 and 6 might have on amphibian larval development. However, a qualitative assessment of a 0.6 m increase in reservoir elevations (Figure 6-3) suggests that overall, the impact of reservoir operations on amphibian larval development is likely to be minimal, given that the timing of inundation occurs after eggs have hatched. This appears to be the case regardless of the annual hydrograph because in general, the pattern of reservoir filling is the same, with maximal elevations achieved between the end of June and August, which coincides with the latter stages of tadpole development and transformation to metamorphs.

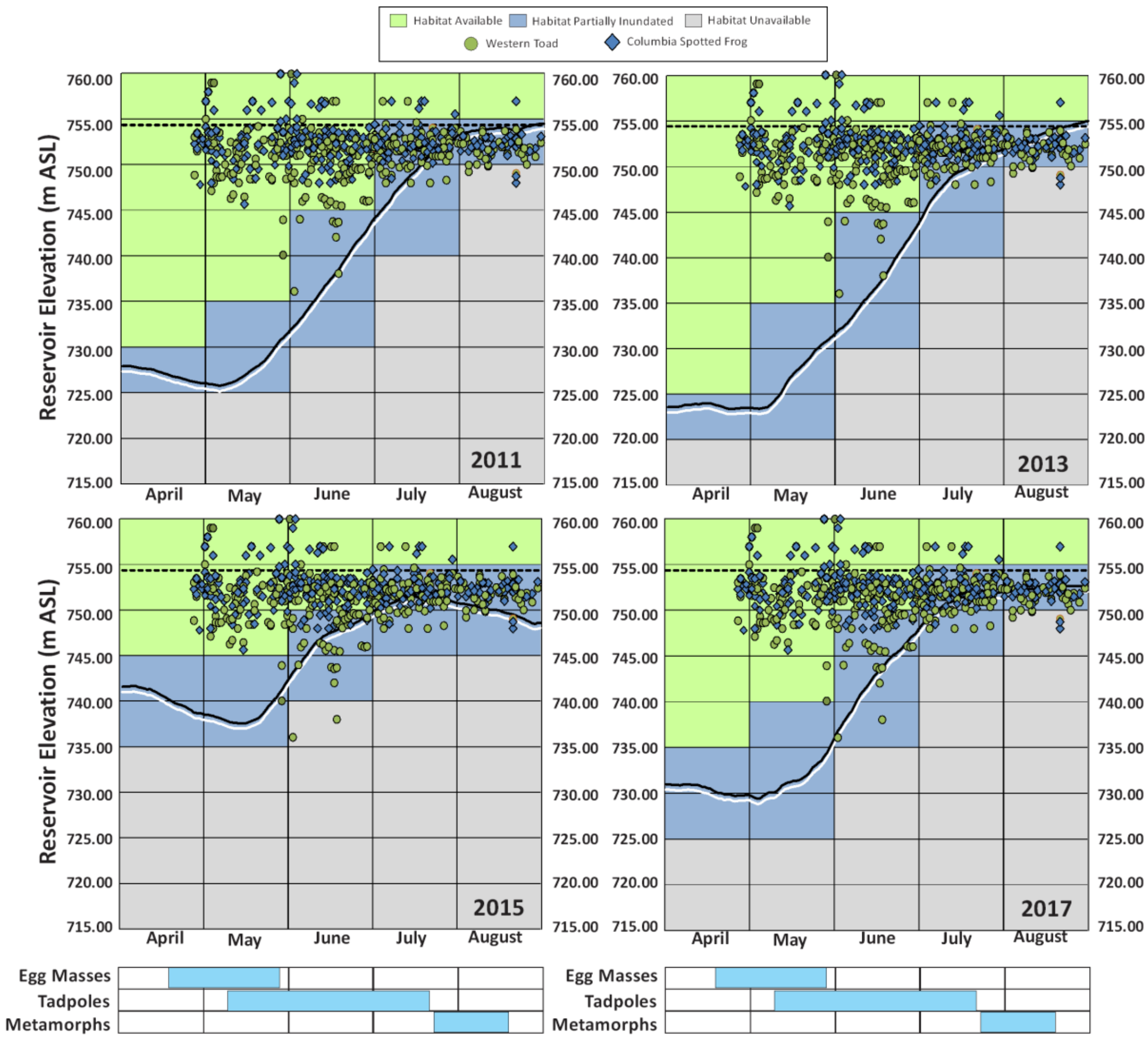

Figure 6-3: Changes in amphibian habitat availability in the drawdown zone of Kinbasket Reservoir relative to actual reservoir operations (black line) and to a predicted increase of 60 cm resulting from the installation of Mica units 5 and 6 (white line) for the period April 1 to August 31, 2011, 2013, 2015, and 2017. The dashed line represents the normal operating maximum of 754.38 m ASL. The phenology of various amphibian life stages is shown relative to date and elevation. Amphibian observation data from all years pooled and displayed on each plot

Most habitats used by amphibians in the drawdown zone are inundated late in tadpole development, close to the time of metamorphosis. As tadpoles are able to swim freely at the time of inundation, we assume they follow the edge of the reservoir as water elevation increases, as has been observed in other reservoirs (e.g., Arrow Lakes Reservoir: Hawkes et al. 2017, Figure 6-4). This assumption is bolstered by the observation of toadlets near key breeding sites in the Valemount Peatland, at Ptarmigan Creek, and in Bush Arm. Young-of-the-year froglets have not been observed emerging from breeding ponds, but the size of young frogs observed in the drawdown zone each spring suggests that some frogs born the previous year are successfully overwintering. Field observations of tadpoles following the leading edge of the reservoir could be used to test our assumptions.

Figure 6-4. Aggregation of Western Toad tadpoles following the leading edge of Arrow Lakes Reservoir in Cartier Bay. Photo taken July 5, 2017, reservoir elevation 439.04 m ASL. Photo credit: Virgil C. Hawkes

Inundation affects the availability and suitability of pond habitats located in the drawdown zone, which are used by local populations of amphibians and reptiles for breeding and foraging. Of the species studied in the drawdown zone of Kinbasket Reservoir, Western Toad are likely the most affected by early inundation because they breed in ponds at lower elevations in the drawdown zone than other species (see Figure 5-7). These low elevation ponds get inundated in early May in most years with complete inundation by July. This puts species like Western Toad at greater risk because their breeding ponds have a higher probability of being inundated before eggs have hatched. Even if inundation coincides with the period of hatching, Western Toad tadpoles stay attached to the remnants of their egg string for several days following hatching. Inundation during this time could negatively affect both unhatched eggs and recently hatched tadpoles because neither have the ability to swim to shallower water; however, the effects of inundation on tadpole survival has not been studied.

