Columbia River Project Water Use Plan
Kinbasket and Arrow Revegetation Management Plan

Wildlife Effectiveness Monitoring in Arrow Lakes Reservoir

Implementation Year 3

Reference: CLBMON-11B3

Revelstoke Reach Painted Turtle Monitoring Program

Study Period: 2012

Okanagan Nation Alliance
Kelowna, BC
and
LGL Limited
Sidney, BC

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CLBMON-11B3 Revelstoke Reach Western Painted Turtle Monitoring Program




Monitoring Year 3 – 2012
Final Annual Report

Prepared for

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Water Licence Requirements
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Cover Photographs

From left to right: Arrow Lakes Reservoir near Revelstoke; Juvenile Western Painted Turtle (*Chrysemys picta* belli); Adult Western Painted Turtle at 9 mile, Arrow Lakes Reservoir; and Arrow Lakes Reservoir photographed at full pool. Photos © Krysia Tuttle and Virgil C. Hawkes LGL Limited environmental research associates.

EXECUTIVE SUMMARY

This year marked the third year of monitoring under CLBMON-11B3, a 10-year Western Painted Turtle life history and habitat use monitoring study in the drawdown zone of Arrow Lakes Reservoir near Revelstoke, BC. Initiated in 2010, this study is intended to address the relative contribution and importance of the current reservoir operating regime (i.e., timing, duration and depth of inundation) on the life history (e.g., abundance, distribution and productivity) and habitat use of painted turtles occurring in habitats within Revelstoke Reach. Eight management questions are investigated in this study, with the primary objective being to provide information on how painted turtles 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 this population or the habitats in which turtles occur.

The focus of this report is the monitoring that occurred in 2012 and the development of a program that will investigate turtle overwintering in 2013 and 2014.

In 2012, through a variety of survey methods (radiotelemetry, hoop trapping and visual searches) we documented Western Painted Turtles in two main areas within the drawdown zone of Revelstoke Reach at the north end of Arrow Lakes Reservoir: Airport Marsh; and Montana Slough. Observations were also made at Williamson Lake and Turtle Pond, two ponds located outside of the drawdown zone, but less than 2 km from the edge of the reservoir. All sites are documented areas where turtles spend time in the summer and winter.

Twenty-four turtles were outfitted (or re-fitted) with Holohil radio transmitters and were tracked from November 2012 to February 2013 to examine overwintering habitat site selection and microhabitat use. Most painted turtle detections were distributed within an elevational band of 435 to 445 m ASL. The influence of reservoir operations on the availability of habitat in the drawdown zone was evident: as reservoir elevations increased throughout the season, the total amount of available habitat decreased. As such, the locations of painted turtles in the drawdown zone were partially a function of seasonal habitat availability. Direct impacts from reservoir levels in 2012 were observed in Revelstoke Reach because water levels were higher earlier in the year and inundated areas showed drastic amounts of habitat change (e.g., lack of basking logs and floating vegetation mats, flooded shorelines near Airport Road).

Monitoring will continue in 2013 and will follow the same methods used in 2012 (and previously in 2010-2011) along with the development and implementation of a graduate program to investigate the characteristics of overwintering sites in Revelstoke Reach.

Key Words: Western Painted Turtle, reptile, life history, habitat use, reservoir operation, drawdown zone, Arrow Lakes Reservoir

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1.0 INTRODUCTION

The Columbia River Water Use Plan (WUP; BC Hydro 2005a) was developed as a result of a multi-stakeholder consultative process to determine how to best operate BC Hydro's Mica, Revelstoke, and Keenleyside facilities in order to balance environmental values, recreation, power generation, culture/heritage, navigation, and flood control. The goal of the WUP is to accommodate these values through incremental changes on how water control facilities store and release water, or to undertake physical works in lieu of changes to reservoir operations to meet the specific interests. During the WUP, the Consultative Committee (CC) supported the implementation of physical works (revegetation and habitat enhancement) in the mid-Columbia River in lieu of changes to reservoir operations to help mitigate the impact of Arrow Lakes Reservoir operations on wildlife and wildlife habitat. In addition, the CC also recommended monitoring the effectiveness of these physical works at enhancing habitat for wildlife (BC Hydro 2005).

During the Columbia WUP, the Western Painted Turtle (*Chrysemys picta belli*) was identified as a species that may be vulnerable to fluctuating water levels resulting from operations of the Arrow Lakes Reservoir (BC Hydro 2005). It is a provincially blue-listed species and the intermountain population is listed as Special Concern under Schedule 1 of SARA (COSEWIC 2006). The population that occurs near Revelstoke, BC is one of the most northern populations and has regional importance (Schiller and Larsen 2012a and 2012b; Maltby 2000). Furthermore, the Western Painted Turtle was identified as a species that may benefit from habitat enhancement via physical works (Golder Associates 2009a and 2009b).

Western Painted Turtles are small freshwater turtles with smooth, dark carapaces with pronounced red and yellow pigmentation on the limbs and plastron. They are slow to mature sexually (8 to 10 years for males and 12 to 15 years for females) and long-lived, living to 50 years or more. They are found in the shallow water ponds, lakes, sloughs, and slow-moving streams or rivers (e.g., the Columbia River), but like many aquatic reptiles they require three types of habitats corresponding to their life history needs. These include: 1) summer habitat with muddy substrates, an abundance of emergent vegetation, and numerous basking sites; 2) nesting habitat with loose, warm, well-drained soils; and 3), aquatic overwintering habitat that does not freeze and does not become severely hypoxic (COSEWIC 2006).

Western Painted Turtles are found in all provinces in Canada except Prince Edward Island, Nova Scotia, New Brunswick and Québec. The species range appears to be limited by the length of the turtle's active season, mean ambient temperature during egg incubation, and mean winter temperature (COSEWIC 2006). Due to low adult recruitment and delayed maturity, Western Painted Turtles are particularly susceptible to mortality of juveniles and adults (COSEWIC 2006). Factors contributing to low recruitment include road mortality (particularly of females during the nesting season), predation on dispersing turtles, and depredation of nests. Habitat degradation, loss, and fragmentation are also threats (e.g., Maltby 2000). While reservoirs have contributed to the loss of habitat during construction (COSEWIC 2006), impacts caused by fluctuating reservoir levels on turtle population have not received much attention.

During 2010 and 2011, a pilot project was conducted to collect baseline data on a population of Western Painted Turtles near Revelstoke, BC. The goal of this study was to determine the extent to which painted turtles use the reservoir, provide a preliminary assessment of the population, and develop a long-term monitoring strategy to address the concerns raised during the WUP. This two-year study employed a number of techniques including visual encounter surveys (VES), nesting and hatchling emergence surveys, trapping, mark-recapture, and radiotelemetry to obtain data on painted turtles. A monitoring strategy was developed by Schiller and Larsen (2012b) who identified key information gaps and outlined how to proceed to determine the impacts of reservoir operations on Western Painted Turtles in Arrow Lakes Reservoir near Revelstoke BC and address management questions and hypotheses.

This report summarizes work completed in 2012 and 2013 for BC Hydro's Monitoring Program CLBMON-11B3: *Arrow Lakes Reservoir: Revelstoke Reach Western Painted Turtle Monitoring Program.*

2.0 MANAGEMENT QUESTIONS AND STUDY DESIGN

2.1 Management Questions and Hypotheses

As part of BC Hydro's long-term monitoring program CLBMON-11B3, eight management questions were developed to determine the impacts of reservoir operations on Western Painted Turtles that use habitats in the drawdown zone of Arrow Lakes Reservoir near Revelstoke Reach BC:

Theme 1: Life History and Habitat Use

Q1: During what portion of their life history (e.g., nesting, foraging, and overwintering) do painted turtles utilize the drawdown zone in Revelstoke Reach?

Q2: Which habitats do painted turtles use in the drawdown zone and what are their characteristics (e.g., pond size, water depth, water quality, vegetation, elevation band)?

Q3: What is the abundance and productivity of painted turtles in Revelstoke Reach and how do these vary across years?

Q4: Does the operation of Arrow Lakes Reservoir negatively impact painted turtles directly or indirectly (e.g., mortality, nest inundation, predation, and habitat change)?

Theme 2: Mitigation – Reservoir Operations and Effects

Q5: Can minor adjustments be made to reservoir operations to minimize the impact on painted turtles?

Q6: Can physical works be design to mitigate the impacts of reservoir operations on painted turtles?

Theme 3: Effectiveness Monitoring

Q7: Does revegetation of the drawdown zone affect the availability and use of habitat by painted turtles?

Q8: Do wildlife physical works (e.g., habitat enhancement) affect the availability and use of habitat in the drawdown zone by painted turtles?

Related to these eight management questions are the following management hypotheses:

H1: Painted turtles are not dependent on habitats in the drawdown zone of Arrow Lakes Reservoir

H2: The operations of Arrow Lakes Reservoir do not affect painted turtle survival or productivity.

H3: Habitat enhancement through revegetation or physical works does not mitigate the effects of reservoir operations on painted turtles. More specifically, wildlife physical work and revegetation projects do not change the utilization of the drawdown zone habitats by painted turtles in Revelstoke Reach.

2.2 Study Design

A monitoring strategy for Western Painted Turtles in Revelstoke Reach, located at the north end of Arrow Lakes Reservoir, was developed by Schiller and Larsen (2012b) that identified key information gaps and outlined how to proceed with addressing the management questions and hypotheses for this project. The strategy identified several monitoring initiatives and has been adapted into the monitoring framework presented below. This monitoring strategy outlines a two-pronged approach to address the various management questions and hypotheses that can be implemented incrementally over time (Table 2-1).

First, the strategy recommended long-term tracking of population trends through mark-recapture techniques to assess the impacts of reservoir operation on the demographics parameters, requiring summer field sampling from 2012 to 2020. Since the nesting locations in Revelstoke Reach are known, monitoring nest success to acquire data on recruitment was also suggested to examine productivity in this population. This initiative will address management questions: Q1, Q3, Q4, and Q5.

Second, a set of initiatives was proposed to address the management questions and hypotheses specific to painted turtle habitat use. Initiatives 2a to 2d would involve graduate student projects over the ten year study period. With the exception of the initiative 2d, these initiatives are intended to be implemented in two-year sampling windows. Initiative 2d will require a longer sampling period than two years; however, it is likely that data for this initiative can be collected in conjunction with 2a and 2c. Collectively these initiatives will provide more information towards addressing management questions: Q2, Q4, Q6, Q7, and Q8.

