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

Implementation Year 2

Reference: CLBMON 11B3

Revelstoke Reach Western Painted Turtle (Chrysemys picta bellii) Monitoring Program

Study Period: 2011

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2011 Annual Report - Revelstoke Reach Western Painted Turtle Monitoring Program

Reference: CLBMON 11B3
Columbia River Project Water Use Plan, Arrow Lakes Reservoir

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Executive Summary

Western painted turtles (WPT) (*Chrysemys picta bellii*) are the only native freshwater turtle in British Columbia. A northern population of WPT resides in the Upper Arrow Lakes Reservoir, British Columbia and was identified by BC Hydro as a component of the monitoring program CLBMON11B: Wildlife Effectiveness Monitoring of Revegetation and Wildlife Physical Works. CLBMON11B is a long-term monitoring program designed to identify opportunities and monitor the effectiveness of revegetation and wildlife physical works within the reservoir drawdown zone for various wildlife species including the WPT.

During 2010 and 2011, a pilot project was conducted in order to collect baseline data on the WPT population occupying the Revelstoke Reach of the Upper Arrow Lakes Reservoir, and in doing so, provide a preliminary assessment of how and if BC Hydro's operations for the Arrow Lakes Reservoir influence the animals (particularly drawdown effects) and provide mitigation through physical works should this be necessary. This report summarizes the activities undertaken during this time.

The specific information collected focuses on the distribution, abundance, and demographics of the WPTs in the Upper Arrow Lakes Reservoir. It also focuses on how the turtle's productivity varies across years, which type of habitats they use, and if any parts of these habitats are located within the drawdown zone. Information on nesting and overwintering locations were a priority, as these aspects of turtle ecology may be impacted directly or indirectly through winter mortality, nest inundation, predation risks, reservoir operations (e.g., water levels) and habitat alterations. A number of techniques were employed to collect the information, including mark-recapture and radio telemetry.

Our efforts at sighting turtles through systematic surveys, and while conducting telemetry increased in our second year of study (541 person hours in 2010, versus 954 person hours in 2011). This produced in 2011 a total of 252 turtle sighting (excluding telemetry locations) over six months, or 0.26 sightings/hour across all sites, although this was considerably lower than in 2010 (2.46 sighting/hour).

A total of 203 individual turtles (all age classes and sizes) were captured alive during the pilot project providing a population estimate of 242 turtles in our study area. Adult females were over-represented in our samples, both in 2010 and 2011. This bias may be an effect caused by hand captures, however female biased populations have been observed elsewhere.

Six nesting locations were identified, Airport-Firebase, along the road at Montana Slough and Nichol Road, Williamson Lake and Turtle Pond. All nesting locations identified to date are located above the drawdown zone of the reservoir and all are anthropogenic in origin.

Over the two years, 41 turtles (29 female, 10 males, 1 female juvenile, and 1 unknown juvenile) were outfitted with VHF radio transmitters within the primary sites Airport Marsh (AP) and Montana Slough (MS). Telemetry revealed that turtles moved between our two principal study sites in the reservoir, and between ponds upland of the reservoir. Telemetry also showed that at least one turtle from MS moved as far south as 12-Mile, and along the west side of reservoir. In the opposite direction, public sightings suggest that turtles can on occasion be found as far north as the town of Revelstoke.

Comparisons between turtle movements and water levels (elevation in meters) may suggestion that variations in movements increase and that larger movements are made when water levels rise. Differences in movements may be related to changes in available habitat (including temperature ranges) and/or other resources (e.g. food availability, cover from predation, nesting and overwintering locations, shelter) affected by changes in water levels. Potentially this could lead to higher energetic costs, decreased growth, risk of predation and/or loss of habitat for the turtles occupying the drawdown zone. .

Data collected from the pilot study has provided the foundation for the "Arrow Lakes Reservoir, Revelstoke Reach Western Painted Turtle (*Chrysemys picta bellii*) Monitoring Strategy (2012-2019)" (Schiller and Larsen 2012). The continuation of a turtle monitoring and research program in the reservoir will provide the detailed data needed to further answer the management hypotheses and questions set forth by BC Hydro and the Water Use Plan (BC Hydro 2005; BC Hydro 2009) for the western painted turtles inhabiting the Revelstoke Reach of the Arrow Lakes Reservoir. Additional information regarding the turtle population is planned as a part of Nicole Schiller's MSc. Thesis with Thompson Rivers University, Kamloops, British Columbia.

