Columbia River Project Water Use Plan

Arrow Operations Management Plan

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

Implementation Year 3

Reference: CLBMON-58

Final Annual Report

Study Period: 2015

Okanagan Nation Alliance, Westbank, BC
and
LGL Limited environmental research associates
Sidney, BC

May 13, 2016

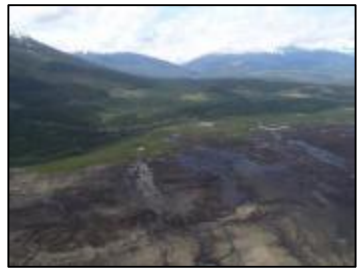
EA3533

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 2015

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Cover photos:

From left to right: Columbia Spotted Frog (*Rana luteiventris*), Western Toad tadpoles (*Anaxyrus boreas*); Valemount Peatland © Virgil C. Hawkes, LGL Limited; and Long-toed Salamander (*Ambystoma macrodactylum*) © Krysia Tuttle, LGL Limited

EXECUTIVE SUMMARY

This year marked the third year of CLBMON-58, which is part of 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 addresses the potential predicted impacts of the installation 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 are investigated in this study, with the primary objective being 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.

In 2015, we documented the presence of three species of amphibian, Western Toad (*Anaxyrus boreas*), Columbia Spotted Frog (*Rana luteiventris*), and Long-toed Salamander (*Ambystoma macrodactylum*). A fourth species, Pacific Chorus Frog **(***Pseudacris regilla***)**, was potentially present in Canoe Reach, but its presence has not been verified (heard, but not observed). Three species of reptile, Common Garter Snake (*Thamnophis sirtalis*), Western Terrestrial Garter Snake (*Thamnophis elegans*) and Western Painted Turtle (*Chrysemys picta*) were also in the drawdown zone of Kinbasket Reservoir. The observation of the Western Painted Turtle is notable as it represents the first detection of this species in the drawdown zone of Kinbasket Reservoir. Western Toad and Columbia Spotted Frog were the most commonly encountered species, usually in wetlands within wool-grass–Pennsylvania buttercup, swamp-horsetail, Kellogg's sedge or willow-sedge habitats. Pond characteristics varied by species with Columbia Spotted Frog using ponds situated at higher elevation and with a higher abundance and per cent cover of aquatic macrophytes compared to Western Toad. Western Toad bred in ponds as low as 734 m 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.

Most amphibian detections were distributed within an elevation band of 749 to 754 m ASL. 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. However, 2015 was a slightly different year for reservoir operations with reservoir levels not reaching full pool (2015 elevation = 750.9 m ASL; maximum elevation = 754.38 m ASL); thus habitat was available for a longer period of time during the amphibian breeding season. The continued presence of Western Toad and Columbia Spotted Frog of all life stages in the drawdown zone in consecutive years suggests that these species are not adversely affected by reservoir operations. However, we do not know if the populations of Columbia Spotted Frog and Western Toad are affected relative to non-reservoir populations, and we won't know that unless suitable non-reservoir populations are studied.

Radiotelemetry was used in 2015 to determine how long Western Toad (*N*=20), Columbia Spotted Frog (*N* =2) and Common Garter Snake (*N* =4) use habitats in the Valemount Peatland. The results obtained suggest that Western Toad migrate to the drawdown zone to breed between late April and early May. Toads stay in the drawdown zone for two to three weeks and following breeding, most move to adjacent upland (i.e., non-drawdown zone) summer habitat. It is presumed that

these upland summer habitats may also represent important winter habitat, but this assumption has yet to be studied. Data obtained from four 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 one snake was captured on the West Canoe Forest Service Road upslope from pond 12. More data are required to better assess seasonal habitat use by garter snake in the drawdown zone of Kinbasket Reservoir.

Several recommendations are made that if implemented, will help to answer management questions associated with CLBMON-58:

Sampling

1. Conduct annual sampling (under CLBMON-37/58) to increase the time series of data. This should extend to sampling Arrow Lakes Reservoir annually under CLBMON-37 as CLBMON-58 focuses solely on Kinbasket Reservoir. The purpose of this sampling is to increase the probability of detecting a trend, which for many species of amphibians and reptiles, can take between 10 and 13 years (e.g., Hayes and Steidl 1997), or even longer if using time series analyses (e.g., Salvidio 2009). CLBMON-37 was first implemented in 2008 with sampling in 2008, 2009, 2010, then bi-annually until 2016, resulting a sample size of six. Sampling on an annual basis will require additional funds, but this is balanced against the risk of not doing so, which is related to a high probability of not having a large enough time series to trends for even those species with relatively large sampled sizes (e.g., Western Toad).
2. Conduct a hoop-trapping session at Bush Arm KM88 in the spring for 3 to 4 days to determine presence of additional Western Painted Turtle at this site.
3. Continue and extend the telemetry study of Western Toad, Columbia Spotted Frog, and Common Garter Snake through the winter season.

Reservoir Operations

1. The inundation of elevations between ~735 and 754 m ASL should occur on or as close to the end of the summer (similar to the dates for the period 1978 to 2015 or around August 25) as possible. This 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 (to accumulate stored resources) and/or develop through to metamorphosis prior to inundation.
2. Climate change may confound future assessments regarding how reservoir operations affect the distribution and habitat use of amphibians and reptiles in the drawdown zone of Kinbasket Reservoir. Climate change models relevant to the study area could be reviewed as part of another study to determine the extent to which climate change might influence the water resources of the drawdown zone, which in turn could affect populations of amphibians and reptiles.

The status of CLBMON-58 after Year 3 (2015) with respect to the management questions and management hypotheses is summarized below.

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	Data collected since 2008 have likely resulted in the documentation of all expected species in the drawdown zone	• N/A	• Natural annual population variation • Inconspicuous species • Variable reservoir operations
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?	Partially	3 years of site occupancy and detection rates data. Productivity estimated for some species	• Annual sampling • Intensive productivity data collection for Western Toad and Columbia Spotted Frog • Add other sites as physical works are implemented	• Natural annual population variation • Unknown rate of immigration may confound productivity estimates • Inconspicuous species • Mortality difficult to assess • Variable reservoir operations
MQ3: During what portion of their life history (e.g., breeding, foraging, and over-wintering) do amphibians and reptiles utilize the drawdown zone?	Partially	3 years of site occupancy data across multiple sites and seasons	• Telemetry studies on Western Toad, Columbia Spotted Frog and Common Garter Snake to assess overwinter habitat use.	• Natural annual population variation • Inconspicuous species • Lack of knowledge regarding the use of the drawdown zone by species in the winter • Variable reservoir operations
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)?	Uncertain	3 years of macro and micro habitat data collection	• Reduce the number of monitoring sites • Focus on Western Toad and Columbia Spotted Frog • Telemetry study on Western Toad and Common Garter Snake to assess habitat use • Re-evaluate existing habitat mapping and its relevance to amphibians and reptiles • Assess turtle presence and distribution at KM88	• Habitat mapping is required at a scale relevant to amphibians and reptiles • Variable reservoir operations

Management Question (MQ)	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
MQ5: How do reservoir operations influence or impact amphibians and reptiles directly (e.g., desiccation, inundation, predation) or indirectly through habitat changes?	Uncertain	3 years of data collected on the occurrence and distribution of amphibians and reptiles in the drawdown zone	• None	• Natural annual population variation • Variable reservoir operations • Habitat mapping is required at a scale relevant to amphibians and reptiles
MQ6: Can minor adjustments be made to reservoir operations to minimize the impact on amphibians and reptiles?	Uncertain	N/A	• Restrict reservoir elevations for one year to elevations < 751 m ASL to determine whether doing so alters the use of the drawdown zone by amphibians and reptiles.	• Variable reservoir operations • Reservoir operations that result in complete inundation of the drawdown zone to elevations of ~754.38 m ASL (full pool) • 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. • This suggested modification occurred via happenstance in 2015. Assessments in 2016 may provide the data necessary to determine if occupancy or abundance differs as a result of this type of management.
MQ7: Can physical works projects be designed to mitigate adverse impacts on amphibians and reptiles resulting from reservoir operations?	Uncertain	Data collected at Bush Arm Causeway from 2008 to 2015 will serve as a pre-treatment reference for the physical works constructed and ponds rehabilitated in 2015.	• Assess efficacy of physical works project implemented in the drawdown zone of Kinbasket Reservoir in fall 2015	• No data to assess whether future use is comparable to historical use.
MQ8: Does revegetating the drawdown zone affect the availability and use of habitat by amphibians and reptiles?	No	N/A	• Ensure wetland-associated plants are included in the planting prescriptions associated with proposed and potential physical works.	• Revegetation of the drawdown zone has not been done in a replicated manner nor were the prescriptions designed to enhance amphibian and reptile habitat. Wetland-related plants would need to be planted to benefit amphibians and reptiles. Work is not applicable to this study.
MQ9: Do physical works projects implemented during the course of this monitoring program increase amphibian and reptile abundance, diversity, or productivity?	Uncertain	Same as MQ7	• Assess efficacy of physical works project implemented in the drawdown zone of Kinbasket Reservoir in fall 2015	• No data to assess whether future use is comparable to historical use.

Management Question (MQ)	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
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?	Partially	Maximum reservoir elevations documented between 1978 and 2015 indicate that the average full pool date is August 25. At this time amphibians should be migrating out of the breeding ponds (Western Toad) or moving to overwintering sites in the drawdown zone of adjacent habitats (Columbia Spotted Frog). This suggests that increasing reservoir elevations by 60 cm in the summer months should not directly impact amphibians. However, important habitats could be impacted.	• Use radiotelemetry to determine where Western Toad overwinter, whether Columbia Spotted Frog overwinter in ponds in the drawdown zone, and to understand garter snake use of the drawdown zone in all seasons.	• Variable reservoir operations • Reservoir operations that result in complete inundation of the drawdown zone to elevations of ~754.38 m ASL • Uncertain the response of plants in the drawdown zone to increasing water levels for longer periods. • It is not clear if surcharge can be used as proxy for increasing the reservoir by 60 cm in the summer months.

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 (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. As a result, 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 to assess whether the incremental increase in summer water levels affect amphibian or reptile populations using habitats in the drawdown zone of Kinbasket Reservoir.

This report summarizes the findings of Year 3 (2015) 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 2011, 2013, and 2015 are used to assess whether any trends are apparent in the data.

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 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), and 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 from the drawdown zone of the Kinbasket Reservoir (Table 1-1). In 2015, a Pacific Chorus Frog (*Pseudacris regilla*) was heard calling in Canoe Reach, but the presence of this species has not been verified. 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. One individual of this species was documented in 2015 using the drawdown zone of Kinbasket Reservoir at the mouth of the Bush Arm River (KM88).

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	COSEWIC*
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**	B	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; *COSEWIC = Committee on the Status of Endangered Wildlife in Canada/SARA Schedule: SC = Special Concern

2.0 STUDY OBJECTIVES

2.1 Study Design

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**		**Annual report**
2016		Year 6	Annual report
2017	Year 4		Annual report
2018*	Year 5	Year 7	Final comprehensive report

2.2 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. 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 or not 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 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 megawatts (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 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).

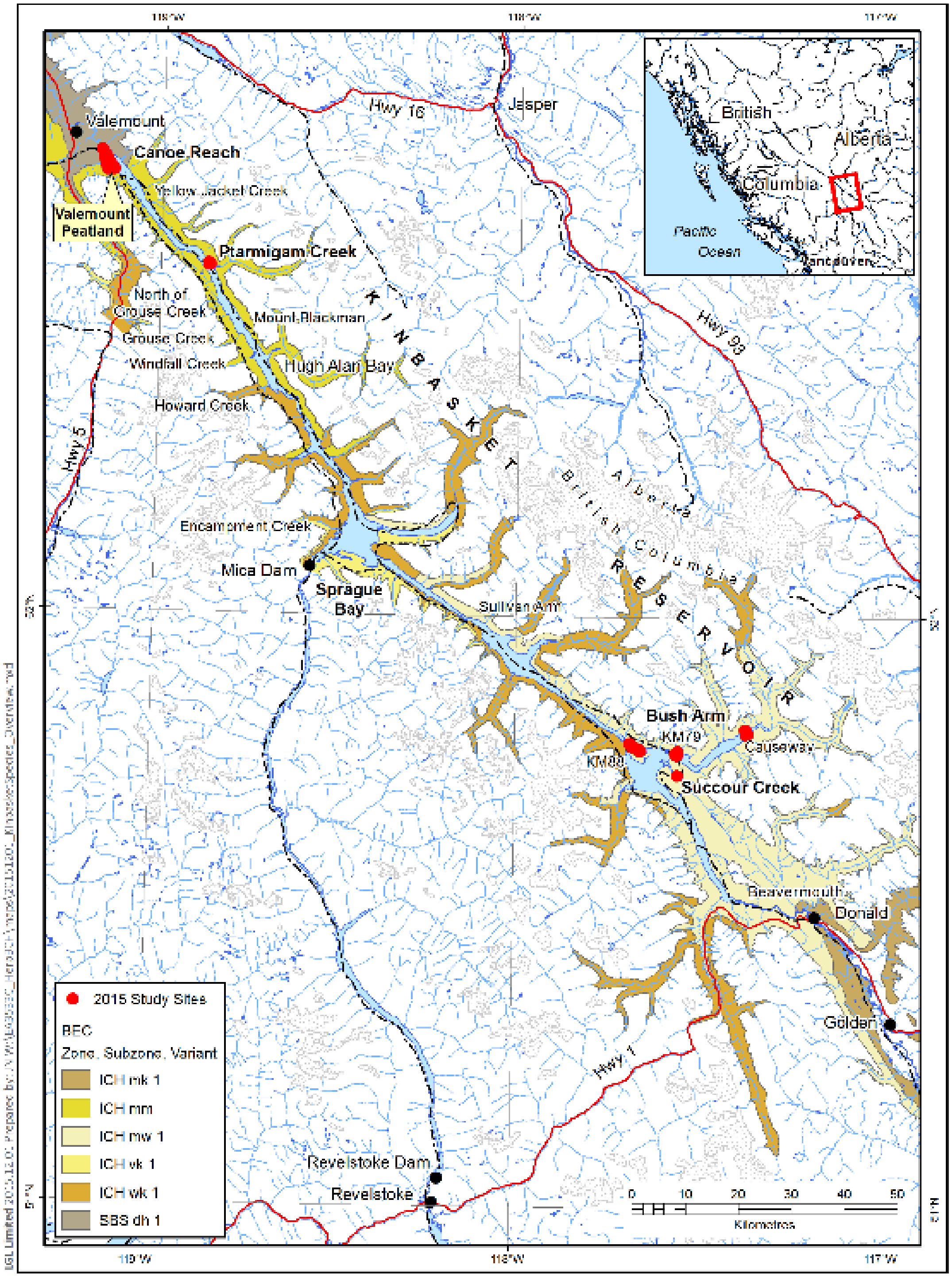

Figure 3-1: Location of Kinbasket Reservoir in British Columbia and locations sampled for CLBMON-58 in 2015. Naming of study sites follows Hawkes et al. (2007)

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.

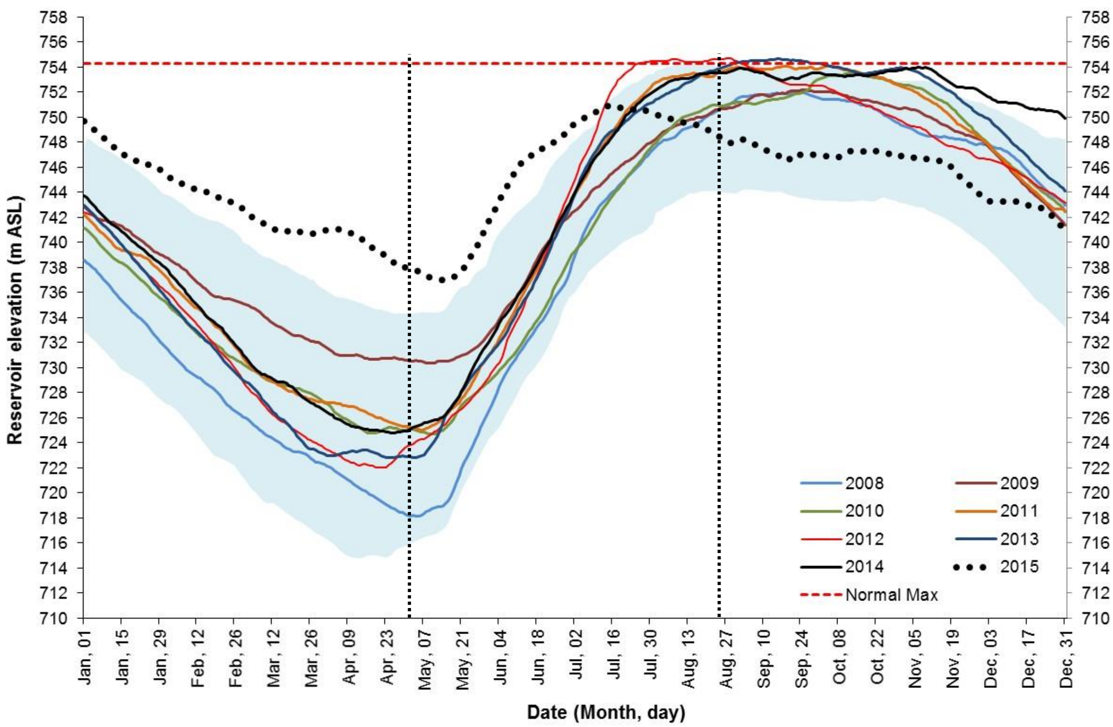

Figure 3-2: **Kinbasket Reservoir hydrograph for the period 2008 through 2015.** The shaded area represents the 10th and 90th percentile for the period 1976 to 2015; the dashed red line is the normal operating maximum. Vertical dashed lines indicated start and end dates of sampling in 2015.