Table 2-1: Relationship between the management questions, hypotheses, and the long-term monitoring strategy for Western Painted Turtles in Revelstoke Reach, Arrow Lakes Reservoir. Seasons are grouped into S/S (spring /summer) and F/W (fall/winter)

Initiative		Management Question Addressed	Season		Study Years
			S/S	F/W	
1	Long term tracking of turtle demographics to monitor population trends (abundance, recruitment/productivity, and mortality) and assess the impacts of reservoir operations on these parameters	Q1, Q3, Q4, Q5	X	X	2012-2020
2	Conduct focused studies on the fine scale seasonal habitat use of turtles	Q2, Q4, Q6, Q7, Q8	X	X	2012-2020
2a	Conduct a focused study on the fine-scale habitat use by turtles during spring and summer and investigate potential impacts of reservoir operations on summer habitat use, habitat availability, and turtle movements	Q2, Q4, Q5	X		2014-2016
2b	Conduct a focused study on fine-scale habitat use by turtles during winter and investigate potential impacts of reservoir operations on winter habitat use and habitat availability	Q2, Q4, Q5		X	2012-2014
2c	Conduct a focused study on turtle fine-scale nesting habitat use within and adjacent to the reservoir and identify opportunities for enhancement of nesting sites	Q3, Q6, Q7, Q8	X		2014-2018
2d	Use radiotelemetry, ground surveys, and habitat assessments to assess the effectiveness of the revegetation program (CLBWORKS 2) and wildlife physical works program (CLBWORKS 29A and 30) to enhance painted turtle habitat in Arrow Lakes Reservoir	Q6, Q7, Q8	X		2012-2020

2.3 Key Water Use Decision

The key operating decisions affected by this monitoring program are the operating regime for Arrow Lakes Reservoir and the implementation of soft constraints for Arrow Lakes Reservoir to balance the requirements of Western Painted Turtles with recreational opportunities, flood control, power generation, and other environmental objectives. Results of this monitoring program will help influence the scope of measures required to minimize or mitigate potential impacts, as well as to evaluate the efficacy of works undertaken to improve habitat for painted turtles. Information on the population demographic requirements of painted turtles will also help inform management decisions regarding the design and location of revegetation efforts and physical works projects within Arrow Lakes Reservoir. Operational changes to be considered will be limited to soft constraints that govern daily operations such as timing, magnitude and flow rate as opposed to hard constraints that include reservoir and turbine capacities, spillway rating, licensing requirements and Columbia River Treaty obligations.

2.4 Program Linkages

CLBMON-11B3 is directly and indirectly linked to other programs being implemented in the Arrow Lakes Reservoir (Figure 2-1). Over time (and following the implementation of physical works in Revelstoke Reach) the monitoring program developed for CLBMON-11B3 will provide an indication of the efficacy of the physical works implemented in Revelstoke Reach at enhancing wildlife habitat. In addition, data collected as part of that monitoring program are related to several long-term monitoring programs—specifically, CLBMON-37, CLBMON-40 and CLBMON-36. Additionally, the protocols for monitoring physical works implemented in Revelstoke Reach could be applied to physical works proposed for mid- and lower Arrow Lakes where wetland enhancement or creation is the objective (i.e., CLBWORKS-29B).

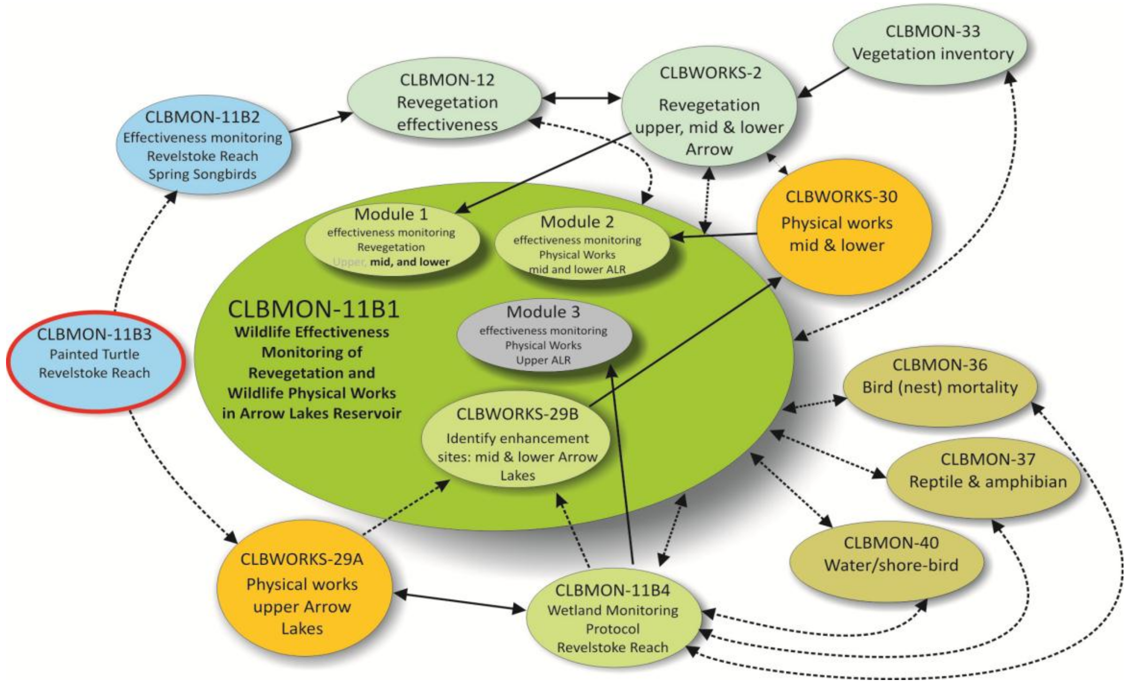

Figure 2-1: The relationship of CLBMON-11B3 (outlined in red) to other physical works and wildlife monitoring projects in Arrow Lakes Reservoir. Direct linkages between relevant projects are shown as solid lines; information flow (e.g., data sharing) is indicated by dashed lines. Module 3 of CLBMON-11B1 has yet to be implemented and Module 1 of CLBMON-11B1 applies only to mid- and lower Arrow Lakes Reservoir

3.0 STUDY AREA

3.1 Physiography and Climatology

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.

The study area is underlain by terraced fluvial and glaciofluvial deposits comprised of sand and gravel, with some silt and clay and glacial lacustrine sediments. Fluvial and glaciofluvial benches and terraces are comprised of sandy and loamy till, which provides suitable nesting habitat for western painted turtles (e.g., Red Devil Hill). In places these deposits may be in excess of 30 meters (Kala Geosciences 2010).

The climate of the Revelstoke area is a cool, humid, and continental. The average temperature of the coldest month is -8.2 C and the average temperature of the warmest month is 18.2 °C. 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.

3.2 Biogeoclimatic Zones

Two biogeoclimatic zones occur at the lower elevations surrounding Arrow Lakes Reservoir: the Interior Cedar Hemlock (ICH) and the Interior Douglas-fir (IDF). Most of the reservoir area occurs within the ICH, with three subzones and four variants represented (Table 3-1). The IDF is restricted to the southernmost portion of the area and consists of a single subzone (IDFun); this area is outside of the study area of this project. The subzones are a reflection of increasing precipitation from the dry southern slope of Deer Park to the wet forests near Revelstoke (Enns et al. 2008). The Arrow Lakes Reservoir study is situated primarily within the Arrow Boundary Forest District, but a small portion of its northerly area is in the Columbia Forest District.

Table 3-1: Biogeoclimatic zones, subzones and variants that occur in the Arrow Lakes Reservoir study area

Zone Code	Zone Name	Subzone/Variant Description	Forest Region & District
ICHdw1	Interior Cedar – Hemlock	West Kootenay Dry Warm	Nelson Forest Region (Arrow Forest District)
ICHmw2	Interior Cedar – Hemlock	Columbia-Shuswap Moist Warm	Nelson Forest Region (Columbia Forest District)
ICHmw3	Interior Cedar – Hemlock	Thompson Moist Warm	Nelson Forest Region (Columbia Forest District)
ICHwk1	Interior Cedar – Hemlock	Wells Gray Wet Cool	Nelson Forest Region (Arrow Forest District)
IDFun	Interior Douglas-fir	Undefined	Nelson Forest Region (Arrow Forest District)

Most of the Columbia Basin watershed remains in its original forested state. Dense forest vegetation thins above 1500 m elevation and tree line occurs at ~2000 m elevation. The forested lands around Arrow Lakes Reservoir have been and continue to be logged, with active logging occurring on both the east and west sides of the reservoir.

3.3 Arrow Lakes Reservoir

Arrow Lakes Reservoir is a ~230 km long section of the Columbia River drainage between Revelstoke and Castlegar, BC. It has a north-south orientation and is set in the valley between the Monashee Mountains to the west and the Selkirk Range to the east.

The Hugh Keenleyside Dam, located 8 km west of Castlegar, spans the Columbia River and impounds Arrow Lakes Reservoir. The reservoir has a licensed storage volume of 7.1 million acre-feet (MAF) (BC Hydro 2007), and the normal operating range of the reservoir is between 440.1 m and 418.64 m ASL. The reservoir is largely operated for downstream power generation and flood control in the United States.

The typical hydrological regime of Arrow Lakes Reservoir is characterized by rapid infill between May through early July followed by a drop in reservoir levels through August. Reservoir levels may continue to decline though the fall but they may also be elevated to near maximum levels to accommodate fall storage. Reservoir levels decline throughout the winter reaching their lowest levels in the late winter/early spring. While levels of the reservoir can fluctuate dramatically (upwards of 60 meters) over the course of a year, there are several water bodies that retain water year round and provide refuge for the population of western painted turtles near Revelstoke.

A single population of Western Painted Turtles in the Arrow Lakes region occurs at the northern end of the reservoir in near Revelstoke, B.C., and the study area for CLBMON-11B3 is restricted to Revelstoke Reach (Figure 3-1), from Airport Marsh southeast to Cartier Bay, with all work focused on the east side of the reach. The area hosts several large wetland complexes, large open sedge/grass habitats and several willow-shrub complexes. Permanent ponds and associated wetland habitats within the reservoir known to support painted turtles include Airport Marsh, Montana Slough, Locke Creek Outflow, and Cartier Bay. Upland ponds that support western painted turtles include Williamson Lake and the aptly named Turtle Pond. The combination of elevation, limited topographical relief, and undulating terrain has contributed to the development of important bird, reptile and amphibian habitats within the seasonally inundated drawdown zone of Arrow Lakes Reservoir.

Western Painted Turtles were studied at three locations in the drawdown zone of Arrow Lakes Reservoir: (1) Airport Marsh; (2) Montana Slough, and (3) Cartier Bay. Turtles were also studied at two upland (i.e., outside of the drawdown zone) locations: (1) Williamson Lake, and (2) Turtle Pond (Figure 4-1).