Acknowledgements

We would like thank BC Hydro and the Canadian Wildlife Federation's (CWF) endangered species fund for providing the financial support for this research on the western painted turtle (*Chrysemys picta bellii*) through Thompson Rivers University (TRU). Special thanks to Doug Adama (BC Hydro) who established the project and provided ongoing support and feedback. Thanks also to Guy Martel of BC Hydro for always providing useful comments, to Purnima Govindarajulu (B.C. Provincial Herpetologist) who provided support through N. Schiller`s Graduate Committee, the Western Painted Turtle Working Group and to Vigril Hawkes with LGL and Jose Galdamez with the Ktunaxa Nation Council for providing their GIS services.

Field work was conducted by Nicole Schiller, with assistance from Tory Anchikoski, Tori Waites and Ken Davis. A special thanks to the volunteers who helped throughout the season, namely Darcy Schiller and Stephen Symes.

Cover Photo: Airport Marsh, Red Devil Hill, Upper Arrow Lakes Reservoir, western painted turtle (*Chrysemys picta bellii*). Photos © Schiller, N.

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1.0 Introduction

The Columbia River Water Use Plan (WUP) was developed through a multi-stakeholder consultative process to inform how to best operate BC Hydro's Mica, Revelstoke, and Hugh Keenleyside facilities so that environmental values, recreation, power generation, cultural/heritage values, navigation, and flood control are balanced (BC Hydro 2005). The goal of the WUP is to accommodate these values through either incremental changes in water storage and release facilities, or to undertake physical works and wildlife mitigation in lieu of changes to reservoir operations.

A population of western painted turtles (WPT) (*Chrysemys picta bellii*) occupies the upper reach (Revelstoke Reach) of the Upper Arrow Lakes Reservoir near Revelstoke, British Columbia (B.C.). These turtles are a provincially blue-listed species and the intermountain population is listed as Special Concern under Schedule 1 of the Species at Risk Act (SARA) (COSEWIC 2006). Due to the "Special Concern" status of the species, its regional importance (Maltby 2000 ; Larsen & Legebokow pers. comm. 2009), and the location of the population at the northern extent of its range, the species was identified as a species that may benefit from wildlife physical works (Golder Associates 2009; D. Adama pers. comm. 2009). The WPT study is a component of the program CLBMON11B Wildlife Effectiveness Monitoring of Re-vegetation and Wildlife Physical Works and includes a literature review (Reference CLBMON11B3: Ecology and Conservation of Turtles in Canada with an Emphasis on painted turtles (*Chrysemys picta*)). The initial two years of this research (2010 and 2011) was a pilot study on painted turtles (CLBMON11B3) to design a long-term monitoring program to assess the population of turtles residing in Revelstoke Reach, the effectiveness of re-vegetation and wildlife physical works in the Arrow Lakes Reservoir drawdown zone, and to increase habitat availability for various wildlife species.

1.1 Management Questions

A number of management questions and hypotheses have been proposed by BC Hydro to be addressed over an eleven-year period, all specific to understanding the life history of the WPT. Through CLBMON11B3, the following management questions will be addressed over this eleven-year period (BC Hydro 2009):

Life History

1) During what portion of their life history (e.g., nesting, foraging, and overwintering) do painted turtles utilize the drawdown zone in Revelstoke Reach?
2) 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)?
3) What is the abundance and productivity of painted turtles in Revelstoke Reach and how do these vary across years?
4) Does the operation of the Arrow Lakes Reservoir negatively impact painted turtles directly or indirectly (e.g., mortality, nest inundation, predation, and habitat change)?

Mitigation

5) Can minor adjustments be made to reservoir operations to minimize the impact on painted turtles?
6) Can physical works be designed to mitigate the impacts of reservoir operations on painted turtles?

Effectiveness monitoring

7) Does re-vegetating the drawdown zone affect the availability and use of habitat by painted turtles?

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

<u>Management hypotheses that will be tested throughout the program include:</u>

HO_1: Painted turtles are not dependent on habitats in the drawdown zone of Arrow Lakes Reservoir.

HO_2: The operations of the Arrow Lakes Reservoir do not affect painted turtle survival or productivity.