3.3.1 Study Locations

Specific habitats 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). 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 FSR) 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).

4.0 METHODS

4.1 Field Schedule

In 2015, field sampling was conducted between May and August to coincide with the active period of amphibians and reptiles. Field sampling in Canoe Reach was more extensive due to a summer student and field technician commencing a radiotelemetry study in the Valemount Peatland. Sampling occurred daily or every other day from May 2 to August 26. Field sampling in Bush Arm occurred between May 9 and 11, June 11 and 14, and July 3 and 6. The 2015 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 (egg mass surveys [EMS], larval surveys [LVS] and visual encounter surveys [VES]) were used to survey amphibians and reptiles (VES only) in the DDZ of Kinbasket Reservoir in 2015. Of these methods, VES surveys were the most appropriate method to sample amphibians of all life stages, mainly because of the conspicuous nature of pond-breeding amphibians, particularly during the breeding season. 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 considered to be a subset survey type of VES and are reported with those results.

All previously mapped ponds and wetlands were surveyed in the Valemount Peatland, at Ptarmigan Creek, and throughout Bush Arm (KM88, Causeway, and KM79). Ponds were numbered at each site and were monitored during the active season (late April through September) to determine amphibian occupancy and use (provided access to the wetlands or ponds was not hindered by inundation from the reservoir or other access issues).

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).

Annual differences in species richness (q), diversity (H) and evenness (J) were assessed. Species richness was defined as the number of species of amphibians and reptiles occurring in the drawdown zone. Diversity was computed as Shannon's entropy and corresponded to a measure of species composition, combining both the number of species and their relative abundances (Legendre and Legendre 1998). For each transect, diversity was computed as:

$$\sum_i p_i \log \frac{1}{p_i}.$$

where pi is the relative proportion of species i.

A value of 0 means that the sampling unit contains only one species; H then increases along with the number of species recorded in the sampling unit. A high value of H means that many species were recorded.

4.2.2 Species 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, and sex was determined when possible. The marking scheme used in previous years was continued in 2015 (e.g., photo identification for adult amphibians and subcaudal scute clipping in snakes).Most captured animals were photographed, and UTM coordinates were obtained for each observation.

Amphibian Morphometric Data—Snout-urostyle length (SUL) was measured using Vernier calipers to the nearest 0.1 mm. Mass (to the nearest 0.1 g) was obtained using Pesola spring scales. The sex of each animal was determined (where possible) based on longer tail and enlarged vent in male salamanders and presence of nuptial pads on forelimbs of male frog and toad species during the breeding season. Larval amphibians were staged according to the Gosner (1960) or Harrison (1969) indexing standards.

Reptile Morphometric Data—Snout-vent length (SVL [mm]), tail length (TL [mm]) were measured using foldable metric rulers (2 m) and mass (to the nearest 0.1 g) was obtained with a Pesola spring scale. Sex in snakes was determined by probing for the spaces that contain the male reproductive organs.

For a more detailed description of the methods used to sample amphibians and reptiles in 2015, refer to the CLBMON-37 Year 1 report (Hawkes and Tuttle 2009) and revised monitoring program sampling protocols (Hawkes and Tuttle 2012).

4.2.3 Pond-breeding Amphibian Data

Assessing the potential impacts of increasing Kinbasket Reservoir elevations by 0.6 m required a combination of modelling and site-specific studies of pond-breeding amphibian habitat locations in the drawdown zone of Kinbasket Reservoir. To address the management question associated with CLMBON-58 and to collect data appropriate for testing the associated hypotheses, the following methods were used:

1. Identifying the locations of pond-breeding amphibian habitat in the drawdown zone of Kinbasket Reservoir

When reservoir levels were low (May), all ponds in the drawdown zone at each monitoring location were visited to determine if they were being used by amphibians for breeding. Ponds were classified as used or unused ponds (as defined by the presence of egg masses or tadpoles).

2. Mapping the location of pond-breeding amphibian habitat in a GIS and determining the elevation at which that habitat occurs

All ponds in the drawdown zone of Kinbasket Reservoir (monitoring locations) were previously mapped between 2008 and 2013 using a handheld GPS receiver (Garmin GPSMap 60cSx). These GPS tracks were mapped using ArcMap 10 to determine the location, total area and elevation of each pond within the drawdown zone. Ponds were visited to determine (1) availability (presence or absence in a given field session prior to inundation), (2) amphibian (or reptile) occupancy, and (3) amphibian breeding activity. The delineation of each pond was updated in 2015 to the 2012 orthorectified imagery of the drawdown zone of Kinbasket Reservoir.

3. Determining use of those habitats by pond-breeding amphibians for breeding

Ponds at each monitoring location were visited twice during the year to document species' presence, relative abundance (based on catch per unit effort [CPUE]), breeding occurrence and productivity, and seasonal use of pond areas as reservoir elevations change the availability of habitat. Egg mass surveys, larval surveys and visual encounter surveys were used to document amphibian habitat use. 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).

4. Studying the development of pond-breeding amphibians from egg deposition through to metamorphosis at various elevations

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, we monitored breeding occurrences, larval development (e.g., Gosner staging) and timing of metamorphosis (where possible) in Canoe Reach and Bush Arm.

5. Modelling the risk impacts of increasing the elevation of Kinbasket Reservoir by 0.6 m on ponds that occur in the drawdown zone

To model the effects of increasing the elevation of Kinbasket Reservoir by 0.6 m on pond-breeding amphibian habitat in the drawdown zone, we:

a. added 0.6 m to reservoir elevation reported during the time of year when ponds would be used by pond-breeding amphibians (April through August)

b. used the results of the site- and elevation-specific studies to determine the time of year when ponds at various elevations were inundated. We assumed that the effects on pond-breeding amphibians and their habitats vary by time of year and life stage (egg mass, tadpole, larvae, juvenile and adult).

c. used the output of the above to develop a risk matrix that portrays the risk of increasing reservoir elevations to pond-breeding amphibians and their habitats depending on the time of year. The risk matrix was developed by creating a plot of the reservoir hydrograph and overlaying the distribution of amphibian eggs, larvae and metamorphs by elevation and time of year. This provided a visual indication of the relationship between reservoir elevation, time of year (month) and life stage associated with pond-breeding amphibians. The risk matrix includes actual reservoir elevations and the predicted maximum increase in elevation (0.6 m) resulting from the installation of Mica 5/6. Colours are used to indicate risk: green = no risk (pond not inundated); yellow = some risk (the pond was partially inundated; and red = high risk (pond completely inundated).

4.2.4 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 2015, refer to the CLBMON-37 Year 1 report (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. A 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.

In 2015, four dissolved oxygen (PME MiniDOT) dataloggers were installed in select wetlands (KM88, KM79, Ptarmigan Creek, Pond 12 – Valemount Peatland) 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.

4.2.5 Radiotelemetry

Radiotelemetry of Western Toad and Common Garter Snake continued in 2015. A pilot to assess the utility of radiotelemetry for Columbia Spotted Frog was also undertaken. Adults of all three species were captured and fitted with radio transmitters (Holohil BD-2 for toads and frogs and PD-2 for snakes) and released at the site of capture. Transmitters had a life expectancy of 4 to 6 months depending on the model. Transmitters weighed no more than 5% of the mass of each toad, frog, or snake (Millspaugh and Marzluff 2001; Jepsen et al. 2003). Transmitters were attached to toads and frogs following the techniques described in Burow et al. (2012) and to snakes using the body method described in Wylie et al. (2011).

Telemetry sessions were conducted every few days between May and August 2015. 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.

4.3 Data Analysis

4.3.1 Site Occupancy

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 was assessed in two ways: (1) the presence of any life stage of a species at a survey site; and (2) the naïve occupancy rate (MacKenzie et al. 2006), or the proportion of mapped sites (ponds and wetlands nested within each survey site) in which a species was detected at least once in any year of study (i.e., 2011 to 2015).

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 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.

4.3.4 Animal Movements

We examined the relationship between the daily movements of radio transmitter-tagged toads, frogs, and snakes by month and inundation period at in Valemount Peatland. Animal movement was expressed as the linear distance (in metres) between telemetry detections. Linear distance was calculated using the Pythagorean Theorem and UTM position of toad and snake locations. The distance between telemetry locations was then standardized by the number of days between subsequent surveys to generate measures of distance traveled (m) per day.

5.0 RESULTS

Our ability to observe possible effects of reservoir activity depends upon the availability of robust occurrence data (i.e., multiple confirmations of species identifications over multiple years), which for this study relates to Western Toad and Columbia Spotted Frog. In 2015, as part of the radiotelemetry component of the study, we also collected data from several Common Garter Snake.

5.1 Environmental Data

Weather conditions are known to affect the surface activity of amphibians. Thus, 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 (Figure 5-1). The level of variation in precipitation and temperature was not sufficient to affect surface activities of amphibians, and thus, is not likely to have influenced detectability measures (Olson 1999; Hawkes and Gregory 2012). Further, temperatures were within the range of conditions considered suitable for amphibian sampling (Olson 1999; Hawkes and Gregory 2012).

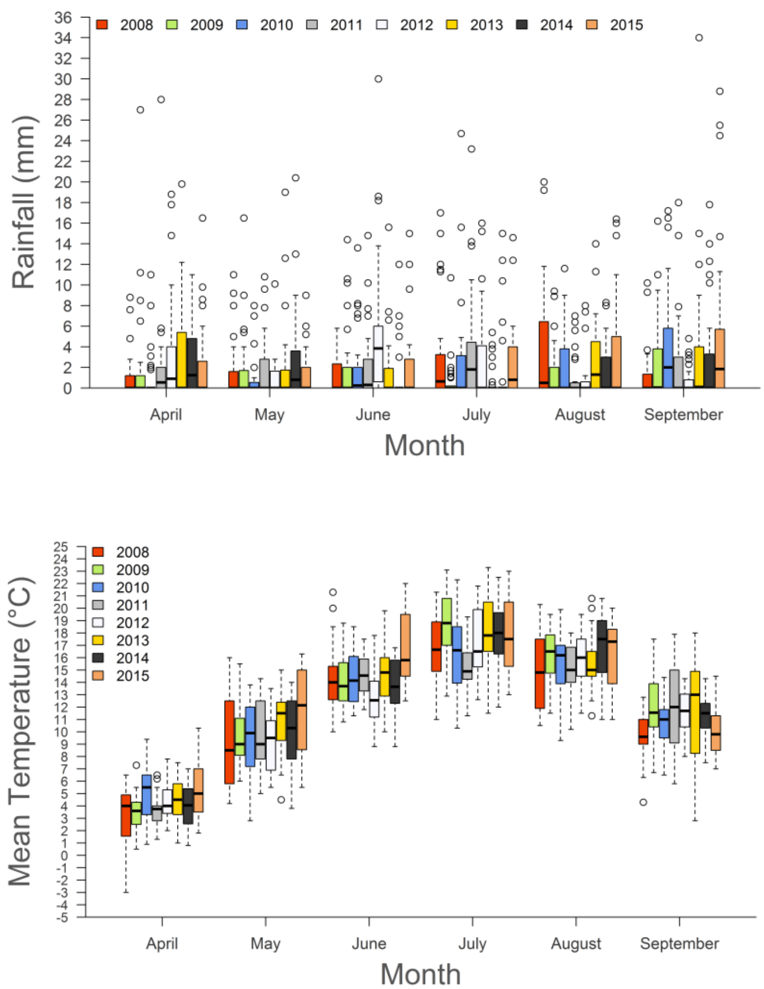

Figure 5-1: Daily precipitation (mm, above) and temperature (°C, below) for April through September, 2008 to 2015 as measured at Mica Dam. Data source: Environment Canada (http://climate.weather.gc.ca/index_e.html)

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). In general, water physical chemistry is believed to play a minor role in affecting the species richness of amphibians (e.g., Hecnar and M'Closkey 1996) and our data suggest that most values are characteristic of sites with relatively low dissolved oxygen, neutral pH, low conductivity, and warm spring and summer temperatures. These conditions are not likely to influence amphibian populations in the drawdown zone of Kinbasket Reservoir.

Table 5-1: Summary of water physicochemistry data collected for amphibian observations in the drawdown zone of Kinbasket Reservoir in 2015. Average and standard deviation values are provided, N = number of measurements from ponds of a particular type

		Conductivity		Dissolved Oxygen		pH		Temperature	
Pond Type	**N**	$\bar{x}$	**SD**	$\bar{x}$	**SD**	$\bar{x}$	**SD**	$\bar{x}$	**SD**
Artificial Pond	3	73.8	127.9	3.4	6.0	3.0	5.2	19.4	11.2
Beaver Pond	35	232.3	154.0	6.5	4.9	7.4	1.5	18.1	4.9
Equisetum Pond	52	167.3	131.9	3.5	4.2	7.1	1.1	19.9	4.0
Open DDZ Pond	157	105.5	73.5	5.1	4.5	6.9	1.6	17.6	5.4
Open Mudflat Pond	31	170.8	97.5	10.7	5.2	8.9	0.9	20.2	5.9
Peatland Pond	688	94.7	50.0	3.6	8.5	6.0	2.0	19.7	6.0
Wetland	125	116.2	94.4	1.6	2.9	5.4	3.7	18.8	8.3
Total	**1091**	**108.7**	**78.1**	**3.9**	**7.4**	**6.2**	**2.2**	**18.5**	**6.6**

Data obtained from ponds in the drawdown zone indicate that water temperature profiles vary throughout the year, with a slow decline in temperature into the winter months and rapid rise in temperature in June and July. The amphibian reproductive period of June through September is associated with the most drastic temperature fluctuations in ponds (Figure 5-2), suggesting that inundation resulting from reservoir filling may affect tadpole development.

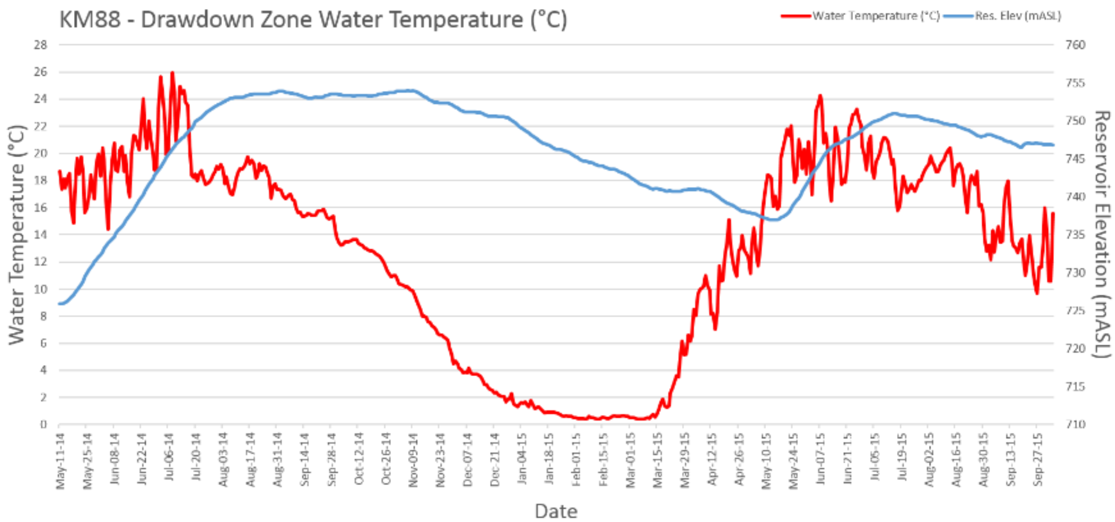

Figure 5-2: Average temperature profiles obtained from three Hobo Onset tidbit temperature data loggers deployed at KM88 Bush Arm, in the drawdown zone of Kinbasket Reservoir in 2015 (data from May to September 2015 shown)

Maximum elevation for Kinbasket Reservoir was 750.9 m ASL in 2015, and therefore not all ponds in the drawdown zone were inundated. For ponds that were inundated, large differences between pre- and post-inundation conditions in dissolved oxygen were not observed (Figure 5-3; Figure 5-4). However, water temperature decreased following inundation. For ponds that did not get inundated in 2015 (e.g., Pond 12 in the Valemount Peatland and Bush Arm KM79), water temperatures remained fairly stable (started to decrease at end of summer) and dissolved oxygen levels steadily decreased; in one pond, the water became hypoxic (i.e., DO < 2.0 mg/L).