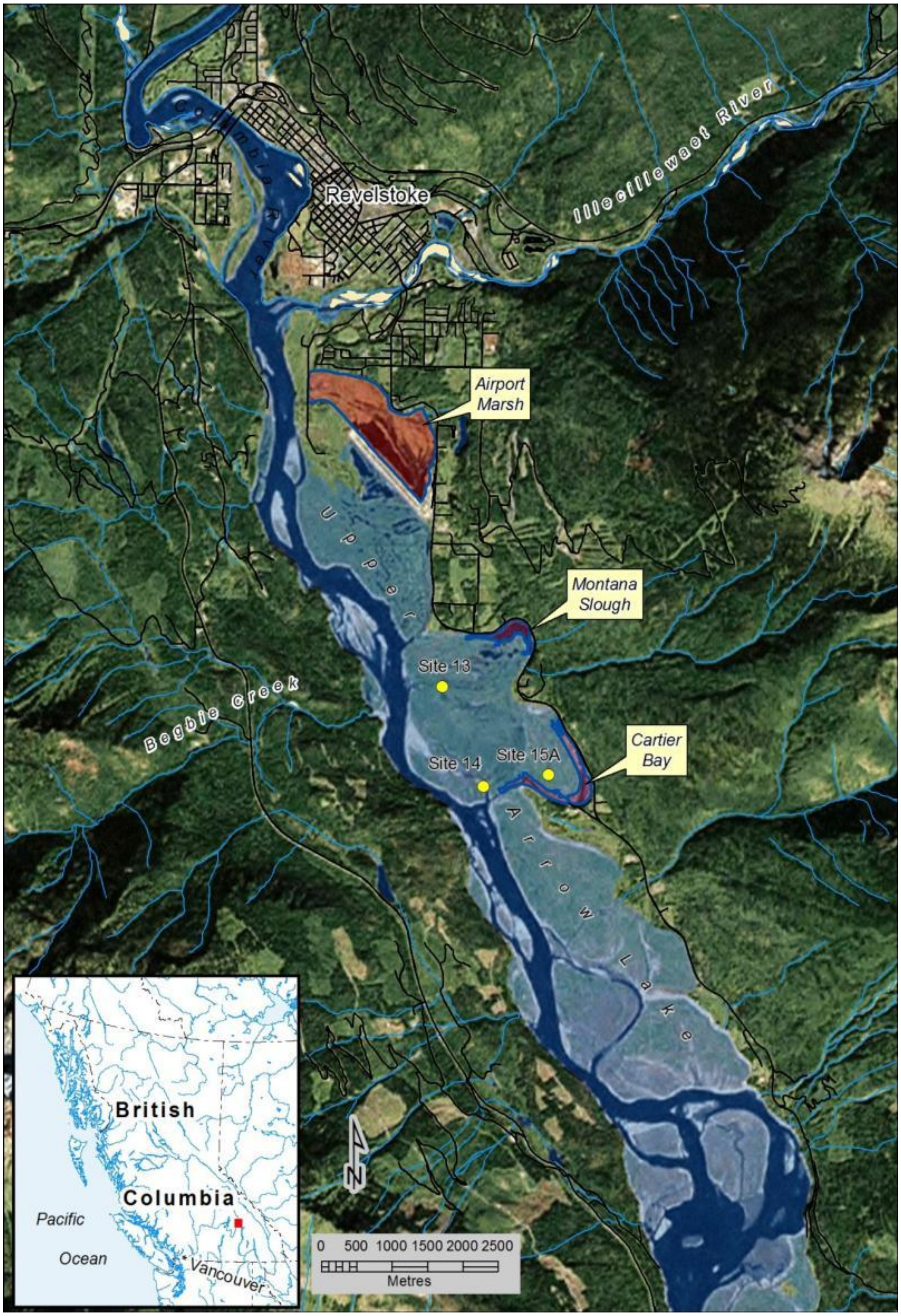

Figure 3-1: Location of Airport Marsh, Montana Slough and Cartier Bay in Revelstoke Reach, Arrow Lakes Reservoir. Sites 13, 14 and 15A are proposed physical works sites

4.0 METHODS

4.1 Scope of Work 2012

For the period 2012 to 2014, LGL and ONA began to implement Initiatives 1 and 2b of the monitoring strategy. We initiated the tracking of abundance and productivity of painted turtles to assess the impacts of reservoir operations on these parameters (Initiative #1), and focused on determining the fine-scale habitat use by turtles during winter to assess the potential impacts of reservoir operations on winter habitat use and habitat availability (Initiative #2b). Much of the data collected in 2012 and 2013 are also relevant to Initiatives 2a, 2c, and possibly 2d. Initiative 2d won't be assessed until habitat enhancement works (physical works) are implemented in Revelstoke Reach.

Work in 2012 and 2013 fell into three different components; each component addresses different management questions and is described as follows:

1) Spring and summer surveys (Initiative #1)

Determining the status of long-lived animals such as chelonians is problematic and long-term studies are required to assess population trends (Whitfield et al 2000). As such, it will be important to continue to monitor population parameters over time. Radiotelemetry, visual encounter surveys (VES) and mark/recapture techniques were employed to monitor population trends (abundance, recruitment/productivity, and mortality) and to assess the impact of reservoir operations on these parameters. These data contribute to addressing Q1, Q3, Q4, and Q5.

During spring and summer surveys in 2012, surveys focused on those turtles captured and previously tagged (i.e., 2011) to monitor coarse turtle movements, monitor animal survival, and obtain data on spring and summer habitat use. VES and mark/recapture techniques provided a relative measure of abundance (e.g., CPUE) and site occupancy, as well as demographic data. Each study area was also searched visually for incidental observations of basking turtles, especially during periods of high reservoir levels.

2) Fall trapping and migration monitoring surveys

The 2012 September trapping session was intended as an intensive capture session of painted turtles to be fitted with radiotransmitters for inclusion in the Initiative #2b component of this study. Work involved the collection of painted turtles via hoop traps, attachment of radiotransmitters, and tracking of fall migration of turtles to overwintering sites occurred in September to November, and a graduate student at Thompson Rivers University (Amy Leeming [M.Sc. student], Dr. Karl Larsen [supervisor]) continued this work in to the winter.

3) Overwintering habitat use surveys (Initiative #2b)

The Western Painted Turtle is one of the most northerly species of turtles. Since turtles overwinter under water, the availability of suitable hibernation sites is key to this species' survival. Key attributes of overwintering sites include high dissolved oxygen levels, cold-water temperatures, and ponds or wetlands that do not freeze to the bottom (Rollinson et al. 2008). Since water conditions in reservoirs are dynamic throughout the year, it is currently unclear how reservoir operations affect the suitability of overwintering habitats within the drawdown zone or consequently, how turtles respond to fluctuating reservoir levels during winter.

Several Western Painted Turtle overwintering locations were identified by Schiller and Larsen (2012b) and include Airport Marsh and Montana Slough within the Arrow Lakes Reservoir, and Williamson Lake and Turtle Pond located outside (less than 2 km) the reservoir.

To identify overwintering sites and characterize habitat, radiotelemetry was used to track the location of each turtle over the course of the winter (November through to March). Turtles were tracked and located every three weeks. Water temperature, depth, conductivity, and dissolved oxygen levels were measured at each location associated with a turtle. Each used location was also paired with a randomly selected non-used location within the same wetland or lake to determine habitat use versus availability. Random sample locations were chosen based on three considerations: (1) distance from shoreline, (2) depth of water based on bathymetric maps, and (3) amount of visible emergent vegetation.

4.2 Selection of Sampling Sites

Five sites were selected for monitoring in 2012 to document the presence, movements and habitat use of painted turtles (Table 4-1). Sites monitored in Revelstoke Reach were consistent with sites previously monitored by Schiller and Larsen (2012b) and are associated with a typical 10 m change in reservoir elevation (430–440 m) as well as with areas associated with proposed physical works. In addition to the sites monitored within Revelstoke Reach (DDZ), two upland reference sites were monitored. Upland ponds are unaffected by reservoir operations, and can thus act as control sites for DDZ sites.

Table 4-1: Study sites surveyed for Western Painted Turtles in Revelstoke Reach, Arrow Lakes Reservoir in 2012. Site type: DDZ - drawdown zone of the reservoir; Upland - reference site outside the drawdown zone. Seasons: SP = spring, SU = summer, F = fall, W = winter

Site	Site Type	Seasons Visited	Types of Surveys Conducted
Airport Marsh	DDZ	SP, SU, F, W	Visual encounter surveys, radiotelemetry, trapping, overwinter monitoring
Montana Slough	DDZ	SP, SU, F, W	Visual encounter surveys, radiotelemetry, trapping, overwinter monitoring
Cartier Bay	DDZ	SP, SU	Visual encounter surveys, radiotelemetry
Williamson Lake	Upland	SP, SU, F, W	Visual encounter surveys, radiotelemetry, trapping, overwinter monitoring
Turtle Pond	Upland	SP, SU, F, W	Visual encounter surveys, radiotelemetry, trapping, overwinter monitoring

4.3 Monitoring Methodology

Determining the status of long-lived animals such as chelonians is problematic and long-term studies are required to assess population trends (Whitfield et al 2000). As such, it is important to continue to monitor population parameters over time. Radiotelemetry, visual encounter surveys (VES) and mark/recapture techniques were used to monitor population trends (abundance, recruitment/productivity, and mortality) and to assess the impact of reservoir operations on these parameters. These data will contribute to addressing management questions: Q1, Q3, Q4, and Q5 over the 10 year study period.

Monitoring in 2012 followed the methods described by Schiller and Larsen (2011) and RISC (1998a), and occurred every two to three weeks between early June and the end of October, and every three weeks between November 2012 and March 2013. Several sampling methods were used to collect field data including visual encounter surveys (VES), nesting surveys, mark-recapture program, radiotelemetry, turtle trapping, and the collection of habitat data. Live-trapping of turtles was required to obtain morphometric data and data for the mark-recapture and radiotelemetry components of the study. Capture methods included hand/net-capturing and the use of baited hoop traps. Radiotelemetry focused on previously captured turtles (i.e., May 2012) to monitor turtle movements, animal survival, and obtain data on habitat use. Visual encounter surveys and mark/recapture techniques provided a relative measure of abundance (e.g., CPUE), as well as demographic data that can be used over the longer term.

The following sections describe each method used to collect data in 2012.

4.3.1 Visual Searching and Hand Capture

Hand/net trapping involved the use of a long-handled dipnet while walking, wading or canoeing along the shoreline of a pond or wetland. Searches were conducted when turtles were most likely to be basking (i.e., mid-morning to early evening on either sunny or overcast, but warm days). In shallow water, searches followed a zigzag course parallel to the shoreline. Hand captures were also performed from boat if a turtle was encountered while paddling between locations.

Although Schiller and Larsen (2012b) found this method to be “highly laborious” and its success dependent on the number of field personnel, size of the study sites, access to and within the sites, character of the habitat (vegetation, water depth, and reservoir levels), and size of the turtle population, we used this method in an incidental capacity during surveys (e.g., CLBMON-37) and during radiotelemetry surveys.

4.3.2 Live-Trapping

In September 2012, 10 hoop traps (Memphis Net and Twine Co., Inc.) were set in Revelstoke Reach and the upland reference sites (Figure 4-1). The traps were partially submerged in the water and were baited with sardines to attract turtles (bait was refreshed every few days). Turtles were trapped when they entered the trap through the submerged funnel opening, and were unable to exit. Baited traps were set and then checked every 12 hours (Gamble 2006). Each hoop trap was anchored to vegetation or the shoreline to partially submerge the trap. Small buoys were placed inside the traps to allow them to float in the event that water levels rose quickly. Hoop traps were placed in areas where turtles had been previously observed basking, near areas that turtles had been detected during the summer using telemetry, or in areas of ample emergent and submergent vegetation along the shoreline.