$HO_{3:}$ Habitat enhancement through re-vegetation or physical works does not mitigate the effects of reservoir operations on painted turtles. More specifically, wildlife physical works and re-vegetation projects do not change the utilization of the drawdown zone habitats by painted turtles in Revelstoke Reach.

To initiate a long-term monitoring program, BC Hydro has funded a two-year pilot study with Thompson Rivers University. This initial study will aid in developing a long-term monitoring framework, and in understanding the relationship between WPTs and the reservoir, their productivity, abundance, and habitat use. The study may also generate tentative recommendations for enhancing habitat for the turtles residing in the reservoir.

1.2 Scope of the Report

During 2010 and 2011, a pilot project was conducted in order to collect baseline data on the WPT population occupying the Revelstoke Reach of the Arrow Lakes Reservoir. This report summarizes the activities undertaken during this time. It incorporates much of the information presented in the 2010 Annual Report, along with that more recently collected during 2011. Differences between the two years, along with overall trends are discussed.

The reader should note further data analysis and in-depth discussion of the ecology of the WPT at Revelstoke will be forthcoming in the MSc thesis of Nicole Schiller (Thompson Rivers University, Kamloops, BC).

2.0 Study Area

The Arrow Lakes Reservoir is the portion of the Columbia River that was created in 1968 with the construction of the Hugh Keenleyside Dam near Castlegar, BC. The reservoir is also influenced by the outflows of Revelstoke Dam, constructed in 1984. The area is associated with the southern interior mountains forest region, and the biogeoclimatic zone within the study area is the Interior Cedar Hemlock – moist warm (ICHmw3) (Braumandl and Curran 1992). The reservoir is divided into the Upper and Lower Arrows Lake spanning 230 km, between the Monashee Mountains to the west and the Selkirk Mountains to the east. The mountains rise to an elevation of 2600 meters and are heavily forested. Revelstoke Reach is the area of importance and is approximately 40 km long. The current water licence allows for a 20 meter (420 m – 440.1 m) fluctuation in water levels within the so-called “drawdown zone”, and annual reservoir levels vary both in time and in magnitude (BC Hydro 2005). These changes in water levels cause seasonal flooding of riparian, wetland, and grassland habitats used by aquatic and terrestrial organisms.

Designated study sites in Revelstoke Reach were along the east side of the reservoir and include primary sites Airport Marsh (AP; 81.5 ha) and, Montana Slough (MS; 28.3 ha). Secondary sites include Cartier Bay, Rob's Willows (an area between 9-Mile and 12-Mile), 9-Mile, 12-Mile, and Turtle Pond (TP), which is a water body adjacent to the reservoir (Figure 1). Primary sites were chosen based on initial surveys at the beginning of the 2010 field season, and on previous sightings that indicated the majority of turtle sightings within the reservoir were made at Airport Marsh and Montana Slough (Adama pers. comm. 2010). Both primary and secondary sites were based on habitat quality as the secondary sites have less emergent vegetation and greater exposure to the main flow of the reservoir. Telemetry locations were also considered as turtles were only detected at Rob's Willows, 9-Mile and 12-Mile with the aid of telemetry.

Airport Marsh is a large (81.5 ha) marshy area sheltered from the main channel of the Columbia River by the airport runway and expands as the water levels rise and inundate adjacent land. It is dominated by bulrush (*Schoenoplectus tabernaemontani*), common cattail (*Typha latifolia*) pondweed (*Potamogeton spp*), milfoil (*Myriophyllum* spp) and reed canary grass (*Phalaris arundinacea)*: turtles are often found basking on or submerged within the shallow waters of the vegetation and within the organic soils. (Appendix 1: Site Photos). Line of sight for turtle detection was poor due to emergent and submergent vegetation: for much of the active season, turtles were often detected by sound as they left basking sites and dove into the water.

Montana Slough is a large wetland complex adjacent to Airport Way Road. This area exists as a functional wetland that floods as reservoir levels rise. A portion of the wetland is a massive floating island of vegetation (fen) that provides unique turtle habitat. The wetland's dominant vegetation is moss (*Sphagnum* spp.), willows (*Salix* spp.), sedge (*Carex* spp.) and reed canary grass (Appendix 1: Site Photos). When water levels are high, small openings within the vegetation of the floating island are exposed and turtles access these locations presumably by swimming under the island. Not only does this provide habitat during high water but it also appears to provide cover. As with Airport Marsh, turtles here were often heard leaving their basking sites rather than seen, and a poor line of sight and a large area to survey (28.3 ha) contributed to poor detection.