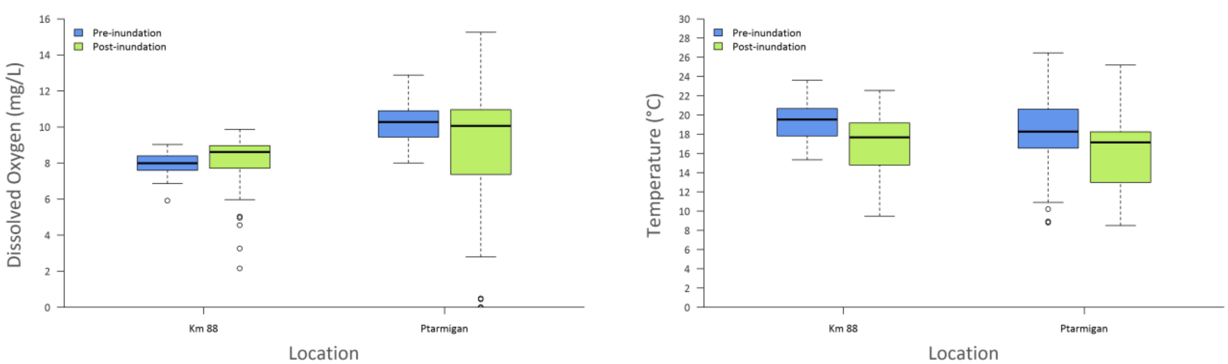

Figure 5-3: Differences in dissolved oxygen (DO; mg/L) and water temperature (°C) before and after reservoir inundation at KM88 and Ptarmigan Creek in the drawdown zone of Kinbasket Reservoir in 2015

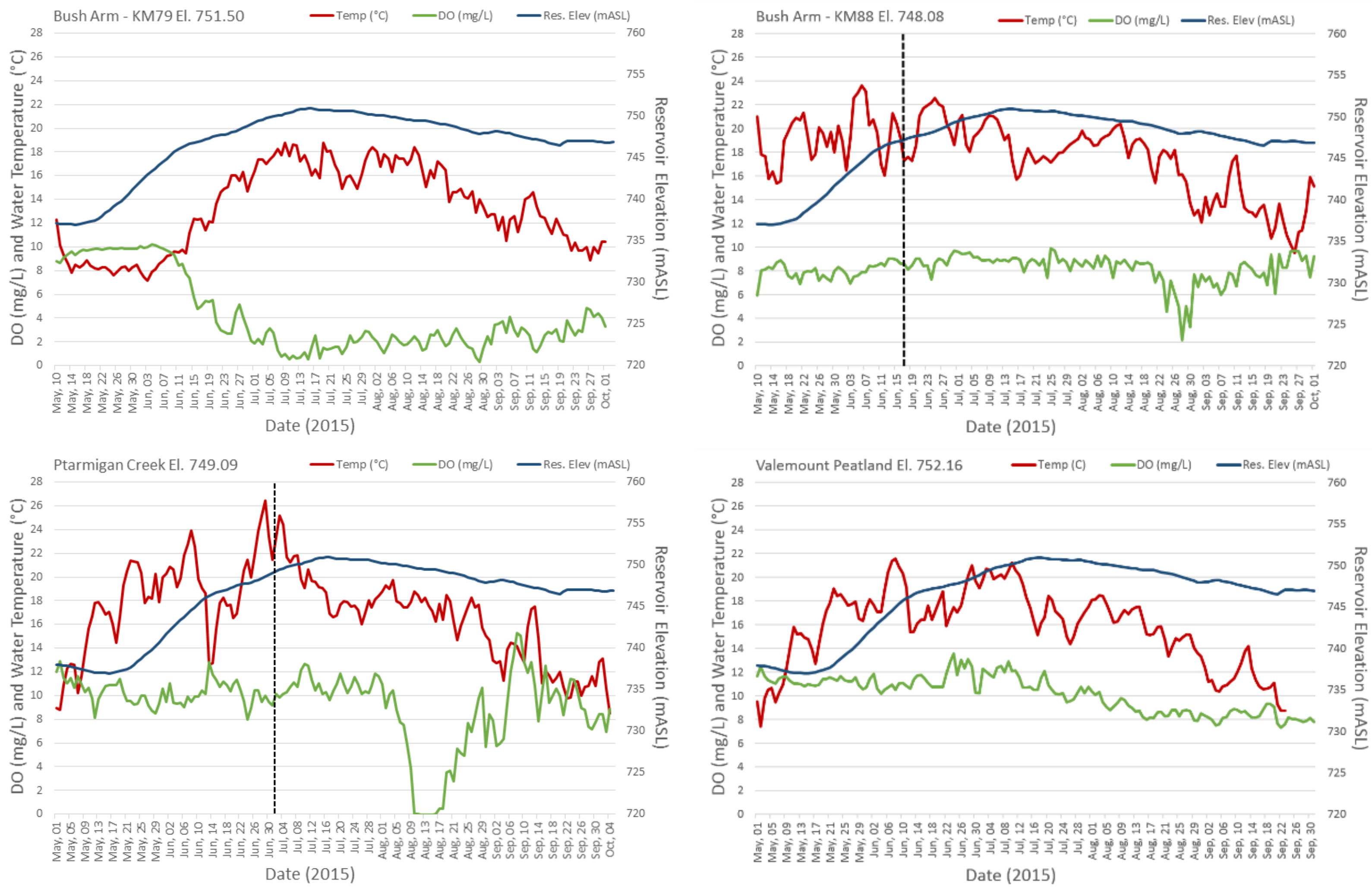

Figure 5-4: **Daily variation in dissolved oxygen (DO; mg/L) and water temperature (°C) relative to reservoir elevation (m ASL) for wetlands at four locations in the drawdown zone of Kinbasket Reservoir for 2015.** The dashed vertical line represents the date of inundation. Data loggers were set at a depth of 30 cm below the surface when first installed

Based on the data presented above, environmental conditions would not have negatively influenced amphibian and reptile surface activity during field surveys. Although DO and water temperature at the depth of the data logger might influence developmental rates of amphibian larvae, tadpoles tend to congregate at the edges of ponds where both DO and water temperature would be higher. Collectively the environmental and water physicochemical conditions associated with field surveys are unlikely to have negatively influenced the species of amphibians and reptiles being studied. Any potential differences in species detectability are therefore unlikely to have been a result of environmental or water physicochemical conditions.

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 2015 (Table 5-2). Two sites supported all three species of amphibians in 2015: 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 garter snakes 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. One Western Painted Turtle was observed at Bush Arm KM88 in 2015, which is the first record for this species in Kinbasket Reservoir. Similarly, a Pacific Chorus Frog was possibly heard calling in the Valemount Peatland, a species that has not been verified (and remains to be with additional observations) from the drawdown zone of Kinbasket Reservoir. Mapped occurrences of all species observed in 2015 are included in Appendix 10-1.

Table 5-2: Site occupancy (shaded cells) of amphibians and reptiles observed in the drawdown zone of Kinbasket Reservoir for 2011, 2013, and 2015. 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	**11**	**13**	**15**	**11**	**13**	**15**	**11**	**13**	**15**	**11**	**13**	**15**	**11**	**13**	**15**	**11**	**13**	**15**	**11**	**13**	**15**	**11**	**13**	**15**
Bush Arm KM88																						4	2	4
Bush Arm Causeway																						5	4	5
Bush Arm KM79 (DDZ)																						3	3	2
Bush Arm KM79 (UPL)																						2	2	2
Ptarmigan Creek																						3	4	3
Succour Creek																						1	0	1
Valemount Peatland																						4	4	5
Total Sites Occupied	**2**	**3**	**2**	**6**	**6**	**6**	**0**	**0**	**1**	**6**	**6**	**6**	**0**	**0**	**1**	**3**	**0**	**2**	**5**	**4**	**4**	**7**	**6**	**8**

5.3.2 Detection Rate

Between April and August, we spent over 975 hours surveying monitoring sites within the DDZ of Kinbasket Reservoir, during which we observed more than 540,586 individuals across multiple life stages of all species (Table 5-3). 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. We examined the detection rates for seven areas in Kinbasket Reservoir of which 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 2015. Blanks indicate the species was not detected. AMMA = Long-toed Salamander, ANBO = Western Toad, RALU = Columbia Spotted Frog, CHPI = Western Painted Turtle, THEL = Western Terrestrial Garter Snake, 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	Time	AMMA	ANBO	RALU	CHPI	THEL	THSI	Total	CPUE
Bush Arm KM88	17.1		46	8	1		4	**59**	**3.45**
Bush Arm Causeway	10.5	85	133	3		2	4	**227**	**21.72**
Bush Arm KM79 (DDZ)	9.1		27	11				**38**	**4.19**
Bush Arm KM79 (UPL)	3.8		1	181				**182**	**48.29**
Ptarmigan Creek	59.4		256	16			25	**297**	**5.00**
Succour Creek	1.1					4		**4**	**3.51**
Valemount Peatland	698.6	**3**	**534**	**352**			**26**	**915**	**1.31**
Totals: Time (hrs), #obs	**799.5**	**88**	**997**	**571**	**1**	**6**	**59**	**1722**	**1.29**
CPUE (#obs/hr)		**0.11**	**1.25**	**0.71**	**0.00**	**0.01**	**0.07**	**2.15**	

5.3.3 Elevation

Amphibians and reptiles were found across a wide range of elevations in Kinbasket Reservoir in 2015 (Figure 5-5). Most observations (all life stages combined) were between 749 and 754 m ASL, a trend that was also observed in 2011 and 2013 (Figure 5-6). 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. A single observation of a Western Painted Turtle was made at 753 m ASL at KM88. The relationship between amphibian and reptile distributions in the drawdown zone is likely a function of habitat availability.

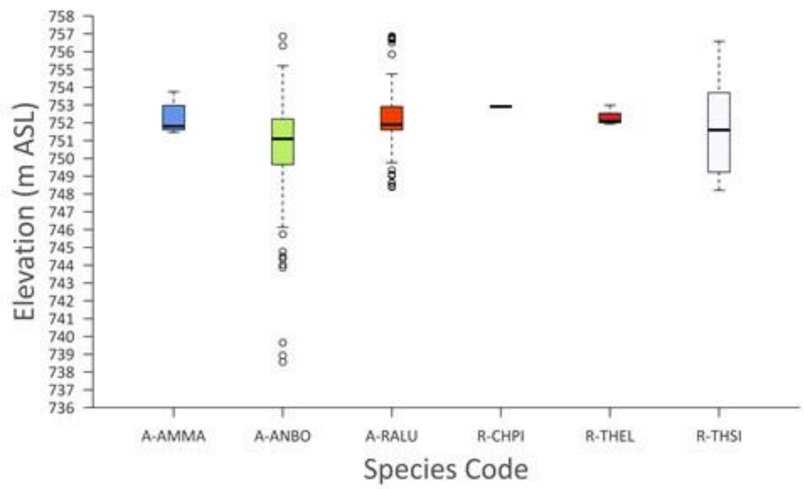

Figure 5-5: Elevation distribution of amphibians and reptiles (number of observations, all life stages combined) documented in and adjacent to the drawdown zone of Kinbasket Reservoir in 2015. A- = Amphibian; R- =Reptile. AMMA = Long-toed Salamander, ANBO = Western Toad, RALU = Columbia Spotted Frog,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

Western Toad and Columbia Spotted Frog were distributed across an elevation range of 737 to 754 m ASL. The largest aggregations of both species were observed between ~750 and 754 m ASL, which is related to the distribution of wetlands in the drawdown zone (see Section 5.4.6). Salamanders occupied only the highest elevation ponds (752 to 753 m ASL), which may be related to the proximity of these ponds to upland forest where this species typically lives. The distribution of snakes in Kinbasket Reservoir overlapped that of amphibians in most cases: Common and Western Terrestrial Garter Snake were typically found between 747 and 753 m ASL. Differences between the species could be due to habitat availability (e.g., habitats at higher elevations were available for longer periods than those at lower elevations), or animals could have preferentially selected habitats based on specific features (e.g., ponds that do not get inundated until later in the season, availability of foraging or basking sites, predation risk, etc.). The current data set does not provide the information necessary to determine habitat associations at this scale.

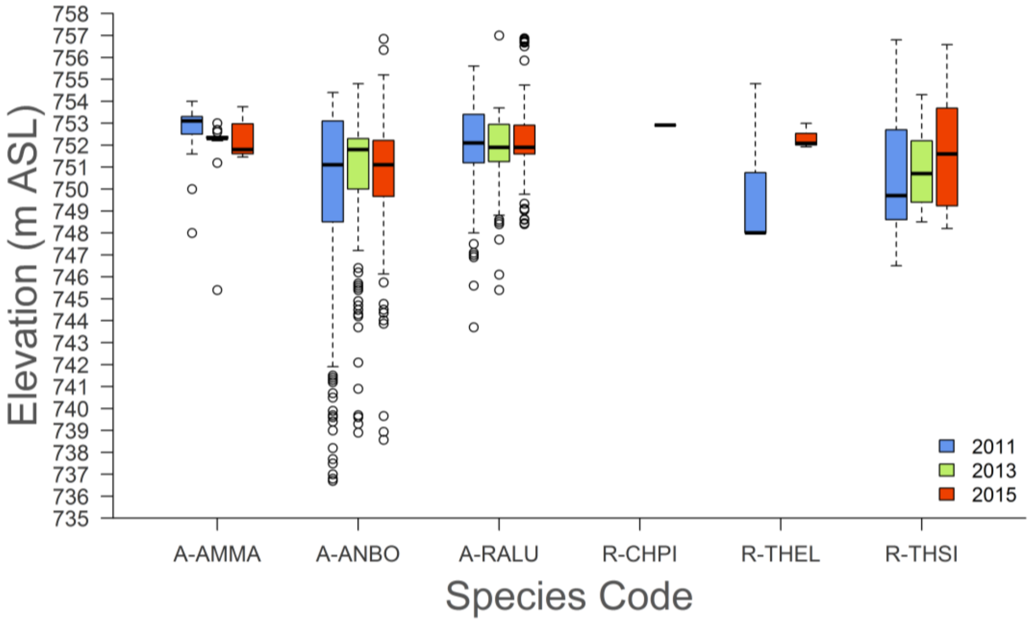

Figure 5-6: **Elevation distribution of amphibians and reptiles (number of observations, all life stages combined) documented in and adjacent to the drawdown zone of Kinbasket Reservoir in 2011, 2013, and 2015.** A- = Amphibian; R- =Reptile. AMMA = Long-toed Salamander, ANBO = Western Toad, RALU = Columbia Spotted Frog, CHPI = Painted Turtle, THEL = Western Terrestrial Garter Snake, THSI = Common Garter Snake

5.3.4 Pond and Wetland Habitat in the Drawdown Zone

One hundred and three ponds ranging from 0.003 ha to 0.945 ha have been delineated across the years in and adjacent to the drawdown zone of Kinbasket Reservoir. Most ponds mapped were < 0.15 ha. Pond habitat occurs between 734 and 756 m ASL and most of the amphibian and reptile observations made in 2015 occurred between 744 and 754 m ASL (Figure 5-7).

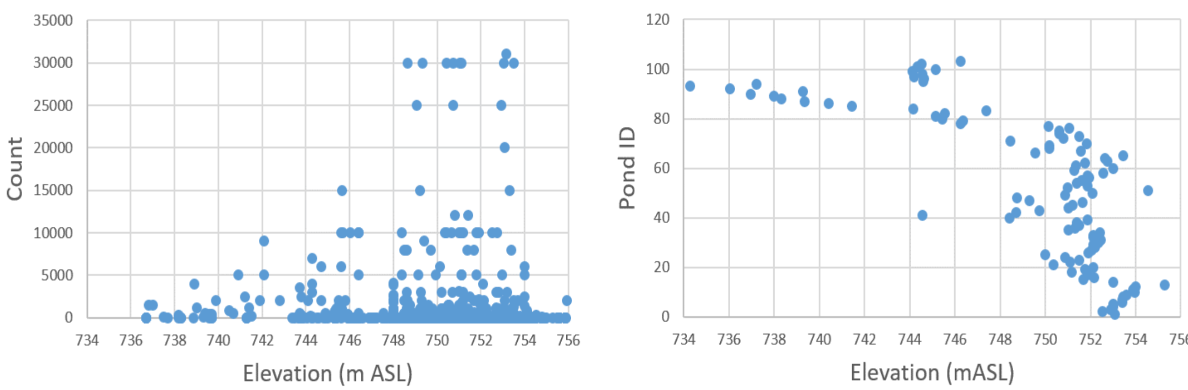

Figure 5-7: **Elevation distribution of amphibians and reptiles detected in 2015 (all species pooled; left) and elevation distribution of ponds (right) in the drawdown zone of Kinbasket Reservoir**

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 5-8). 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) and Kellogg's Sedge (KS) habitats. Vegetation communities in which amphibians were found were distributed between ~740 m and 754 m ASL (Figure 5-8).