To minimize stress to the animals after transmitter attachment and the collection of morphometric data, turtles were immediately released at the site of capture (RISC 1998c). Handlers used gloves during capture and transmitter fitting, and hands were free of insect repellent and suntan lotion.

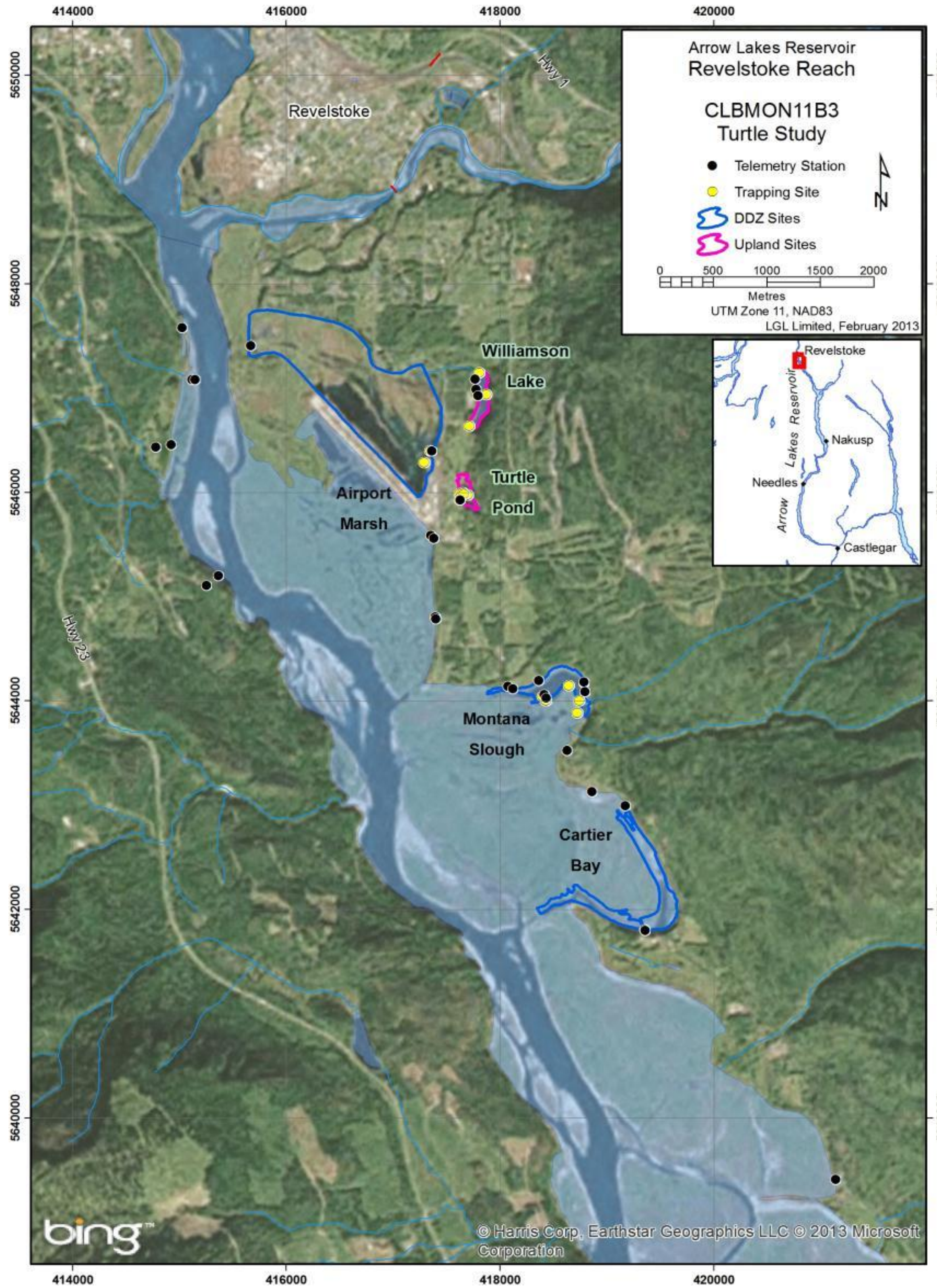

Figure 4-1: Locations of hoop traps and radiotelemetry stations within Revelstoke Reach, Arrow Lakes Reservoir, 2012

4.3.3 Mark Recapture

Mark-recapture techniques involve the capturing, marking, releasing and recapturing of individuals through repeated sampling (Krebs 1999). Recapturing of individuals was conducted opportunistically during nesting, VES surveys, and radio-tracking under CLBMON-11B3 and VES under CLBMON-37. Individuals were marked by notching the carapace following the marking technique developed by Cagle (1939; Figure 4-2). Photographs of the plastron were also taken; however, this method does not permit the identification of individuals in the field, and has been shown to be less reliable (Cowin and Cebek 2006).

Each adult turtle captured was notched following a sequence that enabled individual identification. Neonates and most juveniles were not notched, as their shells have not fully ossified and are soft. Notching was performed using a small triangle file making a series of notches along the middle of the marginal scutes of the carapace and/or plastron (St. Clair et al. 1994). The carapace is divided into right and left sides when looking down at an upright turtle. Usually, there are twelve marginal scutes on each side of the carapace that are labeled from one to twelve, ignoring the small central top scute near the head (Figure 4-2). Scutes 4, 5, and 6 are generally not marked. This method is a standard marking method recommended by the RISC (1998a).

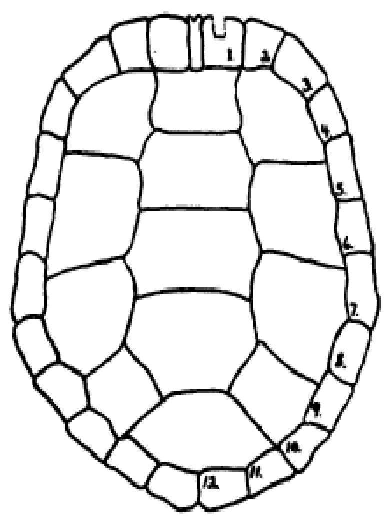

Figure 4-2: Turtle notching scheme showing the marginal plates numbered 1 to 12 on each side on the turtle (RISC 1998a). The marking scheme would be 0-1 in this case

As per Schiller and Larsen (2012b), the notching scheme for this project was recorded with the first number indicating notches on the left side of the carapace with commas separating the individual scutes. A dash indicates the separation between the sides of the carapace and the following number is the notch located on the right side of the carapace and a comma separates the individual scutes notched on that side. For example, 0-1 indicates there is no notching on the left side of the carapace and a notch on the right side of the carapace on scute 1. The notching scheme 2, 3-11 reads that there are notches located on scutes 2 and 3 of the left side of the turtle as well as in scute 11 along the right side of the turtle's carapace. An "N" before a number represents that the "notch" or mark was caused by "natural" reasons but it can still be used as an identifying feature.

4.3.4 Radiotelemetry

Radiotelemetry provides detailed information on habitat use and selection, home range, mortality and survivorship, migration, dispersal, travel routes, and critical habitat (RISC1998b; Millspaug and Marzluff 2001). Radiotelemetry involved affixing a VHF transmitter to the carapace of a turtle and relocating the animal using a VHF radio receiver to directly locate the animal or to obtain an approximate location through triangulation.

There are two main methods of attaching VHF transmitters to freshwater turtles: (1) attaching transmitters to the carapace with an adhesive or an epoxy and (2) securing the transmitter using wire feeds or bolts through holes drilled in the shell of the turtle. The second method is considered more reliable and was the method of choice employed by Schiller and Larsen (2012a, b) and this study.

To affix a transmitter, small holes were drilled along the marginal scutes (usually scutes nine and eleven) on the left side of the carapace with a cordless power drill. The transmitters were placed on one side of the turtle's tail to minimize interference with breeding. As per standard practice, the transmitter package did not exceed 5% of the turtle's body weight (Millspaug and Marzluff 2001). The life expectancy of the transmitters ranges from 10 to 36 months depending on the size of the unit. Depending on the size of the animal, small gauge stainless steel wire was used to attach the transmitter. A marine grade quick drying epoxy putty was applied to streamline the edges of the attachment and secure the radio attachment so that the hardware would not snag on vegetation or move as recommended by Schiller and Larsen (2011). BC Hydro acquired 20 transmitters (ten SB-2F-T @ 6 and ten SI-2F-T @16 grams) from Holohil Systems Ltd for this study. These transmitters have built in temperature sensors that alter the transmitter pulses rates, which record ambient temperature. The transmitter frequencies were registered with Industry Canada in March of 2012.

Turtles were relocated using VHF receiver (Lotek Biotracker with a collapsible antenna). Schiller and Larsen (2012a) reported success in tracking turtles "within meters" of their actual location; however, triangulation was also required in some cases to get an approximate fix of turtles under difficult circumstances. Triangulation required finding the intersection of two or more bearings to determine one location so that an error polygon could be calculated around the point estimate, resulting in a measure of precision equivalent to the area of the polygon (RISC 1998b). The size and shape of the error polygon is determined by the accuracy of the directional antennae, the distance between the two receiving points, the distance of the transmitter from the receiving points, and the angle of the transmitter from the receiving points. To reduce the size of the error polygon, three bearings were taken and the animal's location estimated from the centre of the intersections. Figure 4-1 shows the locations of the telemetry stations used to take bearings for triangulation.

4.3.5 Summer Habitat Use Data

A site assessment was conducted for each turtle observed via telemetry, VES and nesting surveys, or incidental observations. This assessment was conducted within a 5.64 m circular plot and the percent cover of emergent, submergent, floating-leaved vegetation, shrubs, forest, grass and herb, coarse woody debris (CWD) >5 cm, and CWD <5 cm was estimated. Other data collected included the location using GPS (Garmin® GPSmap60CSx), time, date, water depth, water temperature (taken approximately 10 cm from the surface of the water), air temperature, elevation, precipitation, wind speed, humidity (measured using a Kestrel® 4000), cloud cover, distance to water/shore, activity of the turtle, habitat type (Table 4-2), wetland type (Mackenzie and Moran 2004) and vegetation community (after Enns et al 2008; Fenneman and Hawkes 2012).

Table 4-2: General Habitat Types (Schiller and Larsen 2012b)

Habitat Type	Description
Shoreline	The area within 2 meters along which a body of water meets the land
Dry Land	The area of which is dry and which is greater than 2 meters from any body of water
Marsh	An area of land within the drawdown zone that is flooded during high waters, and typically remains waterlogged at all times.
Floating Island	A portion of the wetland that remains above water as a floating island of vegetation when water levels rise.
Nesting	Dry land characterized by small gravel and sand that is well drained during the months of May to July.
Open Water	An area that is 6 meters or greater from the shoreline
Inundated	An area that was characterized by another habitat but is now submerged by increased water levels
Shoreline Due to Inundation	An area that was characterized by another habitat but is now partly submerged by increased water levels creating an area along a body of water
Pond	A fairly small body of relatively still water.