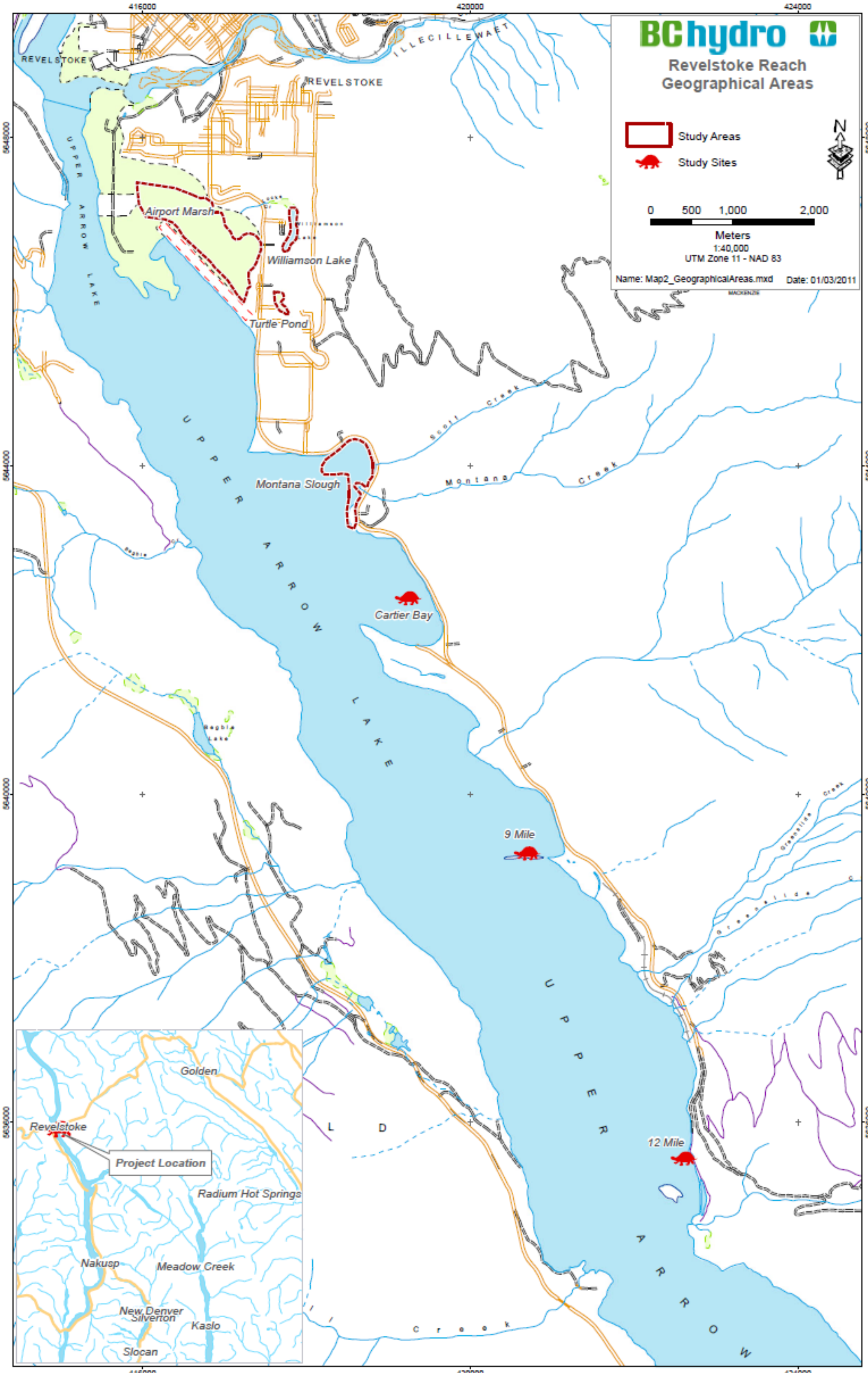

Figure 1 Upper Arrow Lakes Reservoir, Revelstoke Reach B.C. Canada, Western Painted Turtle Study Location. Study areas are sites that were surveyed using boats and had turtles sighted without the use of telemetry while study sites were areas surveyed by land which did not have sighting of turtles other than detection by telemetry (Galdamez 2011).