The effects of reservoir inundation may also vary by reservoir operations conducted in a year, with important breeding habitat for Western Toads impacted or unavailable in some years (e.g., 2015, 2017) to being mostly available in others (e.g., 2011, 2013). The longer-term implications of variable reservoir operations and inundation of important breeding habitats on Western Toad populations remain unknown. Based on what we have observed regarding the location and elevation of ponds used by Columbia Spotted Frog in the drawdown zone for breeding, we suspect the effects of reservoir inundation are not related to habitat selection since breeding is conducted prior to reservoir inundation, but this has not been explicitly tested.

The following sections test each of the hypotheses associated with CLBMON-58 (and CLBMON-37) and lend support to our assessment of the effects that the installation of units 5 and 6 at Mica Dam will have on amphibians using habitats in the drawdown zone of Kinbasket Reservoir.

6.11.2 H1$_A$: Reservoir operations do not result in a decreased abundance of amphibians or reptiles in the drawdown zone.

The annual variability associated with reservoir operations influences the detectability of amphibians and reptiles in the drawdown zone, but not in a consistent manner. In 2017, Western Toad, Columbia Spotted Frog, and Common Garter Snake detection rates (as a proxy for abundance) were not influenced by reservoir elevation (correlation coefficients = -0.16, -0.23, 0.04 respectively; Figure 6-5). For all species the range of elevations across which they were observed is consistent with previous years of study.

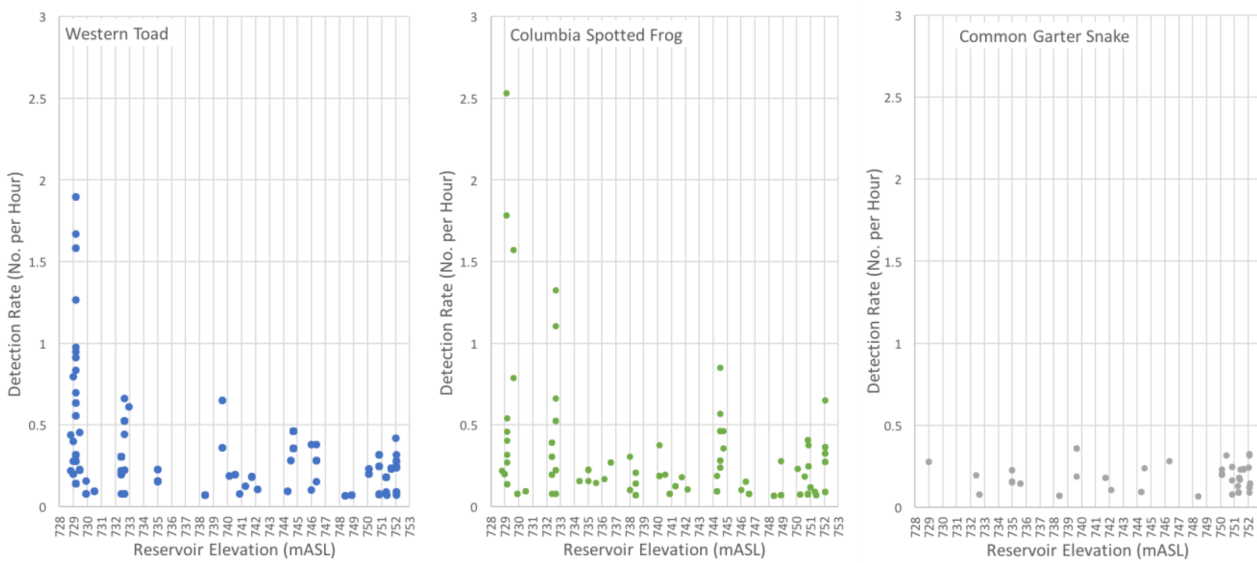

Figure 6-5: Relationship between reservoir elevations and detection rates (number per hour) for Western Toad, Columbia Spotted Frog, and Common Garter Snake in Kinbasket Reservoir, 2017. A large outlier for Western Toad was omitted due to detection of a breeding event

6.11.3 H1$_B$: Reservoir operations do not increase the stage specific (e.g. larval, juvenile, or adult) mortality rates of amphibians or reptiles in the drawdown zone.

We think that certain species use the DDZ to fulfill many of their life history stages (e.g., Western Toad, Columbia Spotted Frog, and possibly Western Painted Turtle), while others (e.g., Long-toed Salamander and garter snakes) appear to use the DDZ to fulfill specific stages (Table 6-2).

Table 6-2: Observed life history activity of amphibian and reptile species in the drawdown zone of Kinbasket Reservoir. Any 'Yes' indicates a direct observation of the life history activity or stage, whereas the rest are inferences

Species	Life History Activity			
	Breeding	Growth	Foraging	Overwintering
Columbia Spotted Frog	Yes	Yes	Yes	Unknown
Western Toad	Yes	Yes	Yes	Unlikely
Long-toed Salamander	Yes	Yes	Likely	Unlikely
Western Painted Turtle	Unknown	Yes	Yes	Unknown
Western Terrestrial Garter Snake	Unknown	Yes	Yes	Unlikely
Common Garter Snake	Unknown	Yes	Yes	Unlikely

Life stage-specific mortality rates have not been directly measured for any species, but instances of mortality have been observed and can be related to natural causes (e.g. depredation, egg mass stranding). For example, there are times when toad egg strings are not fertilized (see previous years reports), which could lead to reduced fecundity, but not mortality. We have not observed depredation (but see previous comment on fish predation concurrent with inundation) or unfertilized egg masses of Columbia Spotted Frog. Egg string and egg mass stranding have also been observed at various locations in the drawdown zone. The number of Western Toad egg strings and Columbia Spotted Frog egg masses that were stranded were difficult to accurately count but were fewer than 10 for each species in all years of study. Egg mass stranding is usually related to decreasing hydroperiod at oviposition sites, which can be a major cause of death to developing embryos. The egg mass stranding phenomenon is not unique to drawdown zones (e.g., Marco and Blaustein 1998). Local environmental conditions can influence the hydroperiod of breeding ponds and are likely to confound reservoir effects that may be linked to egg mass stranding.

6.11.4 H1$_C$: Reservoir operations do not result in decreased site occupancy of amphibians or reptiles in the drawdown zone.