Pond-specific physicochemical data were collected at each site. The physiochemical conditions of ponds and habitats in drawdown areas are likely to be greatly affected by the timing of inundation from the reservoir. Thus, studies examining the effects of reservoir inundation on wildlife should assess (1) abiotic conditions (e.g., water temperature, DO) of the aquatic environment, (2) biotic conditions (e.g., vegetative cover), and (3) population trends (e.g., densities and survivorship) over a period of several years. Comparison of inundated ponds to natural ponds (e.g., Williamson Lake and Turtle Pond) may help to factor in any annual or site variation.

Dissolved oxygen, conductivity, water depth, water temperature, and air temperature was also collected at the turtle capture or visual observation locations. These data will be supplemented by hourly temperature and DO measurements obtained from temperature data loggers (2013). Five conductivity (Onset U24-001) and five dissolved oxygen (PME MiniDOT) dataloggers were installed in each of the five monitoring locations to collect continuous data. The dataloggers were installed between 37 cm and 50 cm below the surface of the water in depths of 65 to 80 cm. The dataloggers were affixed to ¾” rebar (125 cm in length) using a pipe clamp and fitted with an orange plastic safety cap. The dataloggers were factory programmed to record data every 10 minutes and were deployed in November 2012. The dataloggers will be retrieved in April 2013.

4.4 Overwinter Habitat Use

Radiotelemetry was used to track the locations of turtles over the course of the winter (November through to March) and to identify overwintering sites and characterize winter habitat use. Procedures for conducting radiotelemetry followed those described in RISC (1998b) and Schiller and Larsen (2012a, b). Turtles were tracked and located approximately every three weeks.

Water temperature, conductivity, dissolved oxygen, water and ice depth were measured at each location used by turtles. Temperature data were also collected at each of the overwintering sites using temperature data loggers to obtain hourly temperature data throughout the winter. Temperature data were obtained via the Holohil temperature sensitive radio transmitters attached to the turtles. iButton's were also affixed to turtles caught and tagged in the fall of 2012 and 2013. To determine habitat use versus availability these parameters were measured within each water body at randomly selected locations with similar microhabitat characteristics.

4.5 Data Analyses

As this was a pilot year that mainly involved the collection of habitat data for the overwintering habitat use component of this study (which began in the fall of 2012), most of the data is descriptive at this point. Statistical analyses were performed using R and Microsoft Excel.

Relative Abundance

The relative abundance was expressed as a catch per unit effort, with effort recorded as survey time, trap nights, or total area searched. In future years, we will standardize sampling at each site so that seasonal (i.e., within year) and annual (i.e., among years) comparisons of CPUE and site-specific comparisons can be made.

Mark-Recapture

Data obtained from visual encounter surveys and trapping sessions included the number of individuals, mass, length, sex, and age class, which will be used in future demographic analyses. All 2012 captures were entered in the painted turtle database started by Schiller and Larsen (2012b). As it is anticipated that the number of turtle captures and recaptures may be low over the years (Schiller and Larsen 2012b), we will combine capture data over each active season to estimate population size. As suggested by Schiller and Larsen (2012b), a longer-term data base should enable more elaborate methods of population estimation to be conducted, such as application of Jolly-Seber methods (Krebs 1999) or Bayesian estimators (Gazey and Staley 1986) that estimates abundance, survival, and recruitment rates.

Habitat Use

Habitat use of painted turtles was described on several scales. The first and broadest scale of habitat use indicated the presence of a given individual at a particular monitoring location. Second, the type of habitat (e.g., wetland, field, roadside, basking log) was reported for all observations. Third, because all sightings were georeferenced, we related each observation to existing habitat mapping produced under CLBMON-11B4 (Wetland Monitoring in Revelstoke Reach) and CLBMON-37 (Amphibian and Reptile Life History and Habitat Use Study). In future years to investigate relationships between species location and habitat use relative to reservoir operations (MQ #4, 5, 6), revegetation efforts (MQ#7), or physical works (MQ #8), we will use a combination of linear regression, chi-square tests, logistic regression, and ordination techniques.

4.5.1 Data Management

Data integrity is key in each and every project that LGL and ONA complete. Prior to all field sessions, equipment was checked for proper operation and calibrated where required. A combination of notebooks, hand-held computers and data sheets (on water resistant paper) were used to record survey information. Data sheets are modified each year to improve quality and include study design changes. All field staff are familiarized with data sheets and collection methods prior to entering the field. Data was entered each night (or as soon as possible) into Microsoft Excel spreadsheet, and verified for entry error. All verified data was backed up onto a portable hard drive and also onto the LGL backup server. All field notes and data sheets were photocopied to create back-up files.

5.0 RESULTS

5.1 Environmental and Reservoir Data

Environmental conditions in Arrow Lake Reservoir were well within the ranges necessary for Western Painted Turtle detection (i.e., spring and summer, temperatures above freezing; RIC 1998a) (Figure 5-1).

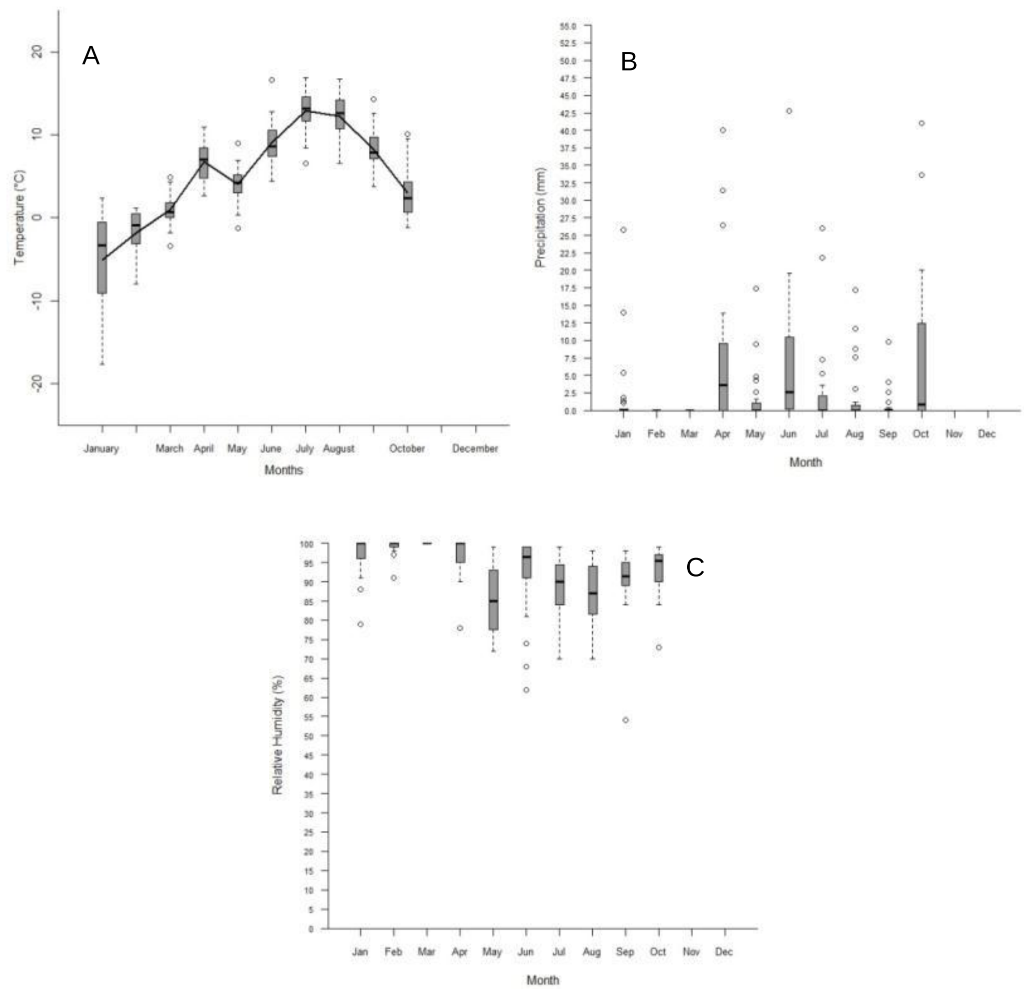

Figure 5-1: Environmental conditions for Arrow Lakes Reservoir at Revelstoke B.C. in 2012 (January through October only). A: Air Temperature (°C) (with average); B: Precipitation (mm); and C: Relative humidity (per cent). Data source = BC Wildfire Management Branch

Reservoir operations affect habitat availability and the degree to which specific areas in the drawdown zone are affected depends on reservoir elevations in any given year and month. The variable manner in which Arrow lakes Reservoir has been operated since 2008 will likely make it difficult to assess the relationship between reservoir operations and habitat availability. Reservoir operations directly affect spatial and temporal habitat availability in the drawdown zone, which may have implications for Western Painted Turtles habitat use.

In 2012, reservoir elevations increased steadily between April and early July and reached a maximum of 440.53 m (Figure 5-2) on July 11, 2012, approximately one month earlier than in 2011. The potential impact of reservoir operations on Western Painted Turtles will be assessed in more detail longer-term research.