3.0 Methods

In 2010, we identified two primary sites of turtle occupation within the Reservoir, namely Airport Marsh (AP) and Montana Slough (MS). These two sites became the main areas of focus for the 2011 field season. Increased trapping and outfitting additional turtles with radios were the main efforts during the second year.

We used three main approaches to collect data in the field: visual/systematic encounters surveys, mark-recapture, and radio telemetry. Mark-recapture and radio telemetry entailed capturing WPTs, which allowed for the collection of morphometric data, age classification, and sex determination. An animal handling permit was obtained from the Ministry of Environment (Permit CB10-60676) and an animal welfare permit was obtained through the Animal Care Committee at Thompson Rivers University (AUP2010-04R and AUP2011-03R); for a more detailed methods protocol please see Schiller and Larsen (2011).

3.1 Surveys

3.1.1 Public Reports and Surveys

Communications with local naturalist clubs and public presentations helped promote awareness of the turtle research being conducted in the Upper Arrow Lakes Reservoir. A specific email account (turtlehotline@gmail.com) was established to promote reporting of public sightings and inquiries. During the 2010 and 2011 field seasons, various news articles in the Revelstoke Times were published (including the email address) and created positive feedback such as turtle locations and potential physical works in the area.

3.1.2 Visual Encounter Surveys

Initial visual surveys, which are informal opportunistic searches, were conducted at the start of each field season to obtain preliminary data on where the turtles were located and where initial trap placement would be best.

Once initial visual surveys were conducted, extensive weekly searches examining the entire area or the shorelines and ponds began and were continued until mid-October. Surveys followed the standard methodology described in Resource Inventory Standards (1998). Surveys were conducted on warm sunny days beginning in the early morning or late afternoon (Lefevre and Brooks 1995). Using binoculars, surveys began along known nesting areas, basking areas, then progressed along the shoreline and then into open water for a minimum of two person-hours at each site in the reservoir. In addition, aquatic vegetative islands such as bulrush islands and inundated grassy areas were surveyed using a watercraft or wading through the area.

It was generally difficult to approach a basking turtle within 20 meters, both within and outside the reservoir, without them retreating into the water. This is likely an anti-predator strategy as turtles are the most agile in the water and camouflage well into their surroundings (Boyer 1965).

3.1.3 Nesting and Emergence Surveys

Nesting surveys (May to mid-July) and emergent surveys (April to May) were conducted by walking known nesting sites and areas that contained suitable nesting substrates. Nesting surveys looked for nesting turtles while emergent surveys looked for neonates that had left their natal nest and emergent holes (small holes in the soil with the approximate diameter of 5 cm; Figure 2). In northern environments oviposting usually occurs when the temperatures are the warmest, usually in the late afternoon and evening (COSEWIC 2006). Therefore, nesting surveys were conducted at these times to optimize detection while emergent surveys were often performed in the morning and late afternoon.

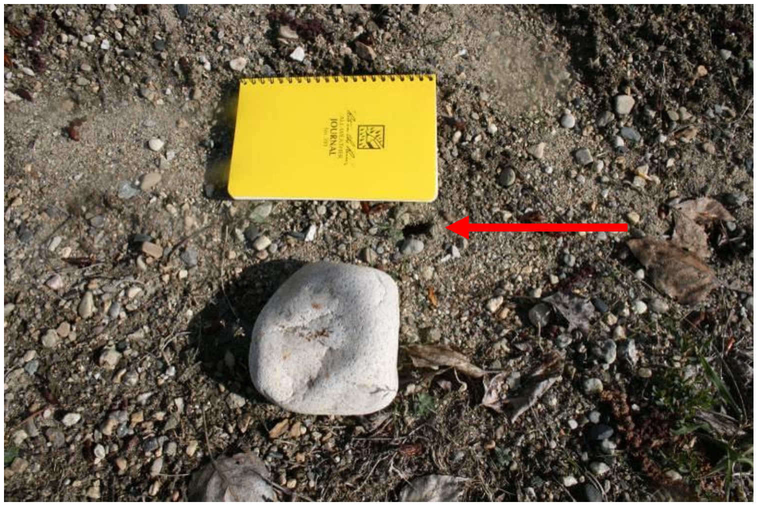

Figure 2 Turtle nest emergent hole as shown by the red arrow (Schiller 2010).