Proportion of Sites

Between 2008 and 2017, seven main locations in the drawdown zone have been surveyed for amphibians and reptiles (Table 6-3). In 2017, the proportion of these sites occupied by each species (i.e., in which a species was detected at least once in a given location per year) ranged from zero per cent for Western Painted Turtle to 85.7 per cent for Western Toad, Columbia Spotted Frog, and Common Garter Snake. Occupancy for Long-toed Salamander appears to be low; however, this species can be cryptic and is likely present at more sites than our data suggest. In previous years, the Western Terrestrial Garter Snake was rarely found in the drawdown zone, with only a few individuals detected at a couple of sites. The number of individual detections was the same in 2017, however new occupied sites were recorded. Unlike the Western Terrestrial Garter Snake, the Common Garter Snake is much more frequently observed each year with annual occupancy ranging from 57.1 to 85.7 per cent. For some species and years occupancy will be a function of survey effort. For example, in 2017, less effort was spent at Succour Creek and more effort was spent at sites in Bush Arm. Despite this, the general patterns of occupancy remain with toads and frogs more widely distributed and more readily detectable than all other.

Table 6-3: Proportion of sites occupied at each survey site for each species of amphibian and reptile known to use habitats in the drawdown zone of Kinbasket Reservoir in 2013, 2015 and 2017. A-AMMA = Long-toed Salamander, A-ANBO = Western Toad, A-PSRE = Pacific Chorus Frog (only a possible occurrence), A-RALU = Columbia Spotted Frog, R-CHPI = Western Painted Turtle, R-THEL = Western Terrestrial Garter Snake, R-THSI = Common Garter Snake. Numbers in table refer to detections of all life stages of each species

	A-AMMA			A-ANBO			A-PSRE			A-RALU			R-CHPI			R-THEL			R-THIS		
Survey Locations	**13**	**15**	**17**	**13**	**15**	**17**	**13**	**15**	**17**	**13**	**15**	**17**	**13**	**15**	**17**	**13**	**15**	**17**	**13**	**15**	**17**
Bush Arm KM88				15	22	14				4	8	17		1				1		4	2
Bush Arm Causeway	52	15	6	134	54	257				4	3	22					2		3	4	8
Bush Arm KM79 (DDZ)				26	15	13				5	11	60						1	2		2
Bush Arm KM79 (UPL)				3	1	141				16	7	24									1
Ptarmigan Creek	1			25	169	100				3	16	2							3	25	20
Succour Creek																	1	1			
Valemount Peatland	1	3	1	49	270	134		1*		33	308	203							1	26	57
Total Locations	**3**	**2**	**2**	**6**	**6**	**6**	**0**	**0**	**0**	**6**	**6**	**6**	**0**	**1**	**0**	**0**	**2**	**3**	**4**	**4**	**6**
Proportion of Locations	**42.9**	**28.6**	**28.6**	**85.7**	**85.7**	**85.7**	**0.0**	**0.0**	**0.0**	**85.7**	**85.7**	**85.7**	**0.0**	**14.3**	**0.0**	**0.0**	**28.6**	**42.9**	**57.1**	**57.1**	**85.7**

*PSRE not confirmed (auditory detection only)

Site occupancy as a function of reservoir operations has not been fully investigated. In general, as reservoir elevations increase, the number and total area of ponds and wetland sampled at each site decreases to the point where occupancy can be said to be zero when these habitat features are inundated. However, species of amphibians and reptiles may continue to be present at the site despite the reduction in habitat availability. The change in habitat availability as a function of reservoir operations is presented below, but sites do become unoccupied when reservoir elevations are high.

6.11.5 $H1_D$: Reservoir operations do not result in decreased productivity of amphibians or reptiles in the drawdown zone.

Amphibian productivity (i.e., monitoring multiple ponds intensively [daily] throughout the breeding period [egg laying through to metamorphosis]) has not been explicitly studied in Kinbasket Reservoir. The data collected thus far indicate that three species of pond-breeding amphibian, Western Toad, Columbia Spotted Frog and Long-toed Salamander, are using habitats in the drawdown zone for breeding. The detection of amphibian egg masses varies between locations, but the observed variation is expected. Although we can calculate detection rates for these species, most of the information we have is based on qualitative observations. We have observed most life stages of these species (i.e., eggs, tadpoles, toadlets, and adults), with the exception of Long-toed Salamander where only egg masses and adults have been recorded.

Although Western Toads breed in wetlands and ponds that occur at lower elevations in the drawdown zone than other species, Western Toad productivity does not appear to be affected by reservoir operations. For example, Western Toad metamorphs have been observed at Ptarmigan Creek, various locations in the Valemount Peatland (e.g., Pond 12), and from the Bush Arm Causeway in most years of study. Each spring, numerous adult Western Toad are documented in the drawdown zone, and egg strings are observed in many of the same locations each year. Adult male to female ratios calculated for each year are consistent with values reported in the literature (Olson et al. 1986), lending support to a stable population of toads in the areas of Kinbasket Reservoir being studied.

Qualitatively, it appears that the productivity of both Western Toad and Columbia Spotted Frog is consistent between years. However, we are currently only assessing these species in the drawdown zone of the reservoir. In the absence of a suitable control or baseline data, we cannot know for certain how the productivity of any species of amphibian might be affected by reservoir operations.

Reptile productivity is not being assessed via CLBMON-58. Assessing reptile productivity (e.g., garter snakes) would require an intensive study involving the capture of numerous female snakes to determine reproductive state, counting eggs, observing where females give birth (i.e., drawdown zone or upland habitats), and assessing to what extent these species use the drawdown zone. Our current understanding of reptile use of the drawdown zone is limited to opportunistic observations (i.e., dictated by our present level of effort), and more recently, telemetry, made during the spring and summer only and these observations are generally of basking or foraging adults.

6.11.6 H1$_E$: Reservoir operations do not reduce the availability and quality of breeding habitat, foraging habitat and overwintering habitat for amphibians or reptiles in the drawdown zone.

Habitat availability was assessed by delineating the total area sampled each year (i.e., terrestrial and aquatic habitat at each survey site) and calculating how much of that area was available monthly relative to reservoir operations (i.e., timing of reservoir inundation at each particular elevation = unavailable). As expected, a negative relationship exists between the availability of habitat and reservoir elevations, with habitat availability decreasing with time. The change in habitat availability is most evident from May to July, when reservoir elevations are increasing (Figure 6-6). A difference occurred in 2015, whereby reservoir levels were lower than usual and began to decline again in July instead of increasing into September; 2017 followed the pattern seen in other years with reservoir level remaining high into September.