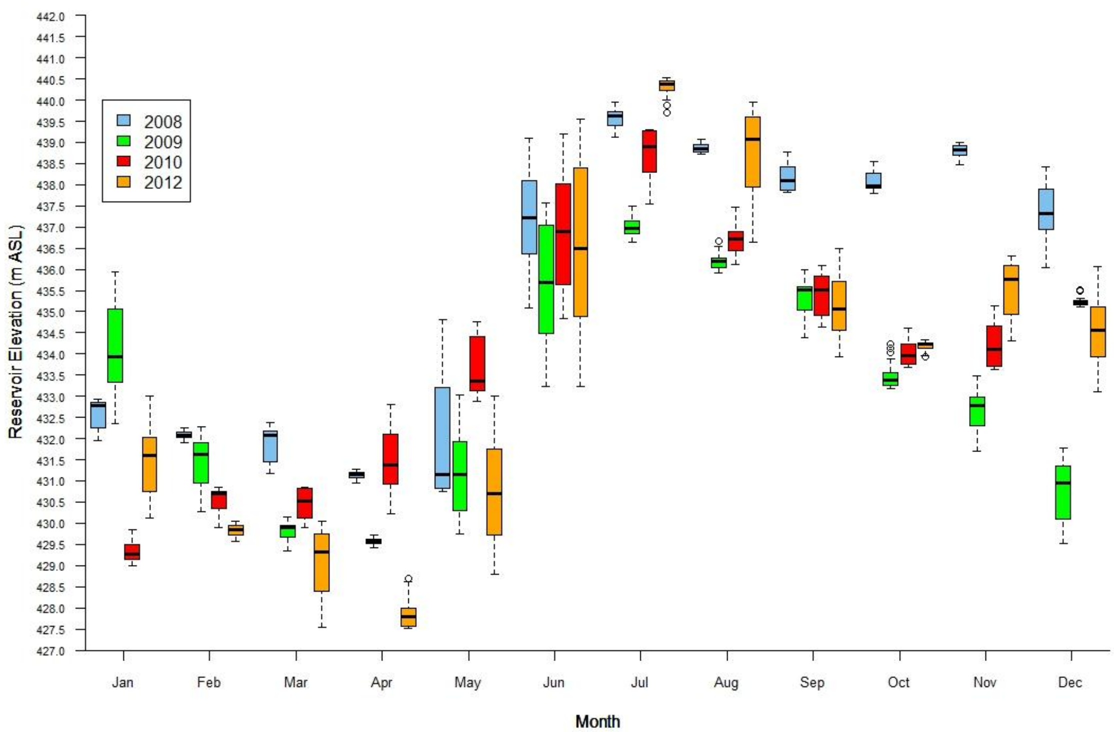

Figure 5-2: Arrow Lakes Reservoir elevations for the period April 1 through September 30, 2008, 2009, 2010, and 2012

5.2 Spring and Summer Monitoring

In May 2012 a live-trapping session was used to capture turtles and replace transmitters that were either about to expire or no longer transmitting (see Schiller 2012). Two additional field sessions occurred to relocate turtles in July and August, mainly using radiotelemetry (e.g., bearing fixation from a canoe and land) and visual encounters (e.g., incidental observations). Nine turtles with transmitters were located in the summer, eight of which were associated with an exact location (i.e., the turtle location was determined to be within 1 m). Eight turtles were consistently found in the same general locations during the summer months, 4 in Airport Marsh and 4 in Montana Slough.

Table 5-1: Habitat descriptions and characteristics for Western Painted Turtle locations in Revelstoke Reach. Variables follow the classification of CLBMON-11B4 (Fenneman and Hawkes 2012) for consistency across studies. ND = No data at time of reporting

Site	Habitat Type	Water Depth	Substrate	Dominant Veg Species	Basking Logs?
Montana Slough	Marsh/Pond Floating island Open water	1.5 to 7.8 m	Soft, muddy soil	Common Hornwort Water-milfoil Rocky Mountain Pond-lily Floating-leaved Pondweed	Yes
Airport Marsh	Marsh Open water Shoreline	0.5 to 3 m	Muck/mud/silts Gravel/cobbles	Common Cattail Soft-stemmed Bulrush Pondweed Spp. Bladderworts, Hornworts	Few
Williamson Lake	Pond	ND	ND	Rocky Mountain Pond-lily Common Cattail Pondweed spp.	Yes
Turtle Pond	Pond	ND	ND	Rocky Mountain Pond-lily	Yes

Additional adult turtles were observed in July via incidental observations. Turtles were observed basking on logs, among floating vegetation and along the sunny edges of the islands in Montana Slough, as well as swimming and floating at the surface of the water. Turtle pond regularly had numerous turtles basking on the fixed basking logs; between 8 and 27 turtles of varying sizes were observed on any given sunny day.

In July, reservoir operations exceeded full pool (440.53 m ASL, July 22, 2012) for a brief period and effects of the extremely high water were observed in Revelstoke Reach. Airport Marsh was inundated creating continuous aqueous habitat between the pre-existing marsh habitat and the slow moving Columbia River on the western side of Arrow Lakes Reservoir (see Figure 5-3). Effects were especially notable in Montana Slough, where numerous pieces of floating woody debris were scattered throughout the willows near Montana Creek and around the edges of the reservoir. Eighteen turtles were observed basking on logs floating among the submerged willow vegetation. Eleven turtles were observed in Airport Marsh during August surveys, four of which had active radiotransmitters.

Figure 5-3: Photograph of Airport Marsh taken on July 19, 2012 showing the level of inundation. The chain-link fence is approximately 1.8 m in height. Reservoir elevation on day of photo was 440.41 m ASL, 30 cm higher than the normal maximum reservoir elevation for Arrow Lakes Reservoir

Vegetation varied considerably between the study locations where turtles were observed. Airport Marsh vegetation is dominated by bulrushes (*Schoenoplectus tabernaemontani*), common cattail (*Typha latifolia*), pondweed (*Potamogeton spp*), and reed canary grass (*Phalaris arundinacea*). The dominant vegetation in Montana Slough is moss (*Sphagnum spp.*), willow (*Salix spp.*), and reed canary grass (*Phalaris arundinacea*). Outside of the drawdown zone, Turtle pond is mainly comprised of Rocky Mountain pond lily (*Nuphar polysepalum*) and Williamson Lake has combination of bulrushes (*Schoenoplectus tabernaemontani*), common cattail (*Typha latifolia*), pondweed (*Potamogeton spp*), and skunk cabbage (*Lysichiton americanus*). Common to all areas of turtle observations was the frequent use of basking logs by turtles, some fixed and some floating, often multiple individuals using the same log. More detail regarding the vegetation of each site within Revelstoke Reach can be found in Fenneman and Hawkes (2012) and Miller and Hawkes (2013).

5.3 Fall Trapping and Radiotelemetry

A three member field crew completed a second live-trapping session between September 11 and 20, 2012. This trapping effort amounted to 1,961.25 trap hours (hours traps were open and available to capture turtles) or 78 trap nights (Table 5-2).

Table 5-2: Western Painted Turtle trapping effort by site in Revelstoke Reach between September 11 and 20, 2012. Catch per unit effort (CPUE) = #captures/# trap nights

Site	Trap Nights	Trap hours	No. turtles	CPUE
Airport Marsh	5	115.9	--	--
Montana	30	840	7	0.23
Turtle Pond	25	576.9	2	0.08
Williamson Lake	18	428.4	5	0.27
Total	**78**	**1961.2**	**14**	**0.18**

Fourteen turtles were trapped, including ten new animals (five males and five females), two recaptures from the May 2012 trapping session, and two recaptures from previous trapping sessions. Using radiotelemetry we tracked three additional turtles in Airport Marsh, caught them and replaced the transmitters. Table 5-3 shows the distribution of captures by site.

Table 5-3: Distribution of Western Painted Turtle captures during fall hand capture and trapping sessions by overwintering site. Sex indicated for recaptures only.

	Airport	Montana	Turtle Pond	Williamson Lake	Total
New	--	**4**	**2**	**4**	**10**
Female	--	--	2	2	4
Male	--	4	--	2	6
Recap	**3**	**3**	--	**1**	**7**
Female	2	1	--	--	3
Male	1	2	--	1	3
Total	**3**	**7**	**2**	**5**	**17**

Following the September 2012 trapping session there were 24 turtles with functioning radiotransmitters in the study area (Table 5-4); however, four of the animals were not located in September and their current location and status is unknown. These animals were previously known to occur in either Montana Slough or Airport Marsh.

Table 5-4: Distribution of radio-tagged Western Painted Turtles by overwintering site in Revelstoke Reach, winter 2012-2013. Unknown locations represent radiotransmittered turtles whose locations could not be determined despite signal reception

Sex	Airport	Montana	Turtle Pond	Williamson Lake	Unknown	Total
Female	5	2	2	2	1	12
Male	3	5	--	1	2	11
Total	**8**	**7**	**2**	**3**	**3**	**24**

5.4 Overwinter Habitat Use and Monitoring

Overwinter monitoring was conducted on December 13, January 13-15, and February 12-14, 2013. The locations of 19 of the 23 turtles located using radiotelemetry were consistent with the previous year (Schiller and Larsen 2012b). Due to safety concerns about the depth of the pond and ice condition, the location of over-wintering turtles was estimated via triangulation. The habitat data collected for each over-wintering location are summarized in Table 5-5.

In January and February 2013 the temperature recorded at the bottom of each monitoring location was higher than at the surface. Similarly, conductivity levels paralleled the higher water temperatures at the bottom, which would be expected as water is more conductive at high temperatures. Water temperatures at the bottom of each monitoring location ranged from 0.3 to 1.8°C in January 2013, with the highest average maximum water temperature associated with Williamson Pond. Water temperatures at the bottom of each monitoring location in February varied less, ranging from 0.3 to 0.9°C. The coldest average bottom temperature recorded in January was 0.3°C at both sites outside of the reservoir (i.e., Turtle Pond and Williamson Lake), and 0.3°C in February at Airport Marsh.

Dissolved oxygen levels were higher at the surface of the water than at the bottom at all sites, which is expected as colder water typically has higher concentrations of dissolved oxygen. Williamson Pond had the highest dissolved oxygen readings in comparison to all other monitoring locations. In January, dissolved oxygen levels fluctuated between 2.05 and 7.90 mg/L, with Turtle Pond and Williamson Lake representing the respective extremes. In February, within the reservoir, the dissolved oxygen values ranged between 1.08 and 4.74 mg/L. Montana was the only location to show a pronounced drop in dissolved oxygen at depth between January and February; this is unexpected since the temperature at this location also dropped.

Table 5-6 summarizes the characteristics of the random sites sampled at each location in January and February 2013. On average water depths at these locations were deeper than those at known overwintering locations. Samples were also obtained from Cartier Bay, where no turtles are presently known to overwinter. The conductivity values collected from Cartier Bay were higher than at any other location sampled. The dissolved oxygen at depth at the suitable but not used sample locations sites ranged from 4.00 and 7.53 mg/L and the temperature from 0.63 to 2.4°C.

The results of the radiotelemetry sessions indicate that turtles were not moving between sites or even within a site; any inconsistency in turtle locations is due to GPS accuracy and variability. With the exception of Montana Slough (winter pond), most of the turtles overwintered adjacent to a shoreline in shallow water. The location of each overwintering location is shown in Figure 5-4.