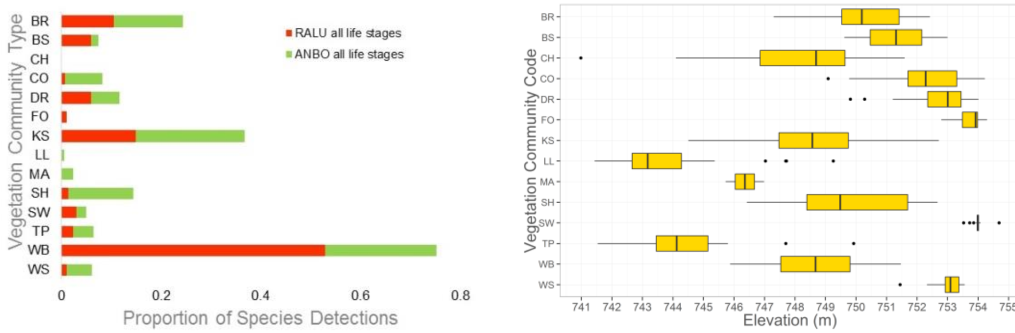

Figure 5-8: Distribution of Western Toad and Columbia Spotted Frog (all life stages grouped) by vegetation community class in the drawdown zone of Kinbasket Reservoir in 2015 (left panel) and elevation distribution of the same VCCs (right panel). ANBO = Western Toad, RALU = Columbia Spotted Frog; BR = 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 5-8). 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 5-8).

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 or bluejoint reed-grass (BR; Figure 5-9). 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.

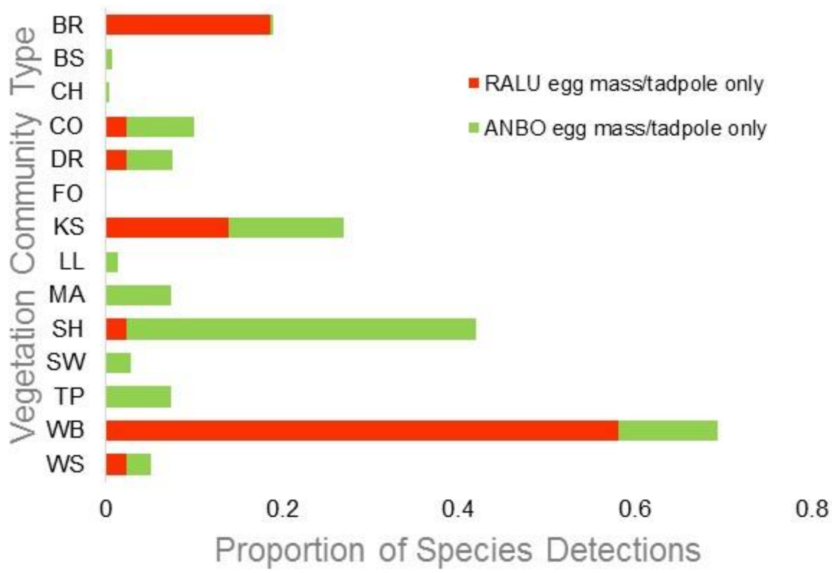

Figure 5-9: Distribution of Western Toad and Columbia Spotted Frog (egg masses and tadpoles only) by vegetation community class in the drawdown zone of Kinbasket Reservoir in 2015. ANBO = Western Toad, RALU = Columbia Spotted Frog; BR = bluejoint reedgrass, BS = buckbean-slender sedge, CH = common horsetail, 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

5.3.6 Radiotelemetry

In 2015, 20 Western Toad (9 females, 11 males), two Columbia Spotted Frog (females), and four Common Garter Snake (all females) were captured and fitted with radio transmitters in the Valemount Peatland. Toads ranged in size from 60 mm to 106 mm SUL and 40 to 152.7 g, with all females being larger than males. Columbia Sotted Frog averaged 46.9 mm SUL and 72.2 g while snakes ranged in size from 654 to 752 mm SVL and 198 to 397 g. Animals were tagged and tracked between May 2nd and August 27th. Individual toads were tracked between 8 and 52 days (average = 30 days), frogs for 3 to 20 days and snakes for 29 to 65 days (average = 49).

Total maximum successive distances travelled by toads differed between males and females with males moving an average of 371.3 m compared to 341.9 m for females, which was not significant ($F = 1.49$, $p = 0.26$; Figure 5-10). Columbia Spotted Frog made short distance movements (~10 to 38 m) and snake movements averaged 428 m (121 to 825 m; Figure 5-11).

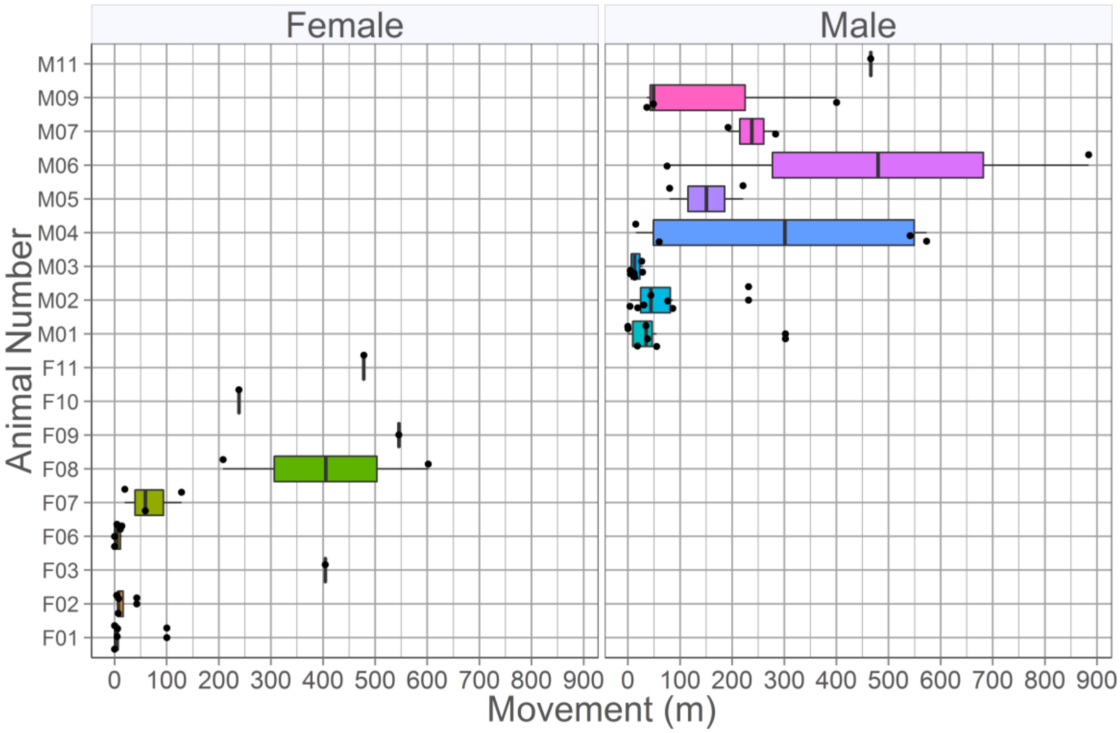

Figure 5-10: Total maximum daily movements made by female and male Western Toad (ANBO) in the Valemount Peatland, Kinbasket Reservoir, between May 2nd and August 27th 2015. F = Female (*N*=9); M = Male (*N*=9)

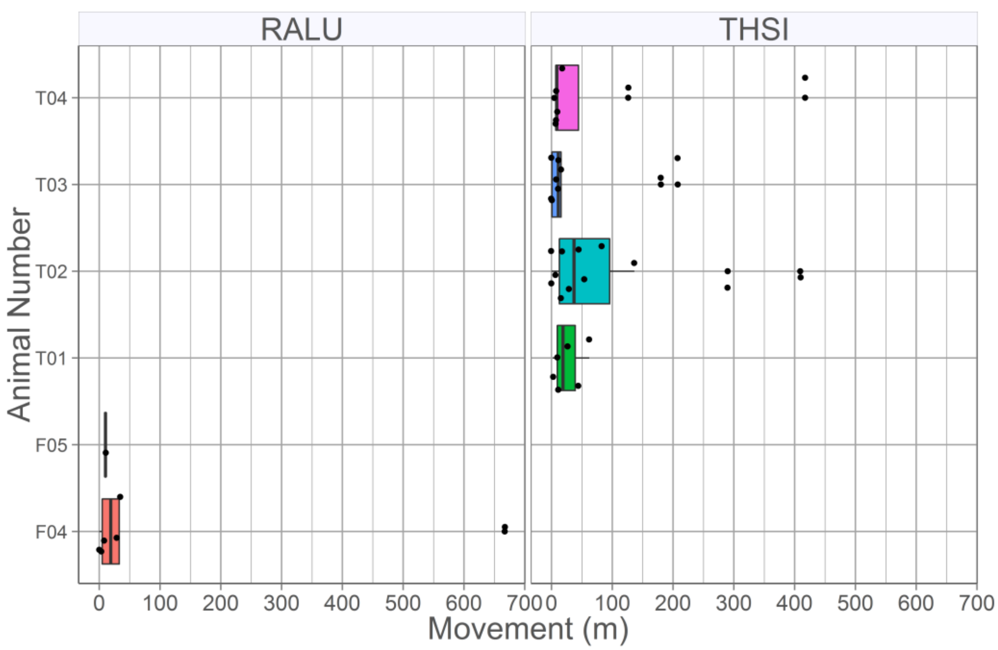

Figure 5-11: Total movements made by female Columbia Spotted Frog (RALU; F04 and F05) and female Common Garter Snake (THSI; T01 to T04) in the Valemount Peatland, Kinbasket Reservoir, between May 15th and August 17th 2015. F = Female; M = Male

On average, male toads had higher average daily movements than females, averaging ~ 19 m per day (vs. 12.8 for females). Despite lower sample sizes, Columbia Spotted Frog tended not to move much on a daily basis, averaging only 2.7 m per day. Common Garter Snake moved an average of 7.8 m per day (Figure 5-12).

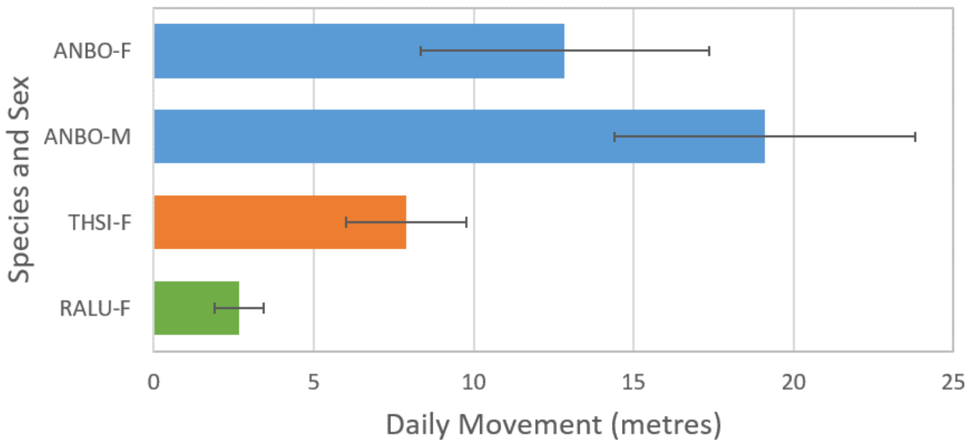

Figure 5-12: Average daily movements of Western Toad (ANBO), Columbia Spotted Frog (RALU) and Common Garter Snake (THSI) in the Valemount Peatland, Kinbasket Reservoir, 2015. F = Female; M = Male

Three of the 20 toads captured in the drawdown zone moved into upland habitats during the survey period, with one toad occupying habitat on the lower slopes of Canoe Mountain (Figure 5-13). Between July 9 and August 20, a female toad (F08) moved ~810 m from the drawdown zone to upland summer habitat.

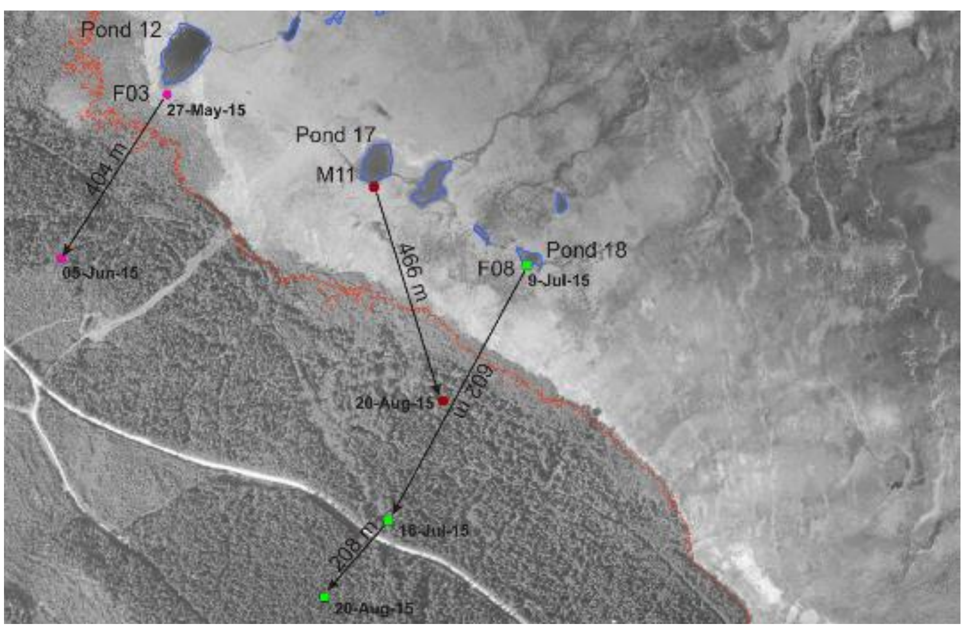

Figure 5-13: Examples of successive movements by two female and one male Western Toad in Canoe Reach, Valemount Peatland 2015. Dates indicate location dates. Vectors indicate presumed (straight-line) direction of movement. The red line is the 754 m ASL contour. Locations above this contour are outside of the drawdown zone

The four tagged Common Garter Snake remained clustered around Pond 12 at the south end of the Valemount Peatland (Figure 5-14, top). Successive movements ranged from 0 m (i.e., snake had not moved) to 417 m (Figure 5-14, bottom) Current data preclude additional analyses related to home range (e.g., Kernel Density Estimates).

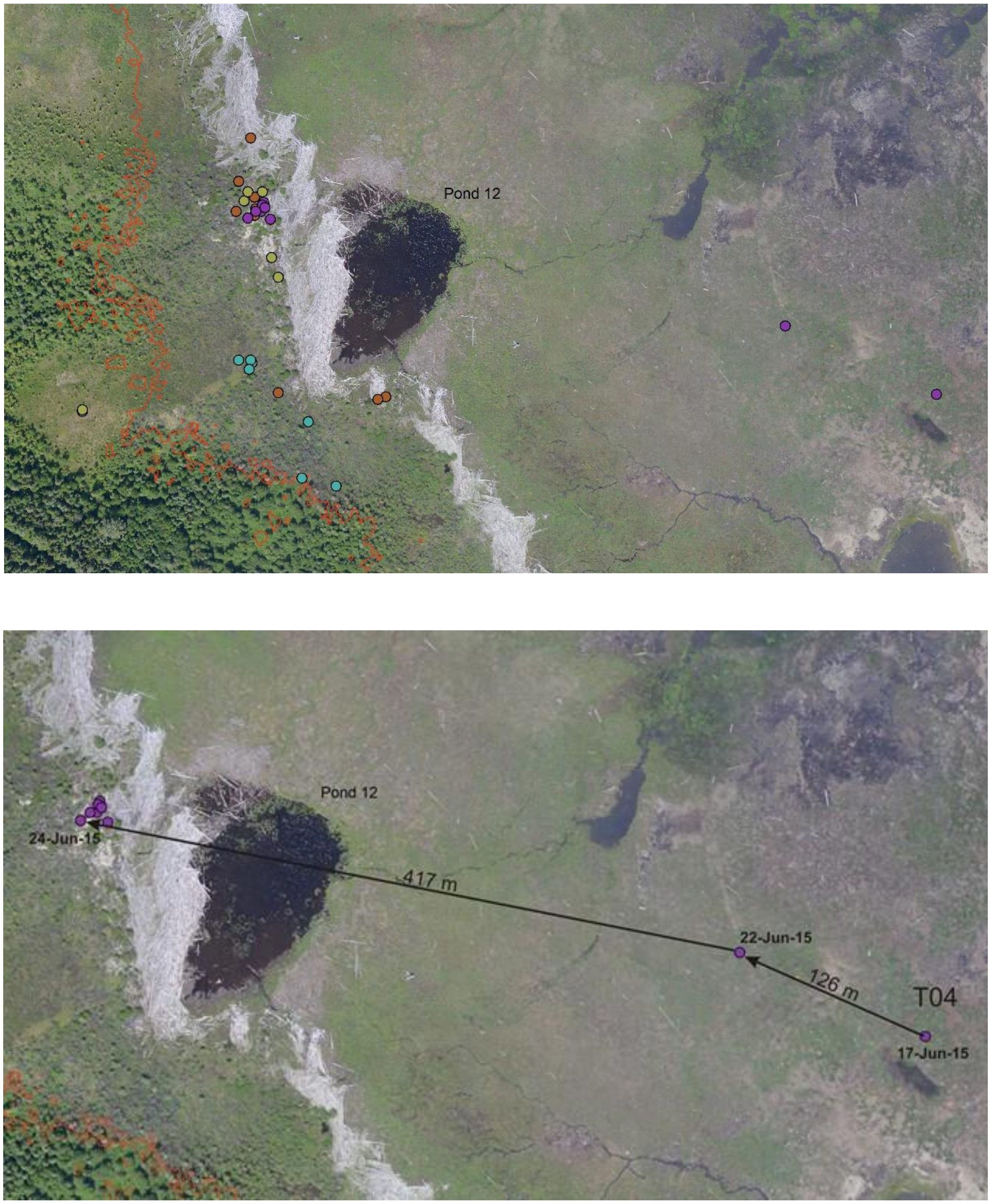

Figure 5-14: Distribution of Common Garter Snake detections between May 2 and August 27, 2015 (top) and maximum (straight line) movements by snake T04 between Jun 17 and June 24, 2015 (bottom). The orange line depicts the 754 m ASL elevation band. Coloured dots on the top panel represent different snakes

5.4 Hypotheses Testing

5.4.1 *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*

Soft Operational Constraints

Section 4.4.1.1 of the Columbia River Water Use Plan (BC Hydro 2007) indicates that the Consultative Committee did not recommend any operational constraints on Kinbasket Reservoir. As such, an assessment of the implementation of soft constraints is relevant to Arrow Lakes Reservoir only.