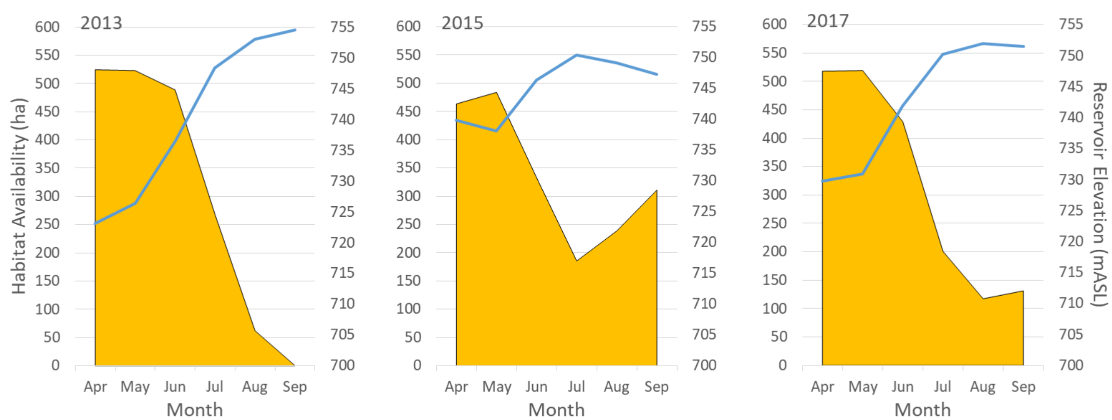

Figure 6-6: Relationship between habitat availability and reservoir elevation (i.e., inundation) in the drawdown zone of Kinbasket Reservoir for 2013, 2015 and 2017. The average reservoir elevation is shown (line)

The availability of amphibian and reptile habitat in the drawdown zone is discussed in the context of (1) breeding habitat, which is defined as those habitats in which amphibian egg masses are deposited, (2) foraging habitat, where amphibians and reptiles obtain prey, which includes both aquatic and terrestrial habitats, and (3) overwintering habitat, or those habitats necessary for the overwinter survivorship of amphibians and reptiles.

Breeding Habitat

The amphibian species using the drawdown zone of Kinbasket Reservoir are pond-breeding amphibians that breed in wetlands, ponds, quiescent backwaters of streams, and sometimes lake margins. One hundred and one[1] ponds representing 9.59 ha were delineated in the drawdown zone in five distinct survey sites. Total pond area per site ranged from 0.9 ha at Ptarmigan Creek (*N* = 1 pond) to 4.9 ha in the Valemount Peatland (*N* = 48 ponds) and most ponds are situated at elevations between 745 m and 753 m ASL (see Hawkes and Tuttle 2012 and 2016 for graphical presentations of pond data).

The quality (i.e., availability) of breeding habitat is affected by reservoir elevation on an annual basis. To demonstrate how reservoir elevation affects the availability, and hence quality of breeding habitat, habitat availability was plotted relative to reservoir elevation in 2013, 2015, and 2017. In 2013, most ponds (i.e., those situated between 745 and 753 m ASL) were available until late June. Beyond this point, the amount of breeding habitat steadily declined until mid-July, at which time most of the 9.59 ha of pond habitat were inundated. In 2015, ponds above 750.9 m ASL did not get inundated and were available throughout the summer (Figure 6-7). In 2017, the pattern of available habitat was similar to previous years (not including 2015), whereby pond habitat steadily declined until end of July with a small portion remaining available all summer.

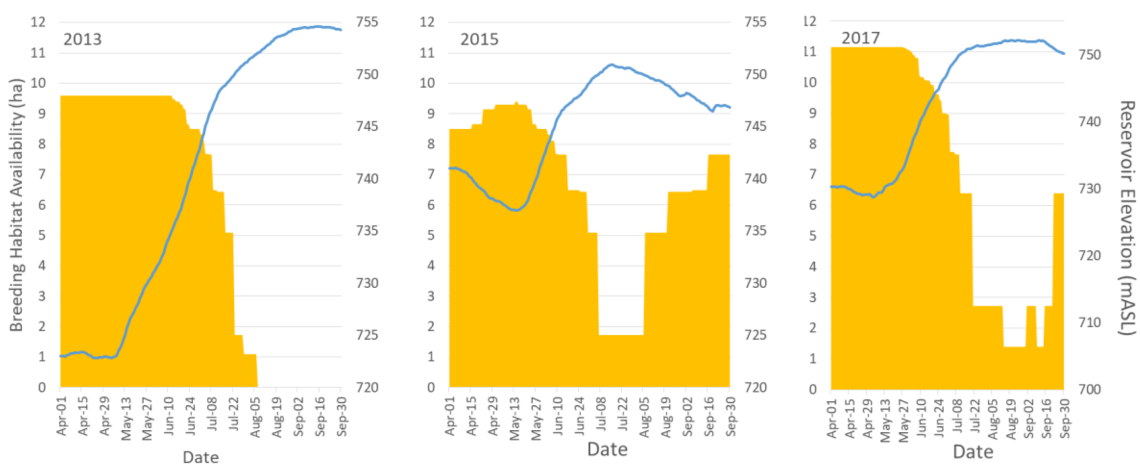

Figure 6-7: Relationship between amphibian breeding (and rearing) habitat availability (pond area) and reservoir elevations for the period April 1 through September 30, 2013, 2015, and 2017

The timing of inundation and occupancy of ponds coupled with the observation of breeding toads and frogs and egg masses indicates that reservoir operations do not preclude toad and frog breeding in ponds in the drawdown zone. Most pond-breeding amphibian egg masses were laid prior to inundation, but not before metamorphosis. Based on our observations of all life stages of Western Toad (eggs, tadpoles, metamorphs, and adults), the reduction in habitat availability

[1] Only ponds with mean elevations <754.38 m are considered here, which is why the number of ponds differs slightly from those discussed in Section 5.3.4.

associated with inundation does not appear to be associated with reduced reproductive success. However, the degree to which reservoir operations might affect amphibian productivity in terms of egg to tadpole to metamorphs survival is not understood and cannot currently be quantified (without following egg mass/tadpole development through to metamorphosis, which would be extremely difficult and labour intensive).

Foraging Habitat

Amphibians and reptiles forage in a variety of aquatic and terrestrial habitats and both general habitat types occur in the drawdown zone of Kinbasket Reservoir. A similar trend to pond habitat is observed for foraging habitat (i.e., terrestrial and aquatic) and as expected there is a strong negative relationship between inundated reservoir elevation and habitat availability (Figure 6-6). During each year, the availability of foraging habitat decreased rapidly as soon as reservoir elevations reached ~740 m ASL (Table 6-4). In 2017, the proportion of habitat inundated was higher than 2015, but remained lower than levels recorded between 2010 and 2014. The annual trends are similar with only the timing and duration of inundation of each elevation band varying (Table 6-4).