Table 5-5: Average water depths and measurements associated with turtle locations at each study site for January and February 2013

Location	No. Turtles	No. Surveys	Total Depth (cm)	Ice Depth (cm)	Water Depth (cm)	Surface Temp (°C)	Surface DO (mg/L)	Surface Conductivity (µs)	Sample Depth (cm)	Depth Temp (°C)	Depth DO (mg/L)	Depth Conductivity (µs)
January												
Williamson	2	2	48.5	13	35.5	0	8.88	--	48.5	0.3	7.9	--
Airport	8	8	57	24.1	32.9	0.06	5.71	46.75	55.9	0.65	3.74	66.67
Montana	6	6	72.7	22	50.7	0.5	4.58	85.88	72.7	1.77	3	114.93
Turtle Pond	3	1	58	31	27	0.1	3.76	22.4	58	0.3	2.05	24
February												
Williamson	2	2	73.5	34.5	39	0.25	7.68	55.05	73.5	0.85	7.13	42.5
Airport	8	8	62.5	34	28.5	0.39	6.55	56.55	62.5	0.33	4.74	68.57
Montana	6	6	68.5	29	39.5	0.05	2.28	69.97	68.5	0.6	1.08	95.1

Table 5-6: Average water depths and measurements associated with non-turtle locations for each study site in February 2013

Location	No. Surveys	Total Depth (cm)	Ice Depth (cm)	Water Depth (cm)	Surface Temp (°C)	Surface DO (mg/L)	Surface Conductivity (µs)	Sample Depth (cm)	Depth Temp (°C)	Depth DO (mg/L)	Depth Conductivity (µs)
Williamson	1	98	37	61	0.2	7.66	58.4	98	2.4	6.09	66.7
Airport	3	97	37.7	59.3	0.6	5.9	85.73	97	0.73	4.23	102
Turtle Pond	3	74	31	43	0.6	7.5	55	74	0.63	4	53.73
Montana	2	75	33.5	41.5	0.1	4.01	92.4	75	1.1	3.46	110.15
Cartier	2	76	24	52	0.35	7.85	169.9	76	1.4	7.53	183.85

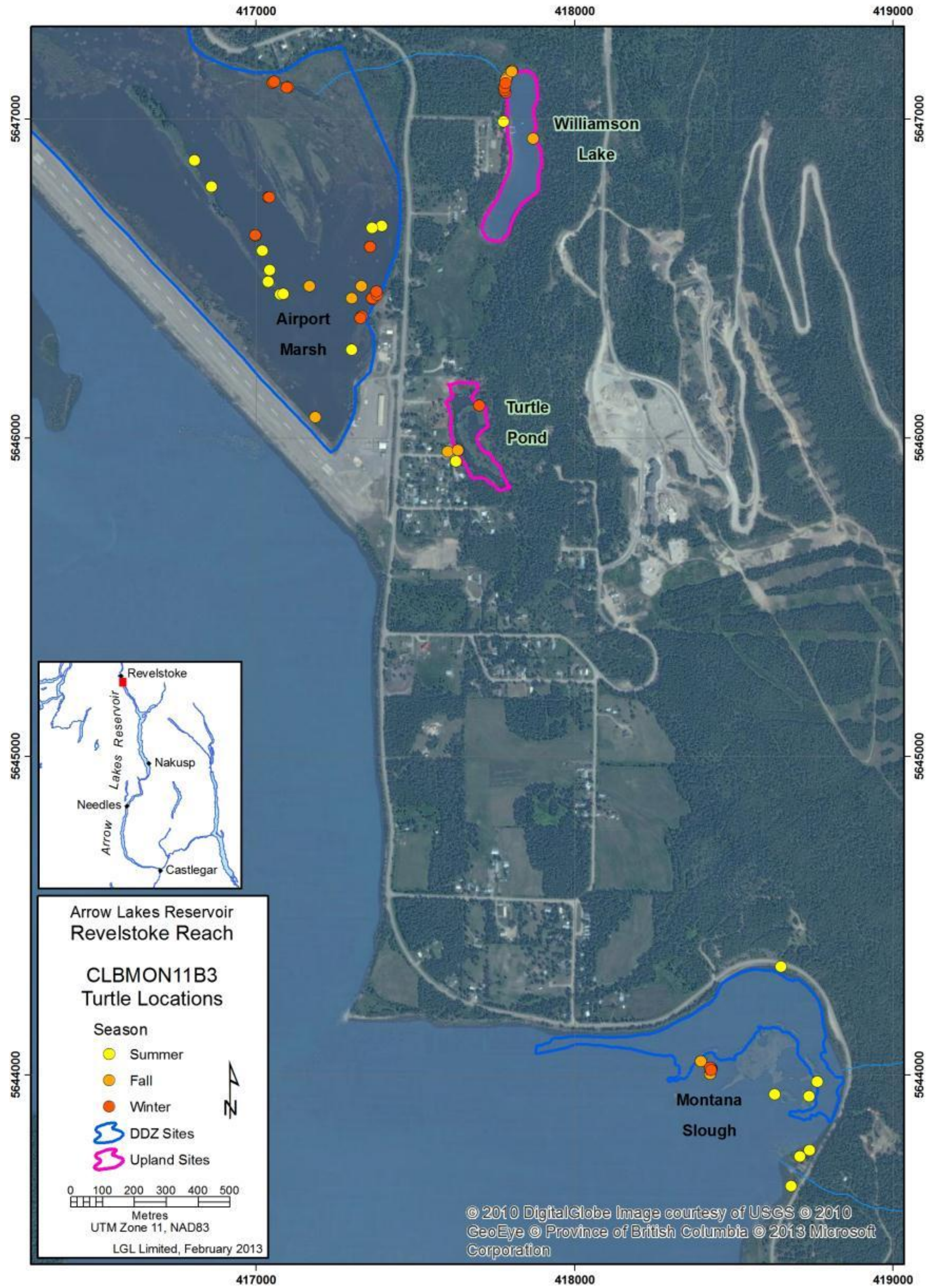

Figure 5-4: Western Painted Turtle locations across the seasons (summer, fall, winter) located in Revelstoke Reach using radiotelemetry

6.0 DISCUSSION

The abundance, distribution, productivity and habitat use of Western Painted Turtles in the drawdown zone of Arrow Lakes Reservoir have been studied since 2010. This long-term study focuses primarily on the demographics and habitat use of a population of Western Painted Turtles in Revelstoke Reach, on how reservoir operations may affect the population and/or the habitats they use, and whether physical works can be implemented to mitigate any potentially adverse effects of reservoir operations on this population or its habitats. Monitoring painted turtles in the drawdown zone over a ten year period will provide the necessary information to address the management questions outlined in the terms of reference for CLBMON-11B3.

The current study focuses on two key initiatives (#1 and 2b, Table 6-1; see Table 2-1 for the ten-year initiatives). The majority of the work in 2013 will be to support the two key initiatives.

Table 6-1: Relationship between management questions, hypotheses, and long-term monitoring strategy for Western Painted Turtles in Revelstoke Reach, Arrow Lakes Reservoir. Seasons are grouped into S/S (spring /summer) and F/W (fall/winter)

Initiative		Management Question Addressed	Season		Study Years
			S/S	F/W	
1	Long term tracking of turtle demographics to monitor population trends (abundance, recruitment/productivity, and mortality) and assess the impacts of reservoir operations on these parameters	Q1, Q3, Q4, Q5	X	X	2012-2020
2	Conduct focused studies on the fine scale seasonal habitat use of turtles	Q2, Q4, Q6, Q7, Q8	X	X	2012-2020
2b	Conduct a focused study on fine-scale habitat use by turtles during winter and investigate potential impacts of reservoir operations on winter habitat use and habitat availability	Q2, Q4, Q5		X	2012-2014

6.1 Management Questions and Hypotheses

Several management questions (Q#1 – #6; Section 2.0) strive to address how reservoir operations affect the use of the drawdown zone by turtles, as measured by indices of habitat use and demographic parameters. Concurrent with the assessment of population characteristics and habitat use, certain components seek to determine whether future physical works projects (Q#8) or various revegetation techniques (Q#7) could affect habitat quality or turtles use of the drawdown zone. The ability to address each of the management questions is discussed below. For the most part, the methods we have used with Initiatives #1 and #2b appear to have been appropriate for collecting data adequate to address the questions; however, time series and the completion of Initiatives #2a, 2c and 2d are required before hypotheses linked to broader management questions can be addressed.

The establishment of a habitat preference study to assess Western Painted Turtle overwintering habitat selection will provide valuable information to BC Hydro to assess how reservoir operations between November and March might influence overwintering locations and how physical works in Revelstoke Reach might contribute to the enhancement of other sites for overwintering (e.g., sites in the vicinity of Cartier Bay). More data are required to test this and the physical works planned for Revelstoke Reach need to be implemented to test this theory.

6.1.1 Theme 1: Life History and Habitat Use

Q1: During what portion of their life history (e.g., nesting, foraging, and overwintering) do painted turtles utilize the drawdown zone in Revelstoke Reach?

Our current understanding of the use of the drawdown zone by Western Painted Turtles in Revelstoke Reach is that turtles use the DDZ to fulfill most of their life history stages (Table 6-2). Site occupancy by life history stage (e.g., adult, juvenile, neonate) followed a somewhat similar pattern to that of previous years of the CLBMON-11B3 study (2010 to 2011). Adult (and some juvenile) turtles used the drawdown zone (e.g., Airport Marsh, Montana Slough) and upland ponds (e.g., Williamson Lake, Turtle Pond) during the summer and winter months. Two nesting sites are located in Revelstoke Reach: Red Devil Hill and Williamson Lake (one nest observed in 2012); this component was not examined extensively this year, and will be addressed by Initiative #2c in future years (i.e., 2013). Neonate turtles are highly inconspicuous and observations of this life history stage are currently few. Although several neonate turtles have been observed in Airport Marsh (as part of CLBMON-11B4), it is currently unknown where these turtles overwinter or how (or if) they move between the drawdown zone and upland ponds. As such, we do not currently have sufficient data to assess the abundance of neonate painted turtles or productivity of this population in 2012.

Table 6-2: Observed life history activities of Western Painted Turtles in the drawdown zone and upland areas in Revelstoke Reach 2012

	Life History Activity			
Study Site	**Reproduction**	**Growth**	**Foraging**	**Overwintering**
Airport Marsh	Yes	Yes	Yes	Yes
Montana Slough	No	Yes	Yes	Yes
Cartier Bay	No	Unknown	Likely	Unlikely
9 mile / 12 mile	No	Unknown	Occasionally	Unlikely
Williamson Lake	Yes	Yes	Yes	Yes
Turtle Pond	Unknown	Yes	Yes	Yes
Red Devil Hill	Yes	No	No	Yes

Schiller and Larsen (2012a) indicated that Montana Slough, particularly an area referred to as 'winter pond', as well as Airport Marsh afforded important overwintering habitat to turtles, and recommended investigating the microhabitat and physicochemical variables within these areas. They also identified Turtle Pond and Williamson Pond as active overwintering habitats; these sites will act as controls to the drawdown zone locations for future habitat use comparisons. The results of the telemetry in January and February 2013 confirm that Montana Slough, Airport Marsh, Turtle Pond and Williamson Pond are all used as overwintering locations by adult Western Painted Turtles. Overwintering will be explored in detail over the next two years as part of the graduate student project.

Q2: Which habitats do painted turtles use in the drawdown zone and what are their characteristics (e.g., pond size, water depth, water quality, vegetation, elevation band)?

Western Painted Turtles that occur in and adjacent to the drawdown zone in Revelstoke Reach depend on aquatic habitats to fulfill their life history requisites (e.g., foraging, basking, and overwintering). To better understand turtle habitat use, particularly in the winter, we established a use vs. non-use study during the 2012/2013 winter with the goal of correlating turtle presence with vegetation communities mapped in the drawdown zone (using vegetation communities classified under CLBMON-11B4 and CLBMON-33), and with continuous water physicochemistry data. In the summer, turtles were dispersed in wetland areas with an abundance of vegetation (emergent and submergent) and basking capabilities (e.g., logs, lily pads, floating mats of vegetation). During the winter, turtles were clustered at winter pond in Montana Slough and along the shoreline areas of Airport Marsh, Williamson Lake, and Turtle Pond.