Effects of Mica 5/6

Data collected between 2011 and 2013 represent the period prior to the installation of units 5 and 6 at Mica Dam. During this time, the operation of Kinbasket Reservoir was different than in previous years (Figure 3-2). Specifically, Kinbasket Reservoir was filled beyond the normal operating maximum in 2012 and 2013, an operation that had not been implemented since 1997 (Figure 5-15). 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.

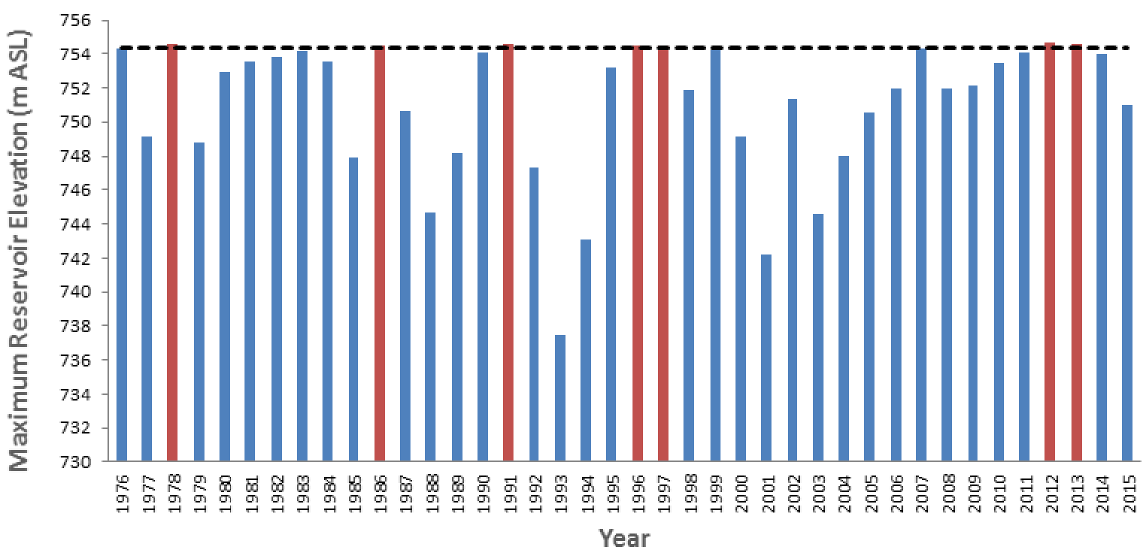

Figure 5-15: Maximum reservoir elevations (metres above sea level, m ASL) achieved in Kinbasket Reservoir, 1976 to 2015. Red bars indicate years when Kinbasket Reservoir was operated beyond the normal operating maximum (black dashed line)

The installation of Units 5 and 6 at Mica Creek is predicted to 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 risk of direct mortality to amphibians and loss of suitable habitats (see Section 5.4.6) has increased relative to 2008 (Figure 5-16).

A lack of observations of the continuous 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 at present (i.e., without in situ or lab experiments it is difficult to clarify this relationship). Observations of delayed development resulting from temperature changes correlated to reservoir filling would be required. Similarly, without observations of mortality events such as a large number of dead tadpoles at the leading edge of the reservoir as it fills it will be difficult 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 are not able to quantify the effects that the installation of Mica Units 5 and 6 might have on amphibian larval development. However, a qualitative assessment of (Figure 5-16) 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. Likewise, an increase of 0.6 m over annual reservoir elevations does not appear to change the level of risk.

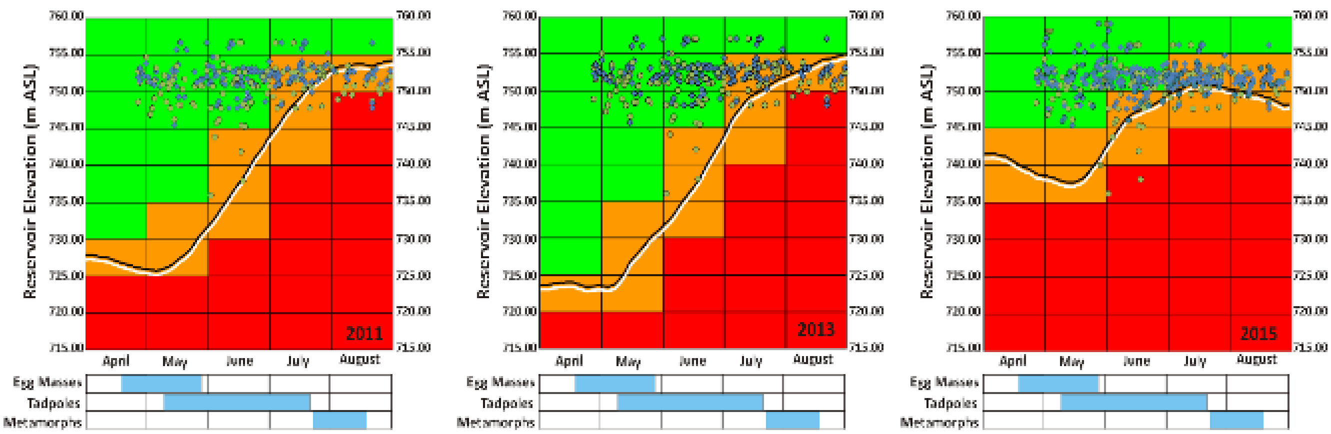

Figure 5-16: Risk matrix portraying risk of increasing reservoir elevations to pond-breeding amphibians and their habitats at various elevations in the drawdown zone of Kinbasket Reservoir, depending on time of year. Reservoir elevation data from April 1 through August 31 in 2008-2011 are plotted (white line) along with the predicted increase in elevation resulting from the installation of Mica 5/6 (black line). The phenology of various amphibian life stages are shown relative to date and elevation. The colours represent high risk (red), moderate risk (orange) and no risk (green). Data points represent observations of Western Toad of Columbia Spotted Frog at various elevations. 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 (Hawkes and Tuttle 2009, Hawkes et al. 2011). 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.

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. Western Toad are likely the most affected by early inundation. Western Toad breed in ponds at lower elevations than other species in the drawdown zone. For example, Bush Arm KM88 and KM79, Western Toad egg masses were documented in low elevation, mud-bottomed ponds (with little vegetation) between 734 and 749 m ASL (see Section 5.4.6). Ponds situated between 735 and 750 m ASL were at moderate risk by early June, with their habitats being completely inundated by early July (Figure 5-16). Timing of inundation for these lower ponds is ~ one month earlier than most other amphibian habitats, occurring just shortly after the last frog egg masses are typically detected. Additionally, Western Toad metamorphs have not been observed at KM88 (but this may be a function of limited site access for field crews). Columbia Spotted Frog are less likely to be impacted by inundation, as they tend to lay their eggs in higher elevation ponds.

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.

5.4.2 $H1_A$: 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 2015, Western Toad detection rates (as a proxy for abundance) were not influenced by reservoir elevation (correlation coefficient = -0.03) and the relatively low reservoir elevations in 2015 meant that more Columbia Spotted Frog were detected (correlation coefficient = 0.37; Figure 5-17). For both species the range of elevations across which they were observed is consistent with previous years of study.

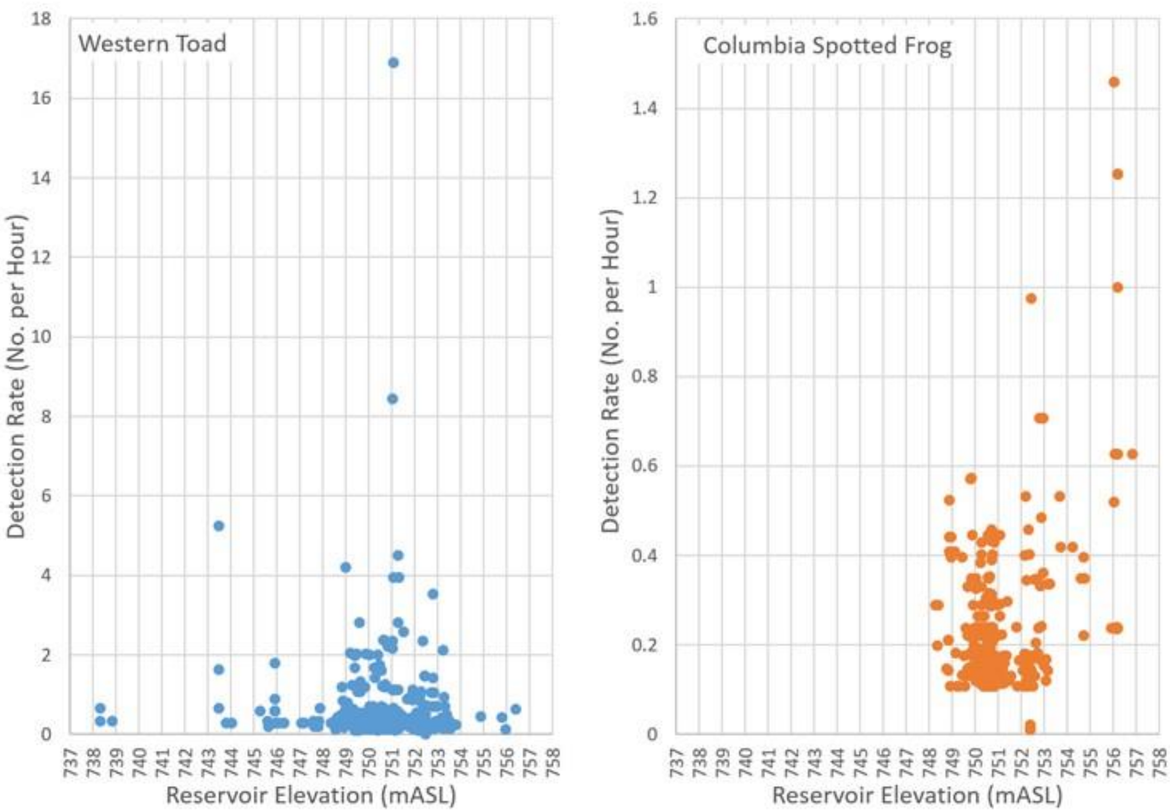

Figure 5-17: Relationship between reservoir elevations and detection rates (number per hour) for Western Toad and Columbia Spotted Frog in Kinbasket Reservoir, 2015. Note different scales on vertical axes

5.4.3 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.

Our current understanding of the use of the drawdown zone by amphibians and reptiles is that certain species use the DDZ to fulfill most 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 5-4).

Table 5-4: 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. Western Toad depredation). 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.

5.4.4 $H1_C$: Reservoir operations do not result in decreased site occupancy of amphibians or reptiles in the drawdown zone.

Proportion of Sites

Between 2008 and 2015, seven main locations in the drawdown zone have been surveyed for amphibians and reptiles (Table 5-5). 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 Terrestrial Garter Snake to 85.7 per cent for Western Toad and Columbia Spotted Frog. 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. Of the garter snakes detected, Western Terrestrial Garter Snake are rarely found in the drawdown zone, with only a few individuals detected in one of the three years. Common Garter Snake were observed each year with annual occupancy ranging from 57.1 to 71.4 per cent. For some species and years occupancy will be a function of survey effort. For example, in 2011 and 2015 surveys focused on the Valemount Peatland. Despite this, the general patterns of occupancy remain with toads and frogs more widely distributed and more readily detectable than all other species.

Table 5-5: 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 2011, 2013 and 2015. A = amphibian, R = reptile; AMMA = Long-toed Salamander, ANBO = Western Toad, PSRE = Pacific Chorus Frog (only a possible occurrence), RALU = Columbia Spotted Frog, CHPI = Western Painted Turtle, THEL = Western Terrestrial Garter Snake, 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	**11**	**13**	**15**	**11**	**13**	**15**	**11**	**13**	**15**	**11**	**13**	**15**	**11**	**13**	**15**	**11**	**13**	**15**	**11**	**13**	**15**
Bush Arm KM88				48	15	22				3	4	8			1	1			1		4
Bush Arm Causeway	4	52	15	41	134	54				1	4	3				1		2	2	3	4
Bush Arm KM79 (DDZ)				27	26	15				61	5	11							4	2	
Bush Arm KM79 (UPL)				9	3	1				32	16	7									
Ptarmigan Creek		1		280	25	169				24	3	16							131	3	25
Succour Creek																1		1			
Valemount Peatland	18	1	3	451	49	270			1	426	33	308							53	1	26
Total Locations	**2**	**3**		**6**	**6**	**6**	**0**	**0**	**1**	**6**	**6**	**6**	**0**	**0**	**1**	**3**	**0**	**2**	**5**	**4**	**4**
Proportion of Locations	**28.6**	**42.9**	**28.6**	**85.7**	**85.7**	**85.7**	**0.0**	**0.0**	**14.3**	**85.7**	**85.7**	**85.7**	**0.0**	**0.0**	**14.3**	**42.9**	**0.0**	**28.6**	**71.4**	**57.1**	**57.1**

*PSRE not confirmed (auditory detection only)

5.4.5 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.

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.

5.4.6 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 on a monthly basis 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 in June and July, when reservoir elevations are increasing (Figure 5-18). A notable difference occurred in 2015, whereby reservoir levels were lower than usual and began to decline again in July instead of increasing into September.

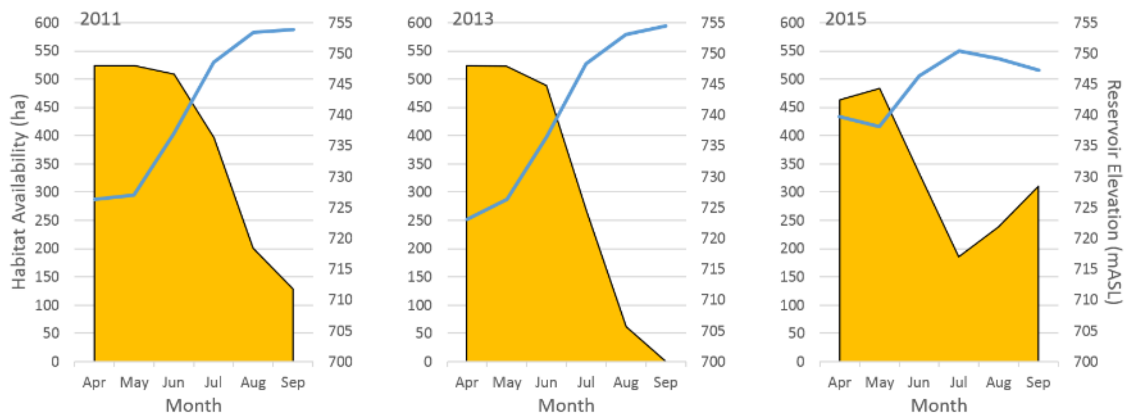

Figure 5-18: Relationship between habitat availability and reservoir elevation (i.e., inundation) in the drawdown zone of Kinbasket Reservoir for 2011, 2013 and 2015. The average reservoir elevation is shown (line)

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

[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.

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 previous years report 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 2011, 2013, and 2015. In 2011 and 2013, the majority of 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 5-19).