Table 6-4: Proportion of time between April and September (n = 183 days) that Kinbasket Reservoir exceeded a given range of elevations from 1997 to 2017

m ASL	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
741-742	0.58	0.60	0.49	0.44	0.21	0.44	0.40	0.34	0.55	0.59	0.55	0.48	0.53	0.46	0.54	0.54	0.52	0.54	0.70	0.67	0.60
742-743	0.58	0.58	0.47	0.43	0.05	0.44	0.37	0.23	0.54	0.58	0.54	0.46	0.51	0.45	0.52	0.53	0.51	0.52	0.67	0.65	0.59
743-744	0.57	0.56	0.45	0.40		0.43	0.26	0.19	0.51	0.56	0.52	0.44	0.48	0.43	0.51	0.52	0.50	0.51	0.65	0.63	0.57
744-745	0.55	0.54	0.44	0.39		0.42	0.09	0.16	0.50	0.54	0.50	0.42	0.46	0.42	0.49	0.50	0.49	0.49	0.64	0.62	0.56
745-746	0.54	0.52	0.43	0.37		0.40		0.11	0.48	0.52	0.49	0.39	0.43	0.39	0.48	0.50	0.49	0.48	0.62	0.61	0.54
746-747	0.51	0.50	0.42	0.36		0.39		0.07	0.46	0.51	0.48	0.37	0.40	0.37	0.46	0.49	0.47	0.46	0.61	0.56	0.52
747-748	0.49	0.48	0.40	0.30		0.37			0.41	0.49	0.46	0.34	0.37	0.35	0.45	0.47	0.46	0.45	0.54	0.53	0.50
748-749	0.48	0.45	0.39	0.17		0.35			0.35	0.48	0.44	0.32	0.34	0.33	0.43	0.46	0.44	0.43	0.38	0.50	0.49
749-750	0.45	0.40	0.37	0.04		0.32			0.28	0.45	0.43	0.27	0.31	0.31	0.42	0.45	0.42	0.41	0.28	0.46	0.47
750-751	0.44	0.29	0.34			0.23			0.16	0.43	0.42	0.23	0.24	0.27	0.40	0.44	0.38	0.39	0.16	0.43	0.45
751-752	0.42	0.14	0.32			0.06				0.37	0.40	0.18	0.16	0.19	0.38	0.43	0.35	0.37		0.37	0.34
752-753	0.39		0.28								0.36		0.06	0.03	0.35	0.42	0.30	0.34		0.02	0.13
753-754	0.34		0.19								0.19			0.01	0.32	0.32	0.25	0.29			
>754.38																0.18	0.14				

Overwintering Habitat

Field work for CLBMON-58 occurs during the snow-free period, usually between the middle to end of April and end of August each year. The availability or quality of amphibian and reptile overwintering habitat in the drawdown zone of Kinbasket Reservoir has not been extensively assessed. Questions related to the availability and quality of overwintering habitat are difficult to answer using existing data. However, the telemetry data collected in 2014 through 2017 suggest that Western Toad are not using the drawdown zone during the winter period and that more likely, they are wintering in upland habitats, which is consistent with what is generally known for this species (e.g., Browne and Paszkowski 2010). Data collected from 2015 to 2017 show that Common Garter Snakes affixed with radio transmitters in the drawdown at Valemount Peatland travel to upland habitats outside of Kinbasket Reservoir to their overwintering locations. The overwintering locations of Columbia Spotted Frog and Long-toed Salamander are currently unknown.

6.11.7 H2$_A$: Revegetation and physical works do not increase species diversity or seasonal (spring/summer/fall) abundance of amphibians or reptiles in the drawdown zone.

Revegetation

The revegetation prescriptions applied were never considered relevant or beneficial to amphibians and reptiles nor were they implemented explicitly to benefit amphibians and reptiles. Moreover, there is no reason to suggest that revegetation would increase species diversity given all expected species have been observed in the drawdown zone. The planting of sedge plugs and live stakes in mostly upland habitats did not appear to improve habitat around important breeding habitats or improve habitat connectivity between upland over-wintering habitats and drawdown zone habitats (see results in Hawkes et al. 2013). Although the hypothesis asks whether revegetation increases species diversity or abundance, we did not test this for the aforementioned reasons. It is the opinion of the authors that revegetation did not, at least in the years covered by this report, increase amphibians and reptiles diversity or abundance in the drawdown zone. This observation is consistent with the findings of Fenneman and Hawkes (2012) and Hawkes et al. (2013). Further, the fall abundance of amphibians and reptiles has not been assessed as the high reservoir level precludes surveys in the drawdown zone during that season.

Physical Works

A physical works pilot project was implemented in 2015 as part of CLBWORKS-1 (Hawkes 2016). Owing to limited scale, it is not expected that any of the work completed in 2015 will result in a measurable change to the overall abundance of amphibians and reptiles in the drawdown zone, and as noted earlier, all expected species have been observed near this site. However, Western Toads have used the newly available wetland habitats at the Causeway for breeding in both 2016 and 2017, providing evidence that physical works can improve habitat suitability for pond-breeding amphibians that use the drawdown zone of Kinbasket Reservoir (see Hawkes 2017).

6.11.8 H2$_B$: Revegetation and physical works do not increase amphibian or reptile productivity in the drawdown zone.

Revegetation

The revegetation prescriptions applied were never considered relevant or beneficial to amphibians and reptiles nor were they implemented explicitly to benefit amphibians and reptiles. The relationship between revegetation prescriptions applied in the drawdown zone and amphibian and reptile productivity has not been assessed. There is a potential link between increasing food resources (e.g., invertebrates and small mammals) and productivity and aspects of this are being studied as part of the Kinbasket Reservoir Wildlife Effectiveness study (CLBMON-11A). Amphibians and reptiles are not focal taxa in that study.

Physical Works

See section above.

6.11.9 $H2_C$: Revegetation does not increase the amount or improve habitat for amphibians and reptiles in the drawdown zone.

As stated above, the revegetation prescriptions applied were never considered relevant or beneficial to amphibians and reptiles nor were they implemented explicitly to benefit amphibians and reptiles.