Known nests were monitored weekly throughout the active turtle breeding season (late May to early July; Schwarzkopf and Brooks 1987; COSEWIC 2006), and periodically throughout the summer and into the winter, to determine their status (intact, depredated or inundated).

3.2 Trapping and Capture

Live trapping of turtles was carried out as part of a mark-recapture study. This also permitted radio-transmitters to be attached to turtles, and the collection of morphometric data. Several methods were used to capture turtles, namely visual searching and hand-capturing, and the use of basking and hoop traps.

3.2.1 Visual Searching and Hand Capture

Active trapping was performed using a dip net while walking along the shoreline, by wading or canoeing and has the advantage of allowing other data to be simultaneously collected, including habitat use. However, this method is highly laborious and its success depends 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), sample size requirement, and size of the turtle population.

3.2.2 Passive Trapping

Basking traps are a type of floating trap consisting of a square frame constructed from PVC, ABS pipe or wood with varying dimensions, generally less than a square meter (Figure 3) (Gamble 2006; Tran and Moorhead 2006).

Initially, basking traps were moored into the study site without any mesh netting. This allowed a habituation period for the turtles to start using the traps for basking. When capture sessions were conducted, mesh netting was attached (usually in early morning) and the traps checked within a 12-hour period (Resource Inventory Standards 1998). Turtles bask on the central board of the trap and plunge into the mesh bag upon leaving the basking site. The centre of the trap is open, which allows movement and room for the turtle to surface and breathe. Baiting of basking traps with cat food or sardines has shown to increase capture rate. Basking traps are supposedly more effective early in the spring when the basking behaviour of the turtles is more pronounced (Resource Inventory Standards 1998).

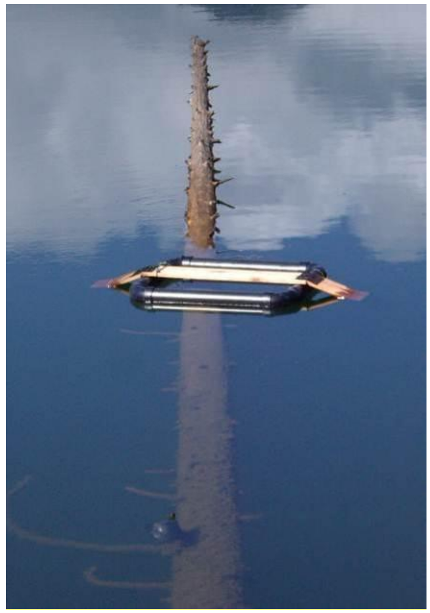

Figure 3 Floating basking trap (Schiller 2010).

Baited ‘hoop traps’ (cylindrical frames covered in a maximum of two inch mesh and baited in the center; (Figure 4) are commonly used in turtle research. The traps are partially submerged in the water and were baited with sardines to attract turtles, which enter the trap through the submerged funnel opening but are unable to exit. Baited traps are set and are checked every 12 hours (Ernst 1972; Lefevre and Brooks 1995; Gamble 2006).

Traps were placed in areas where turtles were seen basking, detected using telemetry, or in areas of ample emergent and submergent vegetation along the shoreline (Figure 5 and 6).

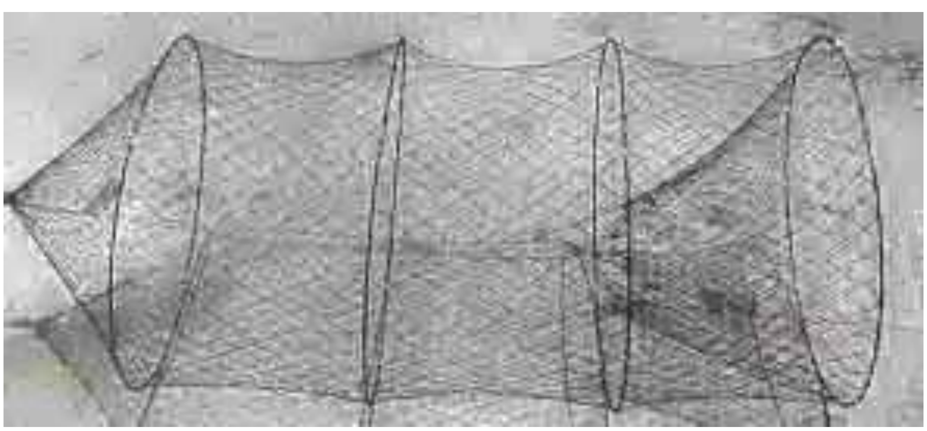

Figure 4 Baited Hoop Net Trap (Heinshon 2010).