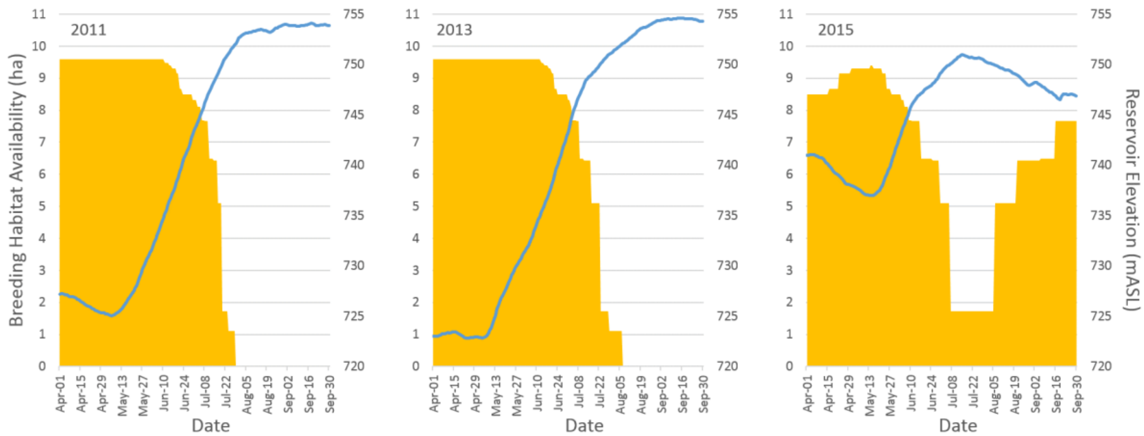

Figure 5-19: Relationship between amphibian breeding (and rearing) habitat availability (pond area) and reservoir elevations for the period April 1 through September 30, 2011, 2013, and 2015

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; however, based on our observations of all life stages of Western Toad (eggs, tadpoles, metamorphs, and adults), the reduction in habitat availability associated with inundation does not appear to be associated with reduced reproductive success. Observations of metamorphosed toads at the Valemount Peatland and Ptarmigan Creek in early to late August suggests that toad egg strings and tadpoles can tolerate some level of disturbance from reservoir operations at lower levels, and ponds that didn't get inundated by the reservoir also had metamorphosed toads. However, the degree to which reservoir operations might affect the success of observed breeding (in terms of the proportion of eggs that survive to metamorphosis) is not well understood and cannot currently be quantified (without following egg mass/tadpole development through to metamorphosis – extremely difficult and labour intensive).

Foraging Habitat

Amphibians and reptiles forage in a variety of aquatic and terrestrial habitats and both of these 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 5-18). During each year, the availability of foraging habitat decreased rapidly as soon as reservoir elevations reached ~740 m ASL (Table 5-6). In 2015, a lower proportion of habitat was inundated than in the previous six years; however, the annual trends are similar with only the timing and duration of inundation of each elevation band varying (Table 5-6).

Table 5-6: Proportion of time between April and September (n = 183 days) that Kinbasket Reservoir exceeded a given range of elevations from 1997 to 2015

m ASL	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
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
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
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
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
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
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
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
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
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
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
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	
752-753	0.39		0.28								0.36		0.06	0.03	0.35	0.42	0.30	0.34	
753-754	0.34		0.19								0.19			0.01	0.32	0.32	0.25	0.29	
>754.38																0.17	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 September 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 and 2015 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).

We are not currently able to confirm where garter snakes overwinter relative to the drawdown zone and although we suspect that they overwinter in upland habitats, data collected as part of a Master's project in 2016 will clarify this.

5.4.7 $H2_A$: 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. 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 2015, draft). Owing to limited scale, it is not expected that any of the work completed in 2015 will change species diversity or abundance of amphibians and reptiles in the drawdown zone. However, it is anticipated that those now-available habitats (previously unavailable because they were choked with wood debris) will be occupied by pond-breeding amphibians and reptiles in future.

5.4.8 $H2_B$: 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

The productivity of pond-breeding amphibians (Long-toed Salamander, Western Toad, and Columbia Spotted Frog) may change as a result of access to new breeding areas. These areas were cleared of wood debris in fall 2015 and will be assessed for use in 2016 during fieldwork associated with CLBMON-37. Preliminary results from the Valemount Peatland suggest that clearing wood from wetlands and protecting the wetlands with a log boom will provide suitable breeding habitat for pond-breeding amphibians.

5.4.9 $H2_C$: 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.

6.0 DISCUSSION

The relationship between habitats occurring in the drawdown zone of hydroelectric reservoirs and their use by wildlife 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 should be 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 as a result 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.

To better assess the within and between season use of the drawdown zone by amphibians and reptiles, a radiotelemetry study was piloted in 2014 and continued in 2015. The results to date indicate that Western Toad use the drawdown zone for breeding and spring and summer foraging, with some individuals retreating to upland habitat for the summer. 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 Columbia Spotted Frog, Western Toad, and Common Garter Snake.

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). In 2015, two unexpected observations, one of a Pacific Chorus Frog (auditory only) in The Valemount Peatland and another of a Western Painted Turtle at Bush Arm KM88; however, more detections of these species at these sites are required to confirm occupancy (i.e., turtle could have been an introduction by human release). The most commonly occurring species 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. The seasonal variation observed in the drawdown zone may be similar to the seasonal variation associated with non-reservoir populations of toads and frogs, but this has not been confirmed.

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 in a given 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 has not been explicitly studied in Kinbasket Reservoir. 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. However, too few data on other species of amphibians exist to discuss how reservoir operations might affect their productivity. To better assess the variation in amphibian productivity across time, increased effort is required to measure reproductive success and survivorship of eggs and tadpoles of pond-breeding amphibians at various elevations in the drawdown zone. This would require intensive site-specific monitoring of ponds used by pond-breeding amphibians, particularly Western Toad and Columbia Spotted Frog, to determine their productivity and survival in various 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 (n= 7 observations, all in 2011), but are known to occur in the upland habitats immediately adjacent to the drawdown zone. In 2015, a surprising observation of a single adult Western Painted Turtle was made at KM88 (near the mouth of Bush Arm); however it is not known 1) if more than one turtle is present at this or other sites, or 2) whether this animal was released from the Revelstoke population or has immigrated on its own into Kinbasket Reservoir (1st observation of this species for the reservoir).

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 2016 at KM88, where the turtle was spotted in 2015. Reproduction for garter snakes occurs near overwintering sites (Garstka et al. 1982; Kromher 2004) which are likely outside of the DDZ (and this requires telemetry studies to locate the overwintering sites and verify reproductive behaviour; see Section 0). 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. The radiotelemetry study planned for Kinbasket Reservoir during field work for CLBMON-37 and 58 in 2016 and 2017 will help to answer this question.

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, but radiotagged frogs could be monitored during winter to assess overwintering habits and is necessary to answer this part of Management Question 3.

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). 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 his 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 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.

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 (swamp-horsetail, wool-grass–Pennsylvania buttercup, and Kellogg's sedge) (see Section 5.3.5). Western Toad used a wider range of elevations (737–754 m ASL) than did 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.). 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 5-19). Habitat availability varies by month and year relative to reservoir operations, and is a function of reservoir elevation (see Section 5.4.6). 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 observed only minor changes in water physicochemical parameters (Section 5.2) and all life stages of both species were observed in 2015. Because amphibians are persisting in the drawdown zone, we can speculate that the annual reduction of habitat availability does not dramatically effect local amphibian populations; however, we do not know if the populations are supressed relative to populations in non-reservoir habitats.

Habitat change may also be assessed in terms of changes in vegetation community. Assessing direct or indirect effects of vegetation community changes on amphibian and reptile populations can be accomplished by assessing habitat availability as a function of reservoir elevation (see MQ4, above) and through the use of vegetation community data obtained for other programs, such as CLBMON-10. This may prove to be quite valuable as Western Toad and Columbia Spotted Frog are associated with a few particular vegetation communities in the drawdown zone of Kinbasket Reservoir (Section 5.3.5). With respect to habitat type, data from CLBMON-10 will be used to determine if the habitats that amphibians and reptiles use change over time relative to reservoir operations. Hawkes et al. (2010) reported that the vegetation communities defined in the DDZ of Kinbasket Reservoir had not changed since 2007, at least not at the landscape scale, but that the composition of certain species and communities had changed. In particular, there has been an increase in vegetation species richness and per cent cover. These changes are believed to be related to reservoir operations (Hawkes et al. 2013), but it is not clear how they might affect reptile and amphibian populations over time.

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 at all results in reduced plant vigour and increased mortality. The extent to which inundation affects wetlands or other pond-breeding amphibian and reptile habitat in the drawdown zone has not been adequately studies. The results of the fall 2015 work will be reviewed for potential linkages to CLBMON-37 and 58.

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 do not impact the species of amphibians and reptiles using the drawdown zone of Kinbasket Reservoir. However, this assessment applies only to Western Toad and Columbia Spotted Frog, for which our data are robust for ecological analyses. We do not currently have sufficient 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 in size such that the effects of inundation would be minimized.

The variable manner in which Kinbasket Reservoir is managed creates somewhat of a conundrum with respect to this management question. In general, the operation of Kinbasket Reservoir in 2011, 2013, and 2015 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?

Wood debris is likely to have the greatest impact on amphibian habitat in the drawdown zone. In 2015, a pilot project to improve habitats in the drawdown zone of Bush Arm was implemented (CLBWORKS-1). The primary objective of the pilot project was to use existing wood debris to create elevated mounds in the drawdown zone into which vegetation could be planted. The removal of wood debris from terrestrial, wetland and pond habitat should benefit amphibians by directly improving habitat suitability, either by increasing the total area of vegetated habitat or by removing wood from wetlands and ponds. The accumulation of wood debris can be detrimental to wetlands for several reasons. First, wood debris displaces existing terrestrial and aquatic vegetation as it accumulates over time affecting the surface and the bottom of ponds. Second, vertical and lateral movement of large wood debris due to fluctuating water levels can cause mechanical damage to established vegetation. Third, the leachate from the large accumulations of wood material can be highly coloured, acidic, of very high oxygen demand, and toxic to aquatic life (Tao et al. 2005). Consistent with these effects, neither Western Toad nor Columbia Spotted Frog was detected in ponds characterised by woody debris accumulation. Following the installation of Mica units 5 and 6, the frequency of inundation at higher elevations (i.e., >751 m ASL) is predicted to increase. A parallel increase in the accumulation of wood debris in wetlands and ponds is therefore expected. Wood debris removal should mitigate the effects of wood debris on wetland function, productivity, and habitat suitability. The results of the 2015 pilot project won't be known until 2016 or possibly 2017, but work completed in 2015 resulted in the rehabilitation of ~ 977 m^2 of pond habitat (Figure 6-1), which will be assessed for amphibian and reptile use in 2016.

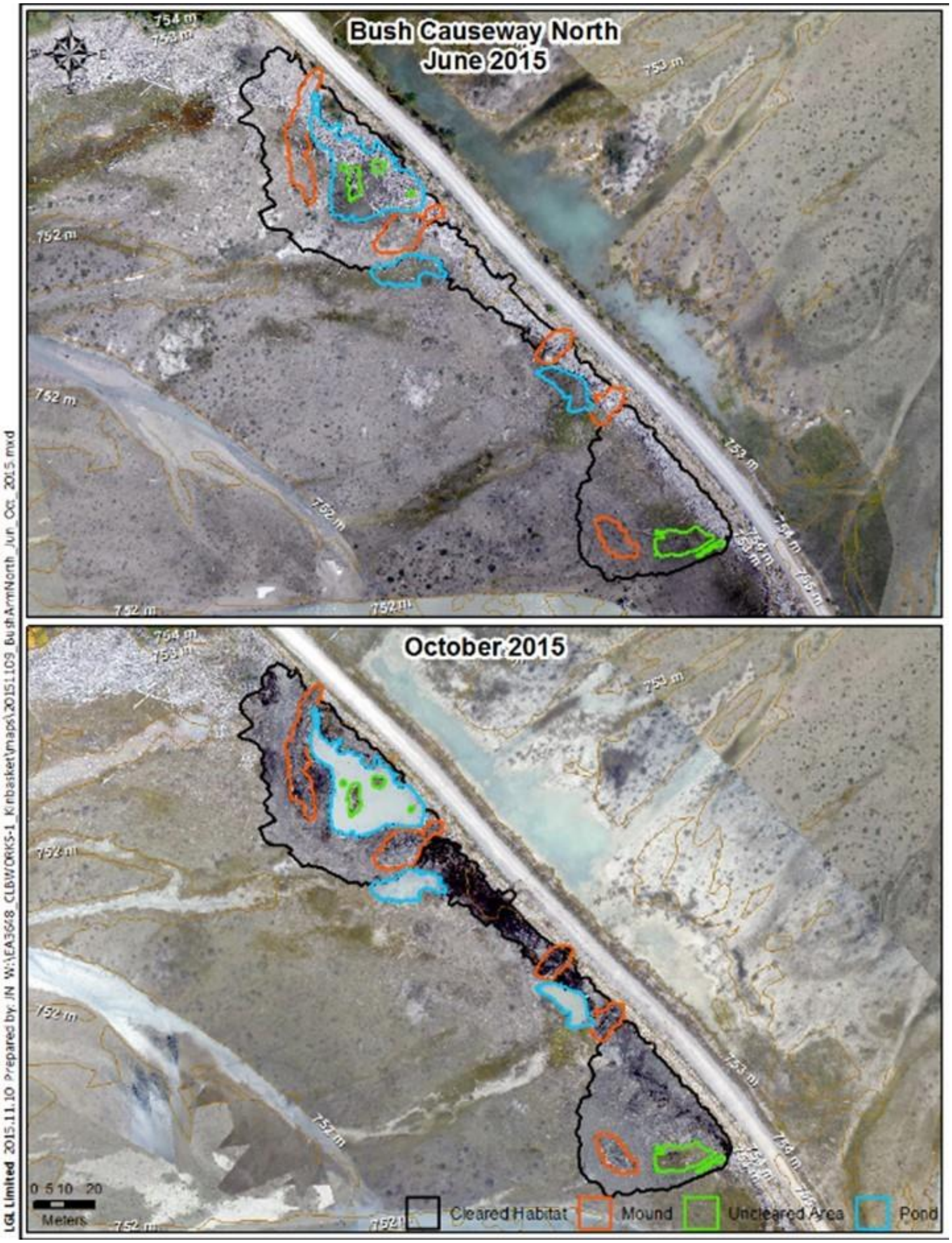

Figure 6-1: Pond habitat rehabilitated in September and October 2015 in Bush Arm, Kinbasket Reservoir as part of a pilot project associated with CLBWORKS-1

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

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. Given the failure of the revegetation program in Kinbasket Reservoir (Hawkes et al. 2013) there is no evidence to support an effect of revegetation on the availability and use of habitat in the drawdown zone by amphibians and reptiles.

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?

It is anticipated that amphibians and reptiles will use the rehabilitated ponds adjacent to the drawdown zone, but the results of the pilot project implemented in 2015 (CLBWORKS-1) won't be known until 2016.

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) (Figure 6-2), which is a function of survey timing and the cryptic nature of these species. In certain locations, Columbia Spotted Frog egg masses (Figure 6-2) provide the best evidence of use.

Figure 6-2: Long-toed Salamander eggs (left), transforming Columbia Spotted Frog (top right) and Columbia Spotted Frog egg mass (bottom right) observed in the drawdown zone of Kinbasket Reservoir during 2015 surveys

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 2015, 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 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 2015. 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 38 years (1978 to 2015; Figure 6-3). 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.