7.0 RECOMMENDATIONS

The objective of CLBMON-37 is to monitor trends in amphibian and reptile populations (relative abundance, detection rates, and productivity), determine the impact of reservoir operations on amphibians and reptiles (CLBMON-58 adds focus related to the impacts of Mica 5/6), determine their habitat use, and assess the impacts of any revegetation and physical works on species that use habitats within the drawdown zone of Kinbasket Reservoir. In 2018 as part of the final year of CLBMON-37, we will continue to monitor amphibian and reptile populations in the DDZ using the methods applied in previous years, but the following suggestions to the field program include:

1. Collect eDNA samples for specific species (Western Painted Turtle and Long-toed Salamanders to remove sources of uncertainty associated with Management Question 1.
2. Auditory surveys, including the deployment of autonomous recording units could confirm the presence of Pacific Chorus Frog in the drawdown zone of Kinbasket Reservoir. These surveys should focus on the Valemount Peatland as this is the only area where Pacific Chorus Frog has potentially been detected and where they are most like to occur. These efforts may remove sources of uncertainty associated with Management Question 1.
3. Monitoring amphibian and reptile use of physical works, including wetlands and ponds cleared of wood debris under CLBWORKS-1. Monitoring is suggested as part of CLBMON-37 in 2018 and would reduces sources of uncertainty remaining for Management Question 9.
4. Increase search effort for Western Painted Turtle at KM88. Include searches for nesting habitat. This can include hoop-trapping session at Bush Arm Bear Island in the spring for 3 to 4 days.
5. Use data from CLBMON-58 and 37 to assist with the development of physical works projects (implemented under other programs, e.g., CLBWORKS-1) to increase the total number and/or area of ponds suitable for Western Toads at higher elevations to offset the loss of these ponds at lower elevations as a result of reservoir operations.

8.0 Additional Reporting Requirements

8.1 Data Deliverables

The following data deliverables have been or will be provided to BC Hydro and/or the B.C. Ministry of Environment to fulfill the Terms or Reference associated with CLBMON-58 or to fulfill the requirements of the wildlife sundry permit provided to LGL Limited for CLMON-37/58:

1. Draft technical report February 7, 2018

2.	300 word abstract	February 2018
3.	Revised sampling protocol	February 2018
4.	Copies of notes, maps, photos	February 2018
5.	Digital appendix (data)	February 2018

8.1.1 Data Provided to BC Hydro

An MS Access database containing all 2011 through 2017 data will be provided to BC Hydro with the submission of the final report. This database conforms to the standards established by the B.C. Ministry of Environment for wildlife species inventories.

8.1.2 Data Provided to the Ministry of Environment

Data collected under CLBMON-58 will be submitted to the B.C. Ministry of Environment Ecosystems Information Section as per the requirements of the Terms of Reference associated with CLBMON-37/58 and the Wildlife Sundry Work was conducted under Wildlife Act Permit MRCB17-266330, which is valid through March 31, 2018. This permit was amended in 2017 to permit the non-surgical application of transmitters to toads and snakes.

8.2 SARA-listed Species

Location data for SARA-listed species and all other amphibians and reptiles observed in and adjacent to the drawdown zone will be provided to the B.C. Ministry of Environment as per the requirements of our wildlife sundry permit.

The only amphibian at risk documented in the drawdown zone of Kinbasket Reservoir is the **Western Toad**, which is a SARA Schedule 1 species of Special Concern. The Columbia Spotted Frog is a 'mid priority candidate' species for a COSEWIC status report (as of December 2013) candidate species. The status of this species remains not assessed and populations are considered to be stable throughout its range The Intermountain–Rocky Mountain Population of the **Western Painted Turtle** (*Chrysemys picta*) is blue-listed in British Columbia and is a SARA Schedule 1 species of Special Concern, and one individual was spotted in the DDZ of Kinbasket Reservoir (Bush Arm, Bear Island).