Rollinson et al. (2008) classified temperature and dissolved oxygen levels as important factors that may contribute to overwintering site selection by Western Painted Turtles. Painted turtles have the ability to depress their metabolic activity and limit dissolved oxygen uptake while overwintering; temperature and dissolved oxygen values measured at the hibernation sites vs. other similar and potentially suitable but not used sites may be indicative of a range of values required for turtle winter survival. Because water depth can affect both temperature and dissolved oxygen, the effect of fluctuating reservoir levels must be considered relative to (1) site selection, (2) overwintering survival, and (3) with respect to the physical works proposed for Revelstoke Reach and their effect on overwintering habitat. Currently, turtles tend to overwinter in sites where water depth ranges from 0.5 to 0.75 m and that are close to shore (with the exception of Montana Slough). These two parameters require further investigation, but suggest that fluctuating reservoir elevations could negatively affect current overwintering sites, particularly if water depth exceeds 0.75 m during winter. Fluctuating water levels have the potential to not only influence temperature and dissolved oxygen levels at the hibernation sites, but may also present the potential for beaching hibernating turtles or possibly crushing turtles by ice left by receding water. These hypotheses will be investigated over the next two years.

Q3: What is the abundance and productivity of painted turtles in Revelstoke Reach and how do these vary across years?

The site locations in Revelstoke Reach with the highest abundance of turtles are Airport Marsh, Montana Slough, and Turtle Pond. These sites are used during both the summer and winter by adult and juvenile turtles, and are thus likely important to this population. Productivity (nest and egg counts) was not measured in 2012; however this component of the long-term turtle monitoring study will be addressed as part of Initiative #2c in future years. Additional years of data collection will allow for comparisons between the years and capture of any potential variability in abundance or productivity due to reservoir operations.

Q4: Does the operation of the Arrow Lakes Reservoir negatively impact painted turtles directly or indirectly (e.g., mortality, nest inundation, predation, and habitat change)?

As of yet, there has been little evidence of mortality, nest inundation or predation occurrences for turtles that could be linked to the operations of Arrow Lakes Reservoir. There exists the potential for both direct and indirect negative impacts from reservoir operations on this turtles within this population (Table 6-3). Possibilities include mortality in turtles due to road kills as turtles move away from the reservoir in periods of high water (and consequent lack of high quality basking areas). An increase in predation risk could be associated with changing water levels in either summer or winter as turtles may be more conspicuous or exposed as the habitat changes. It is unlikely that nest inundation will occur at the Red Devil Hill nesting site; however should there be other unknown nesting areas closer to or within the drawdown zone reservoir, high water levels could pose a risk to such nests. Nesting usually occurs in May or June and nests are typically at least 200 m of water, although they could be nearer to or farther away from water depending on local site conditions (COSEWIC 2006). If nests were in the drawdown zone (none have been documented in the drawdown zone) and were flooded, the nest would fail. Additional years of data collection are required to assess whether the operation of the reservoir effects this turtle population directly or indirectly.

Table 6-3: Anticipated effects of reservoir operations on Western Painted Turtles found in the drawdown zones of Arrow Lakes Reservoir in 2012. Seasons are grouped into S/S (spring /summer) and F/W (fall/winter)

Reservoir Operation	Description of Anticipated Effect	Affected Season	Severity of Effect	Direction of Effect
Reservoir Inundation				
Cold Water Temps	Slows development/growth	S/S	Low	Direct
Cold Water Temps	Changes turtle habitat use	S/S	High	Direct
High Water Levels	May decrease availability of basking and foraging habitat	S/S	Moderate	Direct
High Water Levels	Changes turtle habitat use	S/S	Low	Direct & Indirect
High Water Levels	Possible changes to food availability/access	S/S	Moderate	Indirect
Reservoir Drawdown				
Changes in water temperature	Warmer water temperatures may affect thermoregulation during hibernation	F/W	Moderate	Indirect
Low water levels	Beaching of turtles on shore (dry land)	F/W	High	Direct
Low water levels	Greater access of predators to turtles	F/W	High	Direct

Habitat changes associated with fluctuating reservoir elevations are likely to have the greatest effect on the painted turtle population in Revelstoke Reach. Habitat changes such as the drastic alterations that occur during reservoir inundation and drawdown can be assessed in terms of changes in microhabitat (e.g., immediate plant cover and species, site physicochemical characteristics) or macrohabitat features (e.g., vegetation community and habitat availability).

Over the long term, assessing the effects of reservoir operations on habitat changes and the potential impact of these changes on the painted turtle population in Revelstoke Reach can be accomplished by 1) assessing habitat availability as a function of reservoir elevation, 2) comparing key microhabitat use variables (e.g., water depth, water temperature, dissolved oxygen) of habitats in the drawdown zone, in upland ponds and at locations representative of suitable habitat, and 3) examining use relative to the vegetation communities described for the drawdown zone of Revelstoke Reach (as per CLBMON-11B4 and CLBMON-33.

Currently, more data are required to determine if painted turtle habitat use trends persist across time and if they are affected by reservoir operations. Despite the proposal to conduct surveys over the same general time frames each year, environmental conditions vary between years, often due to changing reservoir levels, so we expect to see some variability in seasonal habitat use over the years. However, due to this population's apparent dependence on established nesting [see Schiller and Larsen (2012a)] locations (e.g., Red Devil Hill) and aquatic habitats to fulfill life history requirements (e.g., foraging, thermoregulation, overwintering), we expect macrohabitat use to be relatively consistent across years (i.e., continued use of Airport Marsh and Montana Slough) and potential variations in microhabitat use.

Theme 2: Mitigation – Reservoir Operations and Effects

Q5: Can minor adjustments be made to reservoir operations to minimize the impact on painted turtles?

This management question is related to H_2 and the discussion associated with this hypothesis relates to Qs 1 to 6 (Section 2.0). Several additional years of documenting the presence of the various life stages and their related habitat use in the DDZ will help determine how the timing of reservoir inundation potentially affects turtles. Based on these data, we will be able to provide recommendations on managing reservoir elevations to benefit the Western Painted Turtle population in Revelstoke Reach.

Currently, we know that cold water can significantly slow movements, alter foraging behaviours, or affect overwintering habits in ectothermic animals, which in turn can delay growth, decrease survival, and reduce reproductive output (e.g., Rollinson et al. 2008). Therefore, the rapid inundation of ponds, wetlands and shallow drawdown zone areas with cold reservoir water, very possibly could have an effect on painted turtles that rely on those habitats, especially if active season basking locations are submerged during inundation. Basking logs (or other equivalent forms of floating basking material) are important to a turtles' thermoregulatory system, as well as offering a certain measure of protection from predators (as opposed to shoreline basking). Alternatively, turtles that overwinter in the drawdown require stable, aquatic habitat (which does not freeze through) with appropriate water temperatures, dissolved oxygen levels, and substrates. If significant changes to reservoir levels occur during winter, this might have an effect on the overwintering survival of turtles in the drawdown zone.

As indicated under Qs 2 and 4, we will correlate turtle presence with number and availability of basking logs (e.g., fixed logs, floating logs, etc.) with reservoir elevations and habitat use by turtles to determine the effect of changing reservoir elevations. We will also compare microhabitat conditions (e.g., water depth, water temperatures, dissolved oxygen and conductivity) between turtle overwintering sites within the drawdown zone and in nearby control sites. These results will address this management question by determining the elevations at which summer and overwintering aquatic areas are impacted and whether recommendations for altering reservoir operations can be made to mitigate for any impact.

Q6: Can physical works be designed to mitigate the impacts of reservoir operations on painted turtles?

Certain physical works, such as the addition of floating islands in Montana Slough and Airport Marsh could potentially mitigate the effects of reservoir operations as they relate to habitat availability in the spring and summer while providing a habitat feature that is currently lacking in the reservoir. Additional physical works such as the maintenance of existing nesting locations at Red Devil Hill to remove weedy vegetation could improve the suitability of those sites for turtles. Although these habitats are known to be outside of the drawdown zone and therefore not subject to the effects of reservoir operations, turtles require access to highly suitable aquatic and terrestrial habitats. Enhancing or managing existing upland nesting habitat is essential to ensure the long-term viability of this population. The creation of additional upland nesting sites away from Red Devil Hill may also be of benefit as the current nesting location and its proximity to the road puts some turtles at risk of mortality from vehicles.

Theme 3: Effectiveness Monitoring

Q7: Does revegetation of the drawdown zone affect the availability and use of habitat by painted turtles?

Q8: Do wildlife physical works (e.g., habitat enhancement) affect the availability and use of habitat in the drawdown zone by painted turtles?

Management questions #7 and #8 are difficult to address at this point, because neither projects (revegetation of the DDZ, physical works) have been implemented in Revelstoke Reach. Several wildlife physical works have been proposed for implementation in select areas of in Revelstoke Reach, Arrow Lakes Reservoir (Golder 2009a and 2009b). These physical works have been designed to specifically address the loss of shallow valley bottom and wetland habitat, which would have been flooded when Arrow Lakes Reservoir was created. The creation or enhancement of habitats in the drawdown zone of Arrow Lakes Reservoir is intended to improve habitat suitability for several species groups including painted turtles, pond-breeding amphibians, and birds (waterfowl).

6.1.2 Recommendations

The objective of CLBMON-11B3 is to monitor trends in the Western Painted Turtle population (relative abundance, productivity), determine the impact of reservoir operations on these turtles, determine their habitat use, and assess the impacts of any revegetation and physical works on species that use habitats within the drawdown zone of Revelstoke Reach, Arrow Lakes Reservoir.

Monitoring of painted turtles in Revelstoke Reach in 2013 should continue using similar methods applied during previous years. A new Master's program under Thompson Rivers University with supervisor Dr. Karl Larsen and potential MSc. student Amy Leeming is being developed for implementation in 2013 and 2014. This program will investigate overwintering habitat use by Western Painted Turtles in Revelstoke Reach and will assess how fluctuating reservoir elevations might impact this population. Additionally, the effect of the proposed physical works on existing overwintering sites will be assessed.

Additional recommendations for consideration in future years include the following:

1. Assess turtle hibernating location (e.g., in or on substrate) using temperature profiles of the water column and substrate and correlate with the temperature data from the transmitters. A similar approach was used by Rollinson et al (2008). If turtles are hibernating on the substrate and not it in, they are more likely to be exposed to predation, which needs to be considered as possible limiting factor.
2. Surveys should be conducted at similar times each year whenever possible. Continue to start spring field surveys early in the year (late April), to capture early emergence of turtles from hibernation sites and nesting at Red Devil Hill. The actual timing of late winter surveys will depend on the amount of ice on the reservoir.
3. Compare the water physicochemistry characteristics between used and unused but suitable habitat during the winter with other studies on Western Painted Turtles. Additional water characteristics should be taken in the shallow water areas of the reservoir; these data can be used to compare what the conditions are like for turtles as the water recedes during winter.

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