Figure 5 Trap locations and type within Airport Marsh Revelstoke Reach, Upper Arrow Lakes Reservoir, Revelstoke, B.C. (LGL 2012).

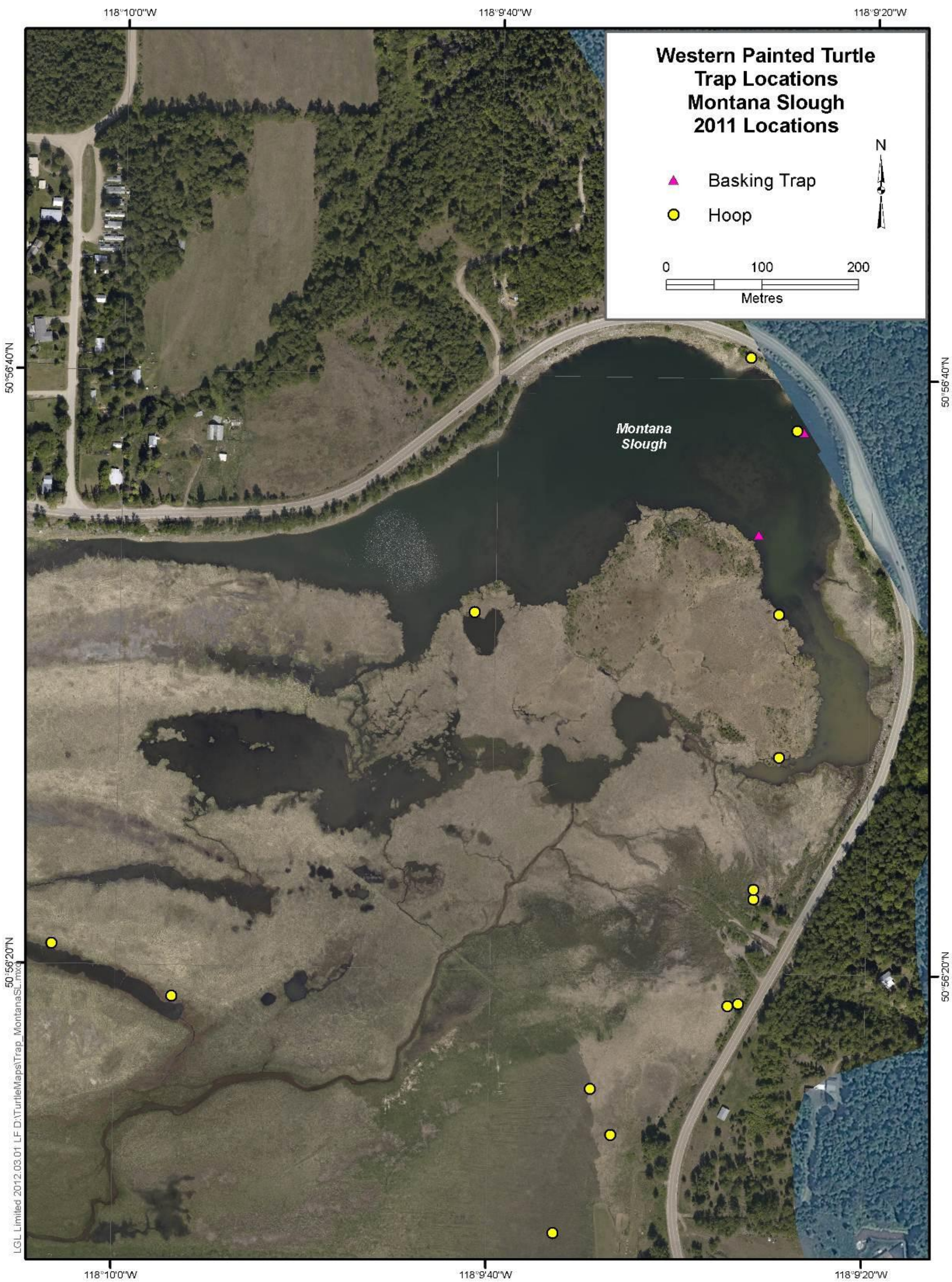

Figure 6 Trap locations and type within Montana Slough Revelstoke Reach, Upper Arrow Lakes Reservoir, Revelstoke, B.C. (LGL 2012).