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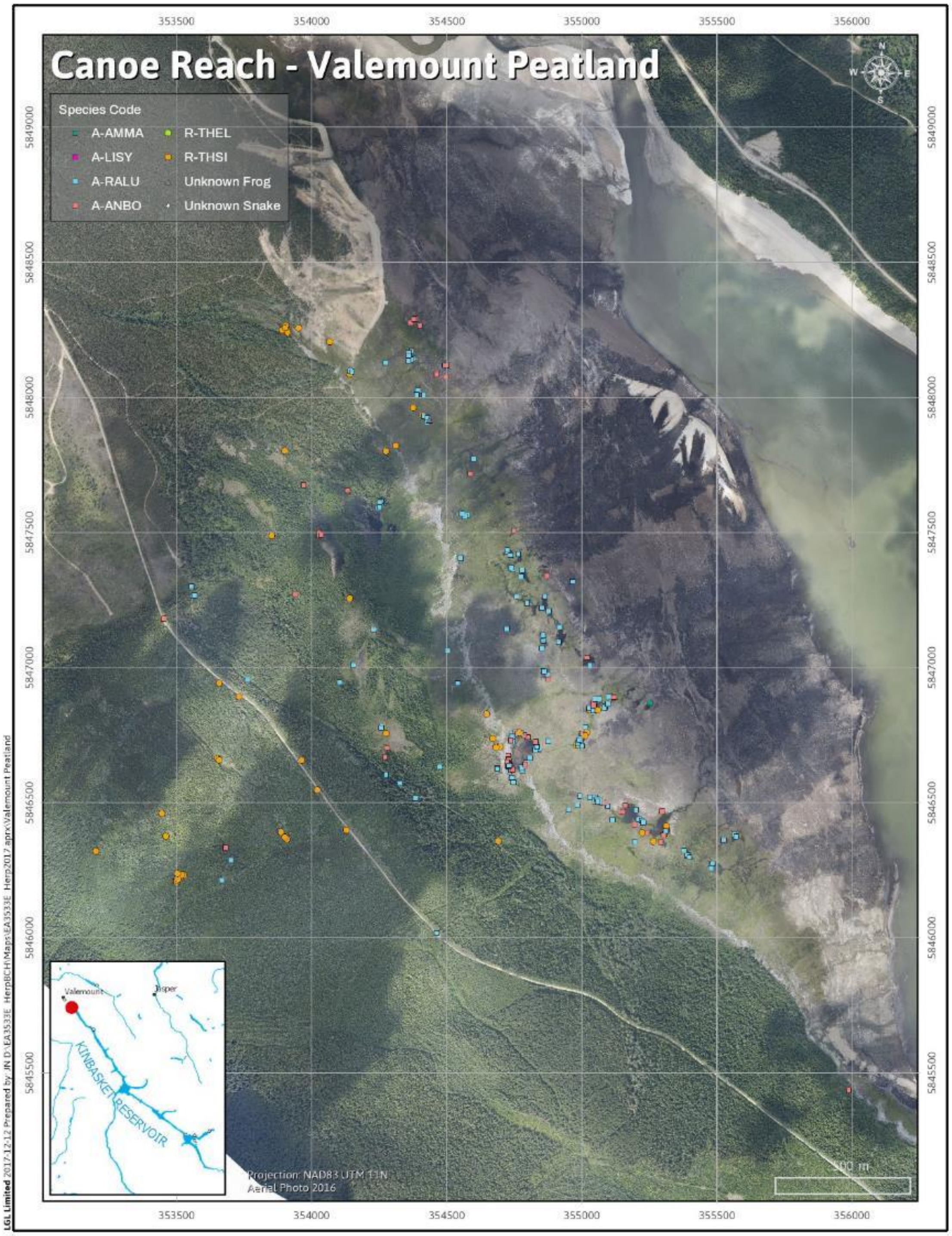
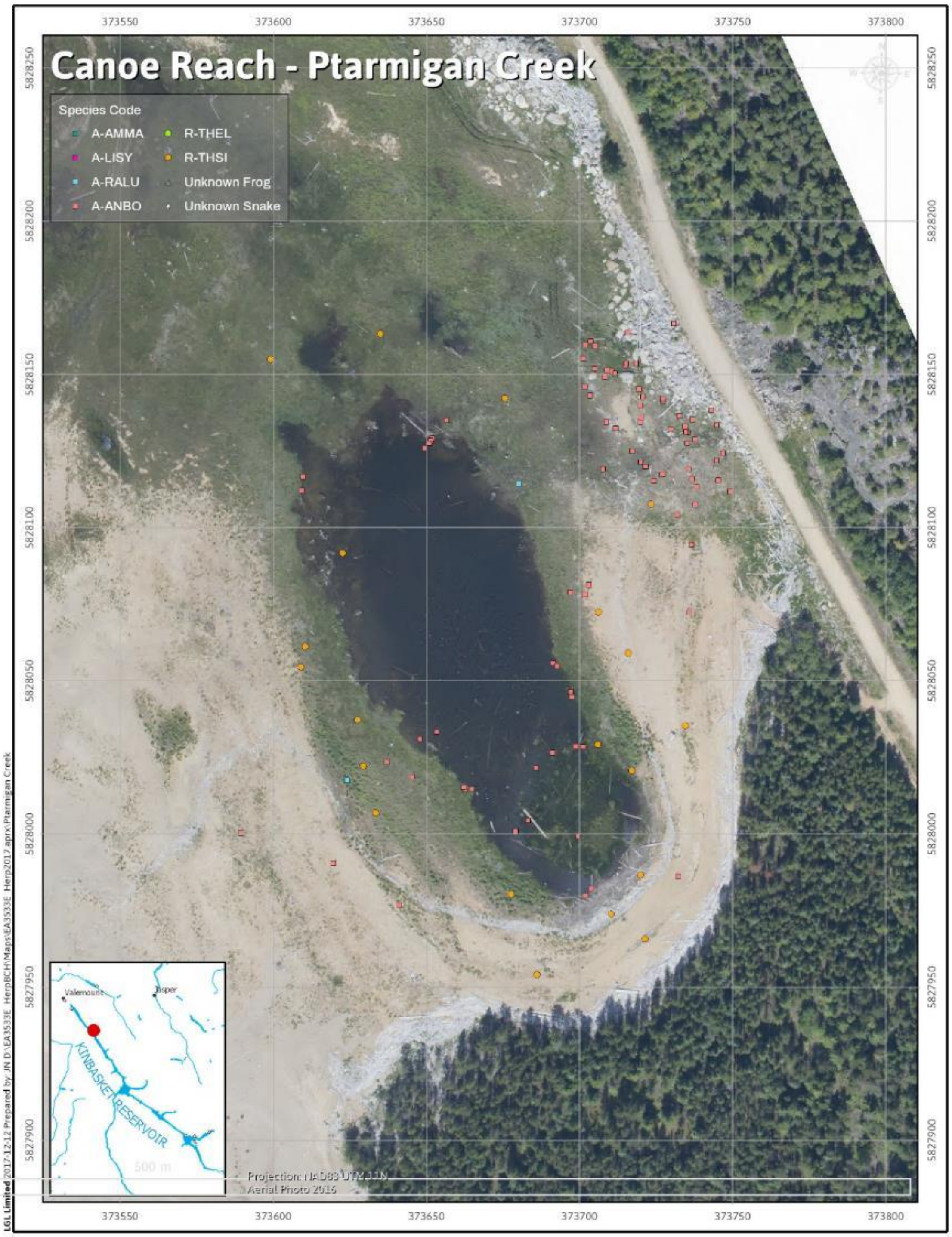
10.0 APPENDICES

Appendix 10-1: Survey locations and amphibian and reptile captures made in the drawdown zone of Kinbasket Reservoir in 2017