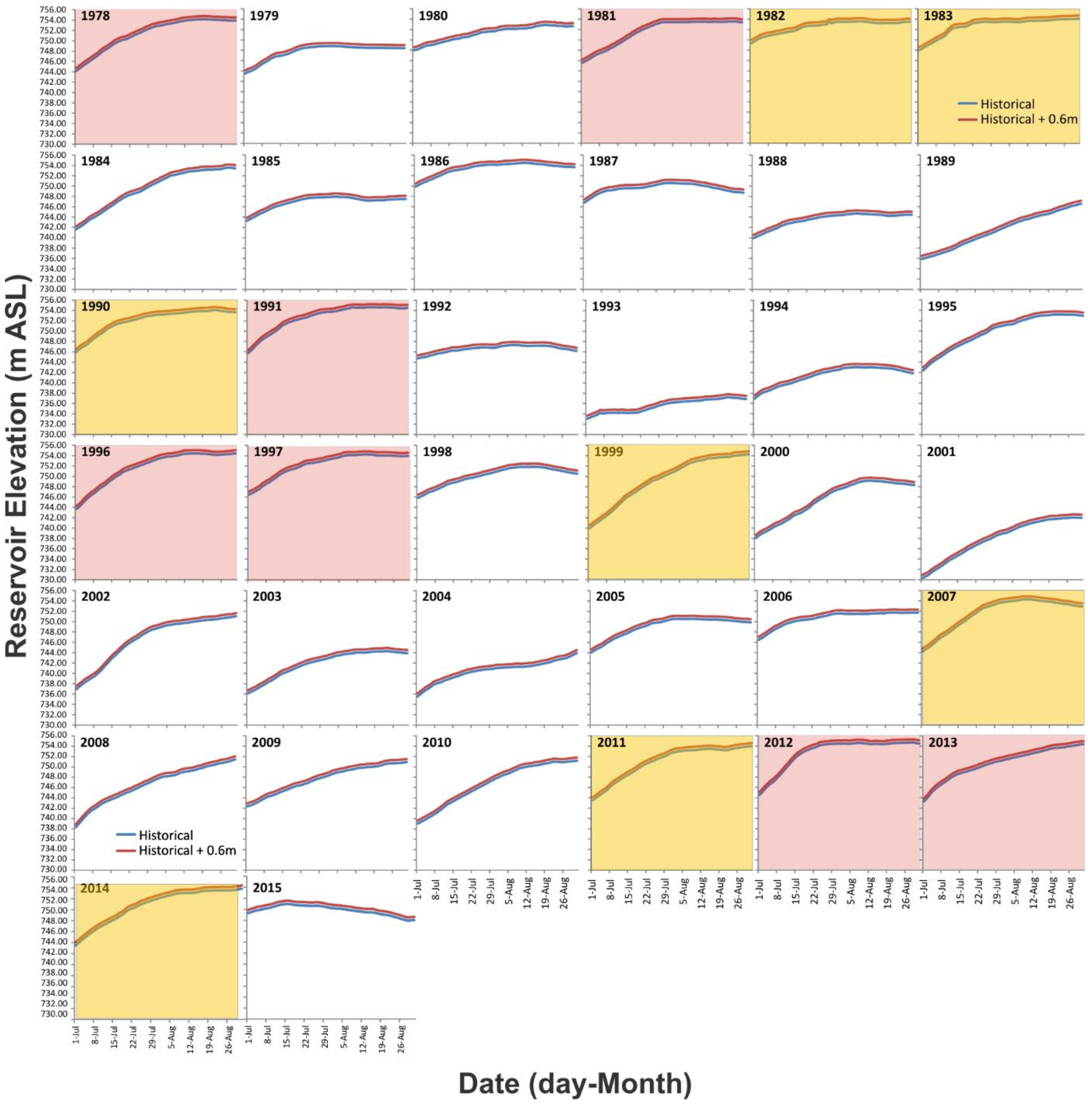

Figure 6-3: Historical reservoir elevations measured in July and August 1978 to 2015, with and without 60 cm added to simulate the addition of units 5 and 6 at Mica Dam. Red shading indicates the years Kinbasket was filled to elevations > 754.38 m ASL (i.e., surcharged). Yellow shading indicates the 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 to reservoir elevations, but relative to the date at which maximum reservoir elevations were achieved. Between 1978 and 2015, Kinbasket Reservoir achieved maximum reservoir elevations between August, 2 (1987) and November 9 (2014). The average date of full pool was August 25. In years when Kinbasket was surcharged, the reservoir reached full pool between August 2 (2007) 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 out of the drawdown zone. Radiotelemetry studies planned for 2016 and 2017 will help identify the location of reptile overwintering sites, which may occur in the drawdown zone of Kinbasket Reservoir.

Our current assessment and the risk analysis (Figure 5-16) suggests 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 careful assessment is required to understand how seasonal changes in precipitation might influence wetlands in the drawdown zone of Kinbasket Reservoir.

6.11 Management Questions - Summary

Our ability to address each of the management questions is summarized below (Table 6-2). The methods used are appropriate for collecting data that can be used to answer certain questions. For others, a different approach is required. Continued monitoring of amphibian and reptile populations in the drawdown zone should provide the necessary information to answer most management questions. To be sure we can answer some of the questions, recommended modifications to CLBMON-58 are provided below.

Table 6-2: Relationships between management questions (MQs), methods and results, Sources of Uncertainty, and the future of project CLBMON-58

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	Data collected since 2008 have likely resulted in the documentation of all expected species in the drawdown zone	• Increased frequency of sampling (i.e., annually)	• Natural annual population variation • Inconspicuous species • Variable reservoir operations

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
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?	Partially	3 years of site occupancy and detection rates data. Productivity estimated for some species	• Annual sampling • Intensive productivity data collection for Western Toad and Columbia Spotted Frog • Add other sites as physical works are implemented	• Natural annual population variation • Unknown rate of immigration may confound productivity estimates • Inconspicuous species • Mortality difficult to assess • Variable reservoir operations
MQ3: During what portion of their life history (e.g., breeding, foraging, and over-wintering) do amphibians and reptiles utilize the drawdown zone?	Partially	3 years of site occupancy data across multiple sites and seasons	• Telemetry studies on Western Toad, Columbia Spotted Frog and garter snake to assess overwinter habitat use.	• Natural annual population variation • Inconspicuous species • Lack of knowledge regarding the use of the drawdown zone by species in the winter • Variable reservoir operations
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)?	Uncertain	3 years of macro and micro habitat data collection	• Reduce the number of monitoring sites • Focus on Western Toad and Columbia Spotted Frog • Telemetry study on Western Toad and Common Garter Snake to assess habitat use • Re-evaluate existing habitat mapping and its relevance to amphibians and reptiles • Assess turtle presence and distribution at KM88	• Habitat mapping is required at a scale relevant to amphibians and reptiles • Variable reservoir operations
MQ5: How do reservoir operations influence or impact amphibians and reptiles directly (e.g., desiccation, inundation, predation) or indirectly through habitat changes?	Uncertain	3 years of data collected on the occurrence and distribution of amphibians and reptiles in the drawdown zone	• None	• Natural annual population variation • Variable reservoir operations • Habitat mapping is required at a scale relevant to amphibians and reptiles

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	N/A	• Restrict reservoir elevations for one year to elevations < 751 m ASL to determine whether doing so alters the use of the drawdown zone by amphibians and reptiles.	• Variable reservoir operations • Reservoir operations that result in complete inundation of the drawdown zone to elevations of ~754.38 m ASL • 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. • This suggested modification occurred via happenstance in 2015. Assessments in 2016 may provide the data necessary to determine if occupancy or abundance differs as a result of this type of management.
MQ7: Can physical works projects be designed to mitigate adverse impacts on amphibians and reptiles resulting from reservoir operations?	Uncertain	Data collected at Bush Arm Causeway from 2008 to 2015 will serve as a pre-treatment reference for the physical works constructed and ponds rehabilitated in 2015.	• Assess efficacy of physical works project implemented in the drawdown zone of Kinbasket Reservoir in fall 2015	• No data to assess whether future use is comparable to historical use.
MQ8: Does revegetating the drawdown zone affect the availability and use of habitat by amphibians and reptiles?	No	N/A	• Ensure wetland-associated plants are included in the planting prescriptions associated with proposed and potential physical works.	• Revegetation of the drawdown zone has not been done in a replicated manner nor were the prescriptions designed to enhance amphibian and reptile habitat. Wetland-related plants would need to be planted to benefit amphibians and reptiles. Work is not applicable to this study.
MQ9: Do physical works projects implemented during the course of this monitoring program increase amphibian and reptile abundance, diversity, or productivity?	Uncertain	Same as MQ7	• Assess efficacy of physical works project implemented in the drawdown zone of Kinbasket Reservoir in fall 2015	• No data to assess whether future use is comparable to historical use.

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
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?	Partially	Maximum reservoir elevations documented between 1978 and 2015 indicate that the average full pool date is August 25. At this time amphibians should be migrating out of the breeding ponds (Western Toad) or moving to overwintering sites in the drawdown zone of adjacent habitats (Columbia Spotted Frog). This suggests that increasing reservoir elevations by 60 cm in the summer months should not directly impact amphibians. However, important habitats could be impacted.	• Use radiotelemetry to determine where Western Toad overwinter, whether Columbia Spotted Frog overwinter in ponds in the drawdown zone, and to understand garter snake use of the drawdown zone in all seasons.	• Variable reservoir operations • Reservoir operations that result in complete inundation of the drawdown zone to elevations of ~754.38 m ASL • Uncertain the response of plants in the drawdown zone to increasing water levels for longer periods. • It is not clear if surcharge can be used as proxy for increasing the reservoir by 60 cm in the summer months.

7.0 RECOMMENDATIONS

The objective of CLBMON-58 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 (especially 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 2017, we will continue to monitor amphibian and reptile populations in the DDZ using the methods applied in previous years. Recommendations are made regarding how amphibians are sampled in the drawdown zone and regarding reservoir operations:

Sampling

1. Conduct annual sampling (under CLBMON-37/58) to increase the time series of data. This should extend to sampling Arrow Lakes Reservoir annually under CLBMON-37 as CLBMON-58 focuses solely on Kinbasket Reservoir. The purpose of this sampling is to increase the probability of detecting a trend, which for many species of amphibians and reptiles, can take between 10 and 13 years (e.g., Hayes and Steidl 1997), or even longer if using time series analyses (e.g., Salvidio 2009). CLBMON-37 was first implemented in 2008 with sampling in 2008, 2009, 2010, then bi-annually until 2016, resulting a sample size of six. Sampling on an annual basis will require additional funds, but this is balanced against the risk of not doing so, which is related to a high probability of not having a large enough time series to trends for even those species with relatively large sampled sizes (e.g., Western Toad)
2. Conduct a hoop-trapping session at Bush Arm KM88 in the spring for 3 to 4 days to sample for Western Painted Turtle;

3. Continue and extend the telemetry study of Western Toad, Columbia Spotted Frog, and Common Garter Snake through the winter season;

Reservoir Operations

1. The inundation of elevations between ~735 and 754 m ASL should occur on or as close to the end of the summer (similar to the dates for the period 1978 to 2015 or around 25 August) as possible. This 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
2. Climate change may confound future assessments regarding how reservoir operations affect the distribution and habitat use of amphibians and reptiles in the drawdown zone of Kinbasket Reservoir. A determination of the availability of climate change models relevant to the study area should be reviewed to determine the extent to which climate change might influence the water resources of the drawdown zone, which in turn could affect populations of amphibians and reptiles.

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	Submitted January 4, 2016
2.	300 word abstract	February 2016
3.	Revised sampling protocol	February 2016
4.	Copies of notes, maps, photos	February 2016
5.	Digital appendix (data)	February 2016

8.1.1 Data Provided to BC Hydro

An MS Access database containing all 2008 through 2015 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 MRCB15-168515, which is valid through March 31, 2016. This permit was amended in 2015 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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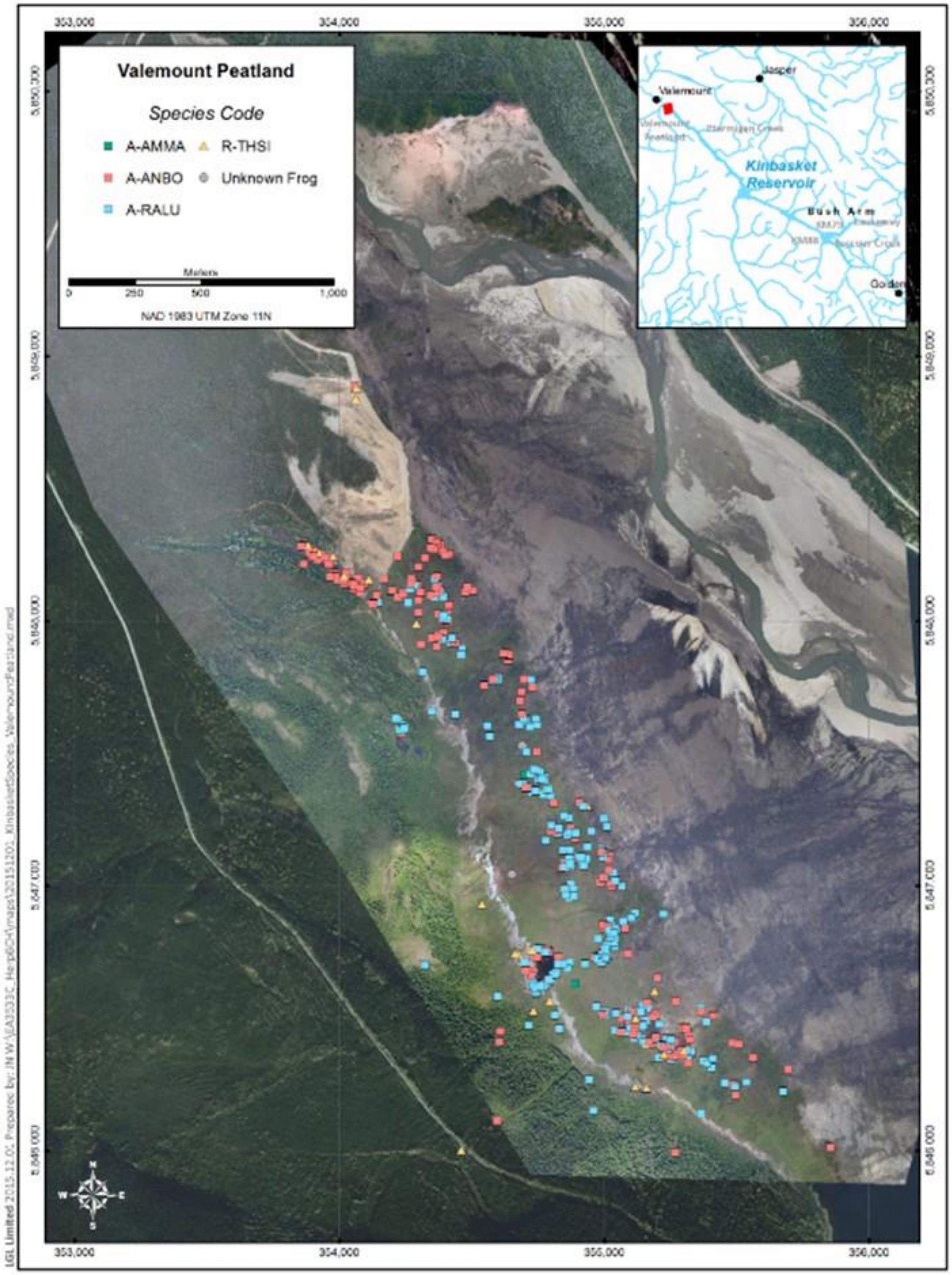
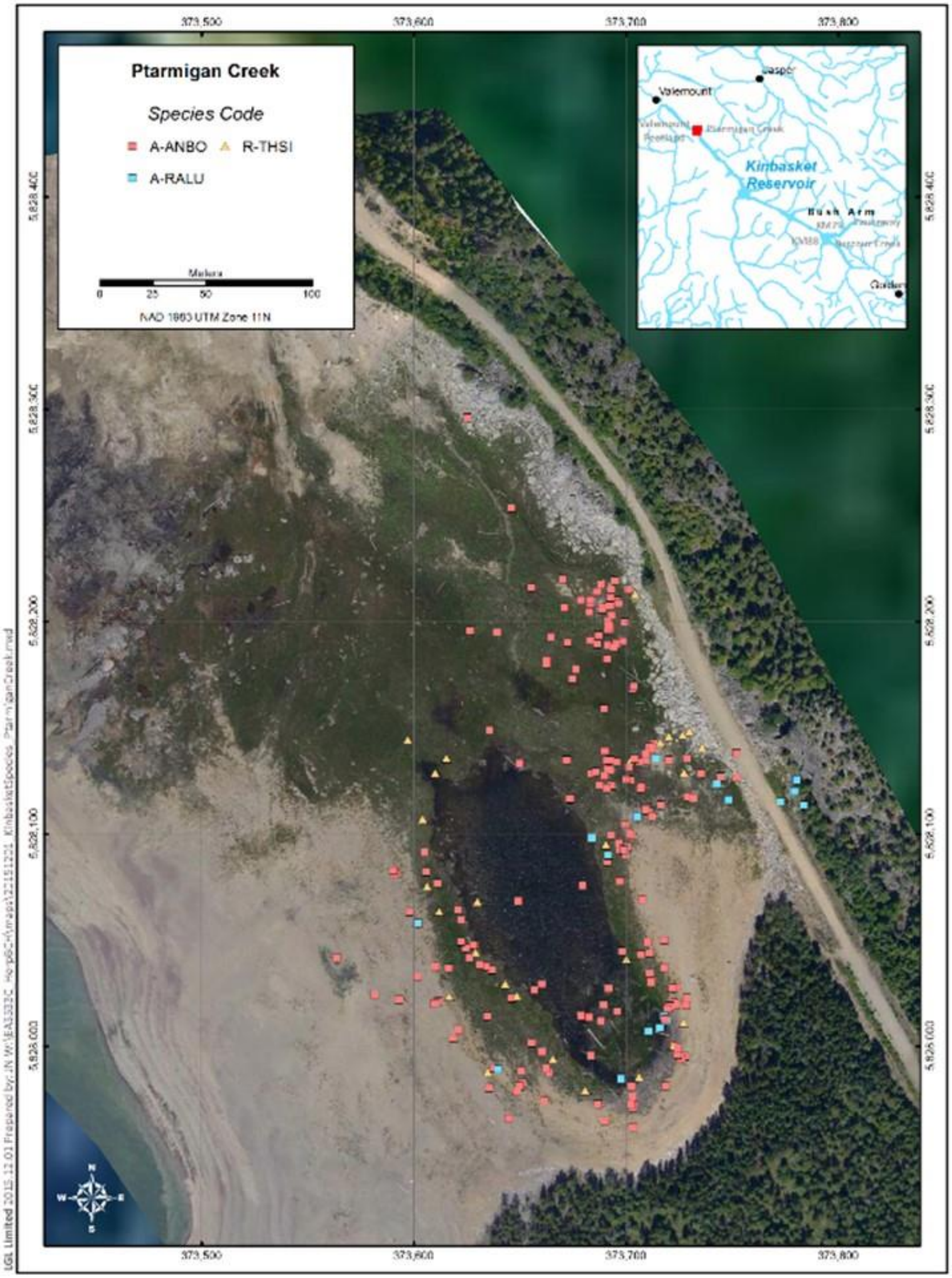
10.0 APPENDICES

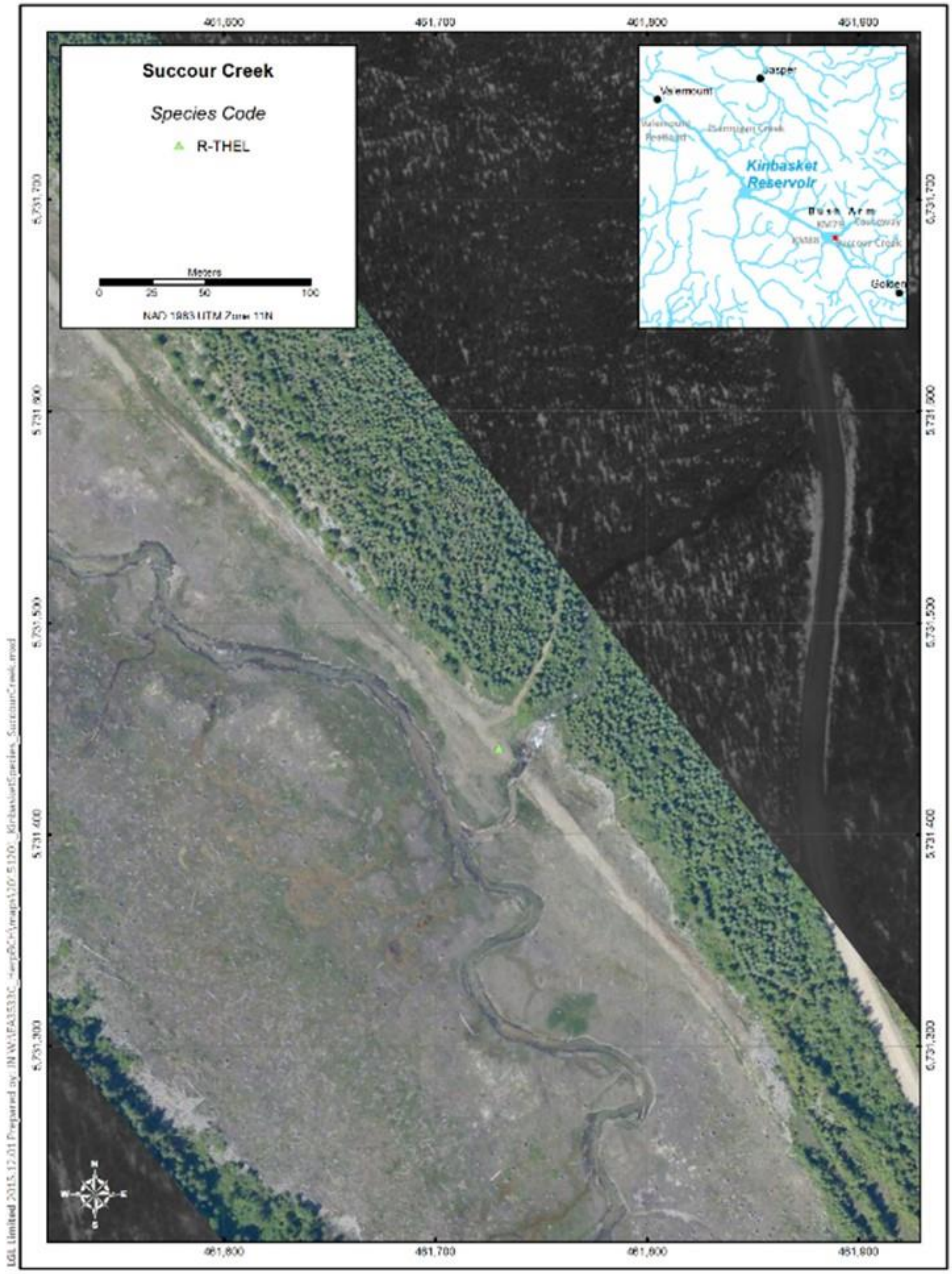
Appendix 10-1: Survey locations and amphibian and reptile captures made in the drawdown zone of Kinbasket Reservoir in 2015



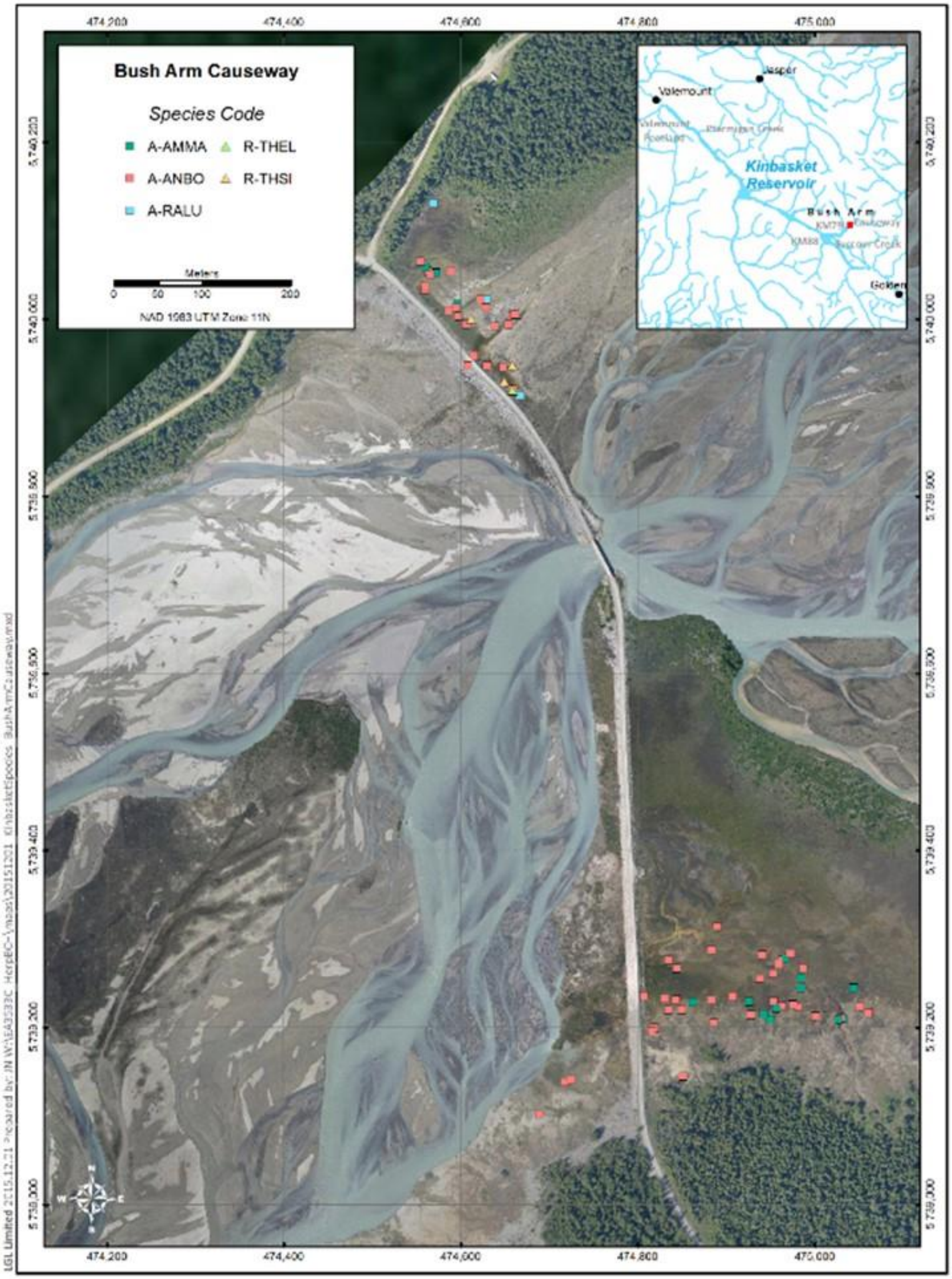
Map 10-1: Species documented in the Valemount Peatland, Kinbasket Reservoir. Species codes can be found in Table 1-1



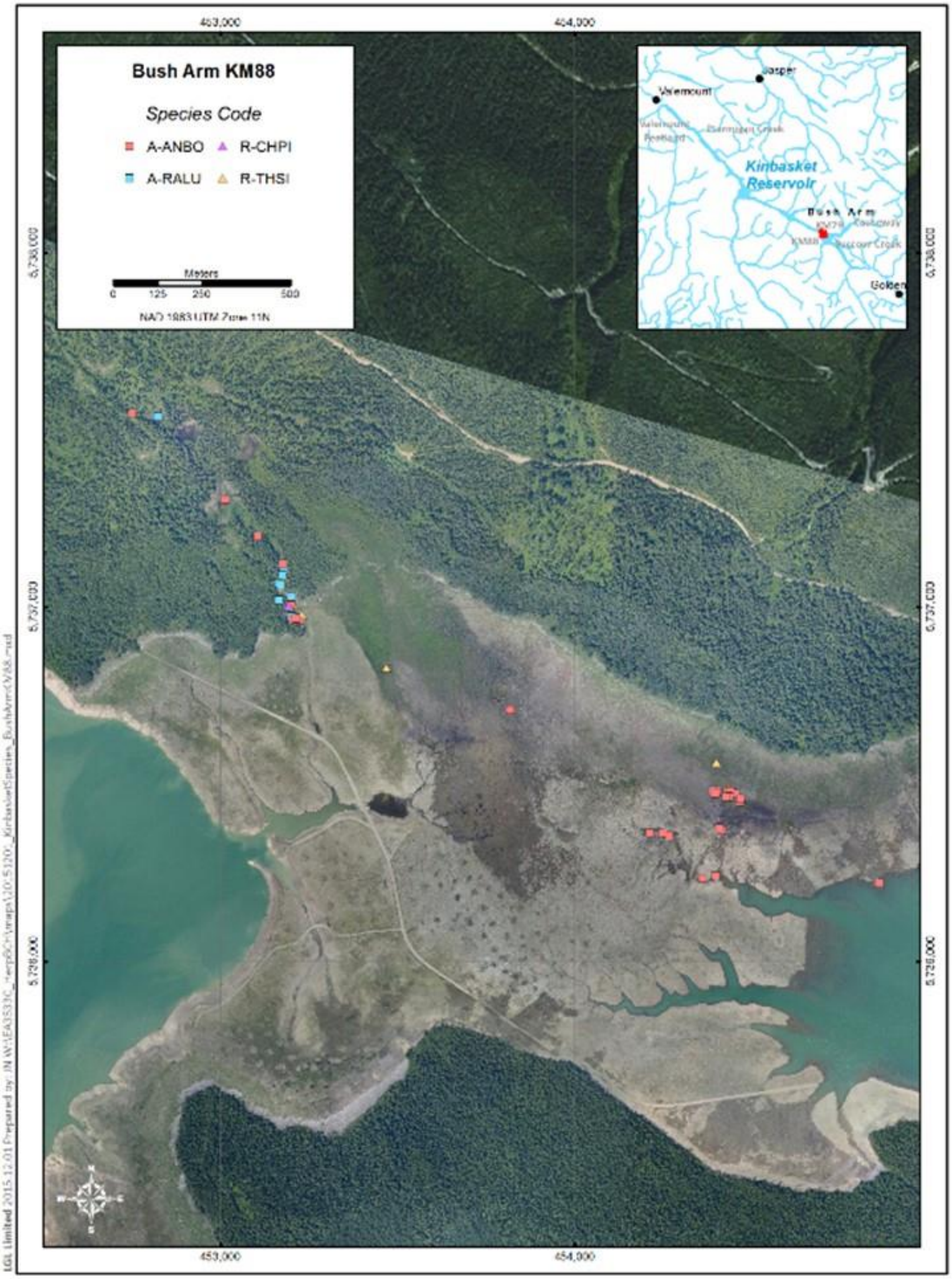
Map 10-2: Species documented at Ptarmigan Creek, Kinbasket Reservoir. Species codes can be found in Table 1-1



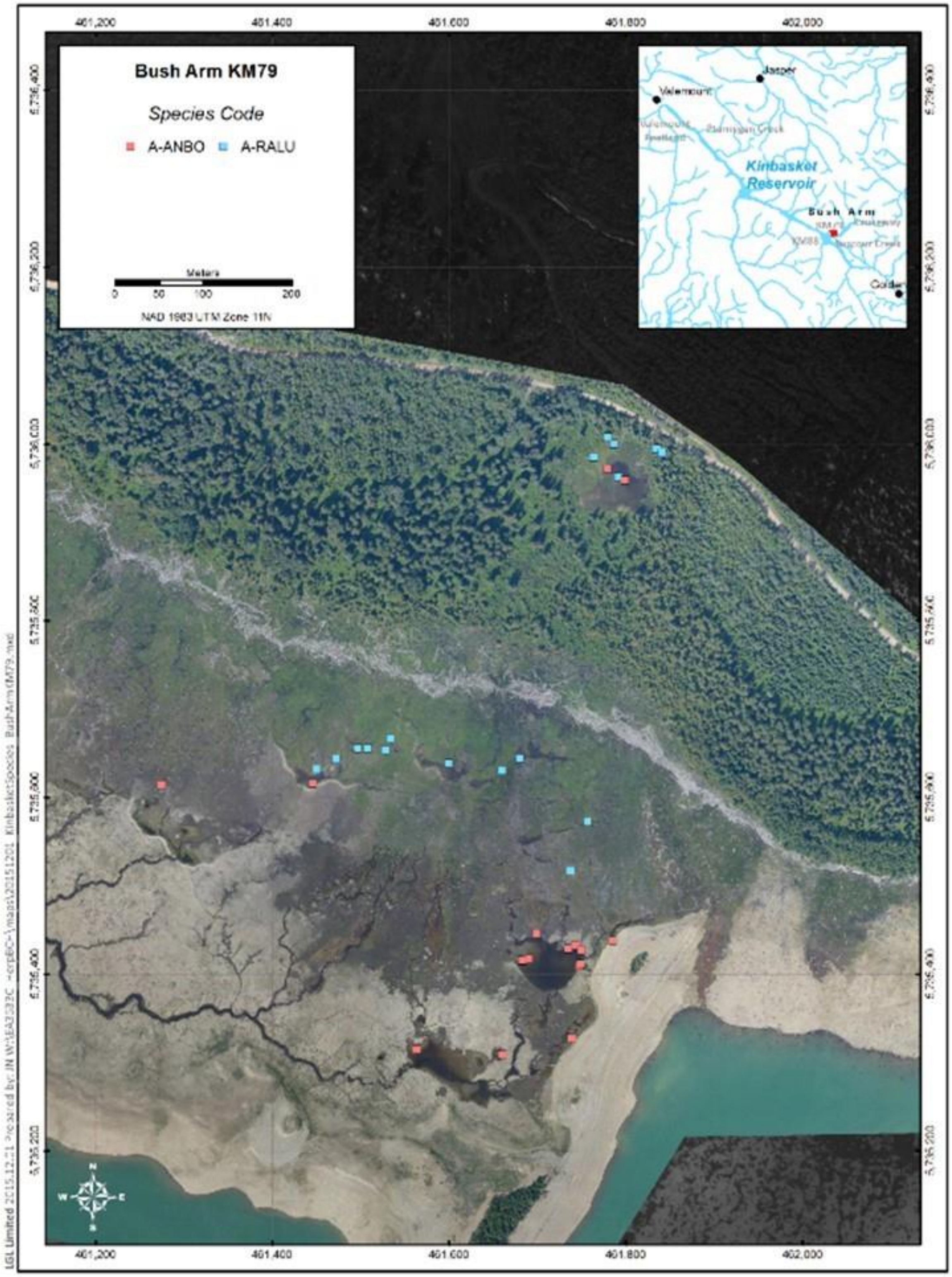
Map 10-3: Species documented at Succour Creek, Kinbasket Reservoir. Species codes can be found in Table 1-1.



Map 10-4: Species documented at Bush Arm Causeway, Kinbasket Reservoir. Species codes can be found in Table 1-1



Map 10-5: Species documented at Bush Arm KM88 (Bear Island), Kinbasket Reservoir. Species codes can be found in Table 1-1



Map 10-6: Species documented at Bush Arm KM79, Kinbasket Reservoir. Species codes can be found in Table 1-1