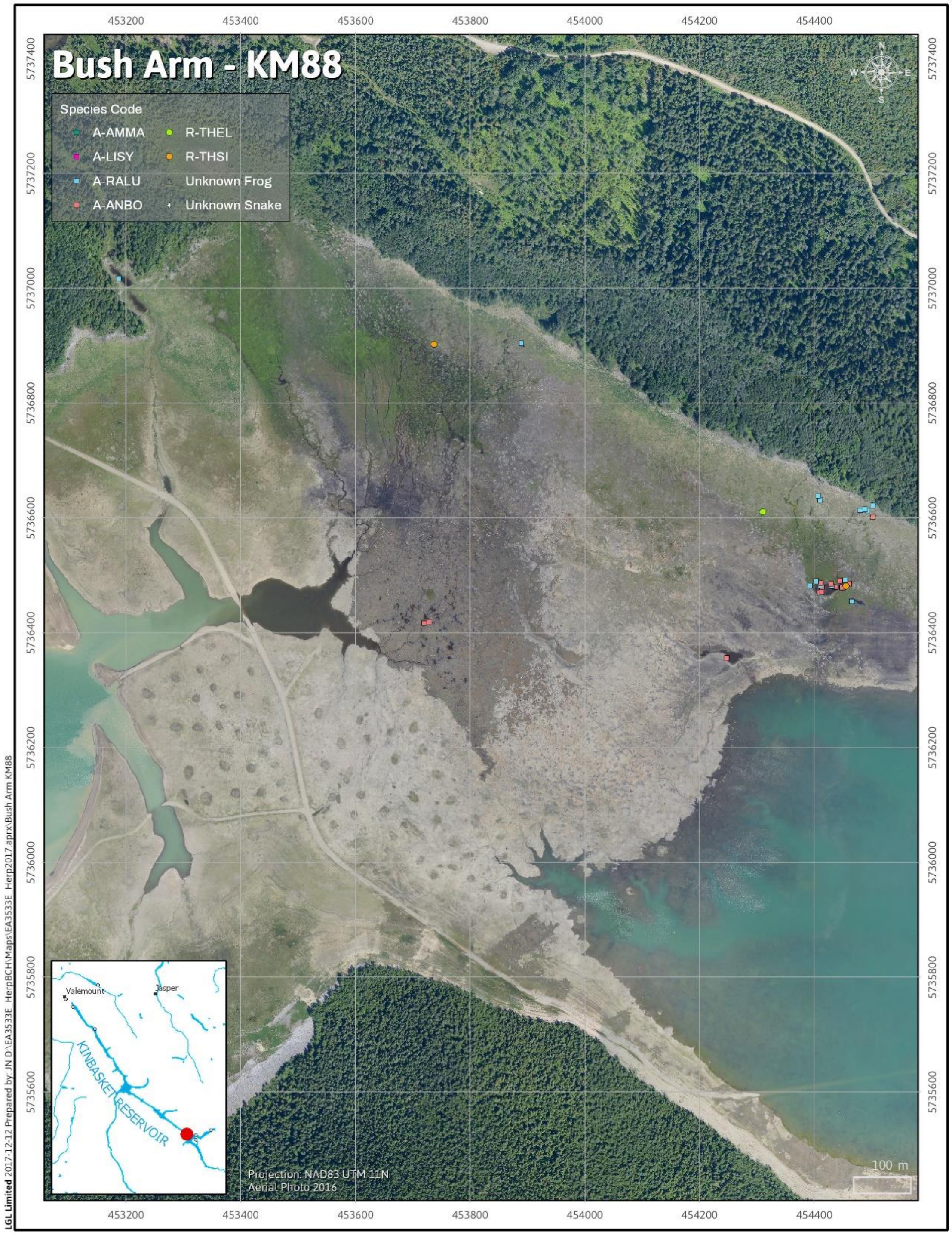


Map 10-1: Species documented in the Valemount Peatland, Kinbasket Reservoir in 2017. Species codes can be found in Table 1-1

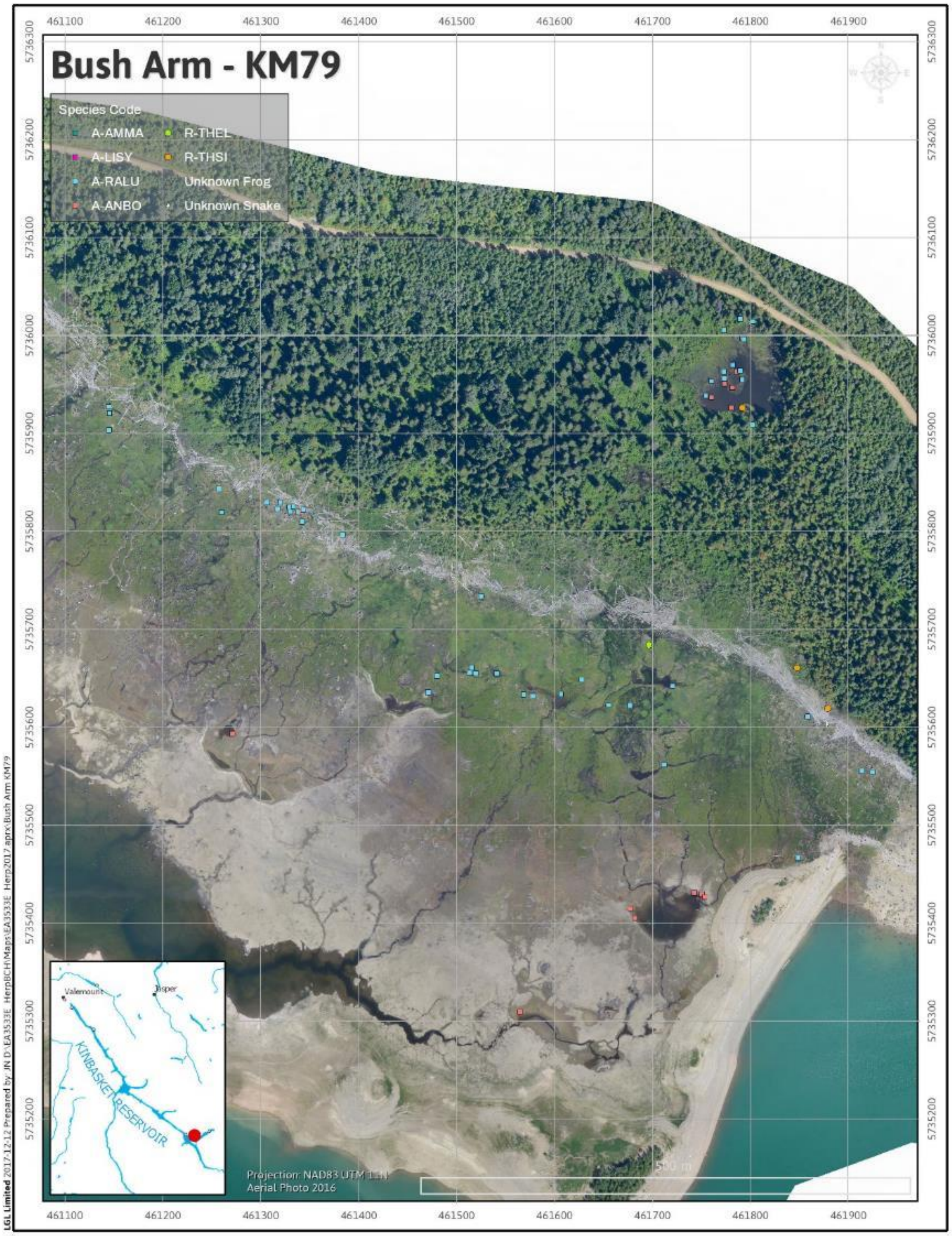


Map 10-2: Species documented at Ptarmigan Creek, Kinbasket Reservoir in 2017. Species codes can be found in Table 1-1

Map 10-3: Species documented at Bush Arm Causeway, Kinbasket Reservoir in 2017. Species codes can be found in Table 1-1



Map 10-4: Species documented at Bush Arm KM88 (Bear Island), Kinbasket Reservoir in 2017. Species codes can be found in Table 1-1



Map 10-5: Species documented at Bush Arm KM79, Kinbasket Reservoir in 2017. Species codes can be found in Table 1-1