3.3 Morphometric and Behavioural Data

Morphometric data were collected on each turtle captured. Animals were weighed by placing them in a pillowslip and using a hand-held Pesola® spring scale (to the nearest 0.1 g). The straight line length and width of the plastron (bottom of shell) and carapace (upper shell) were measured (Grayson and Dorcas 2004). The width of the carapace was measured from scute seven on either side of the turtle (P. Govindarajulu, pers. comm. 2010) Measurements were taken using appropriate sized calliper (to the nearest 0.1 mm) (Buhlmann and Vaughan 1991; St. Clair *et al*. 1994). The average sizes of the turtles were reported as mean plastron length rather than mass, to account for changes in the latter through the retention or loss of eggs, and or water. In addition, plastron length was reported as a size indicator (Gibbons 1967).

The activities of turtles were recorded as basking, walking, mating, nesting, stationary, swimming or unknown. Turtles (other than hatchlings and juveniles) were sexed by using secondary sexual characteristics and the relative positioning of the cloaca (Macartney and Gregory 1985; Matsuda *et al*. 2006).Turtles that could not be sexed were always relatively small, and were hence labelled as juveniles. If the animals were recaptured at a later date, attempts were made to determine sex at that time as well.

3.4 Mark-Recapture

Each captured turtle was permanently marked by notching the marginal scutes of the shell with a triangle file, allowing for the individual identification of turtles in the mark-recapture study (Cagle 1939). Neonates and juveniles were not marked, as their shells are soft and not fully ossified, so notching may cause deformities (Resource Inventory Committee 1998).

Usually, there are 12 marginal scutes on each side of the carapace, labelled from one to twelve, ignoring the central top scute (Figure 7). The carapace is divided into the right side and the left side when looking down at an upright turtle. Notching schemes for this project were 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 gives the notches located on the right side of the carapace. Again, a comma separates the individual scutes notched.

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 (Figure 7). The notching scheme 2,3-11 indicates that there are notches located on scutes 2 and 3 of the left side of the turtle as well as on scute 11 along the right side of the turtle's carapace.

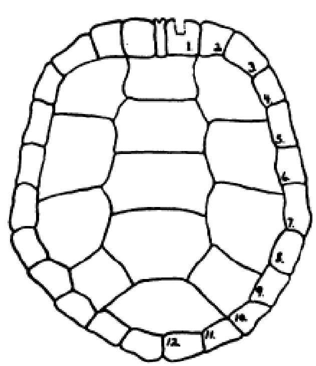

Figure 7 Turtle notching scheme. The marginal plates are numbered 1 to 12 on each side on the turtle (adapted from the Resource Inventory Standards 1998)

In addition to the notching marks given to each turtle, we also assigned a unique ID code, (i.e.,T1, T2...T82, T83). Each location after the initial capture was labelled with a location number such as, T1-01, T1-02, T1-03. If the turtle was released, the transmitter fell off, or mortality occurred, the last location was labelled as END (e.g., T1-END).

3.4.1 Photo ID

The colouration of WPT plastrons is unique among individuals and provides another potential method to verify the identity of recaptured animals. With each turtle capture, a standard plastron photo was taken and added to a digital database. In tandem with the shell-notching, this photo database may be used in the future to determine if individual turtles can continue to be identified by their plastron, or whether this pattern will changes over time. The use of pattern-recognition software may enable long-term cataloguing and identification of individual turtles. At present, however, the shell-notching system was used as a reliable and more quantitative way to mark individuals.

3.5 Telemetry

Turtles were located weekly in the spring and summer by means of triangulation or, whenever possible, by homing in to the precise location of the telemetered animals. We used a Lotek Biotrack wide-band radio receiver (138-174 MHz) (Lotek Wireless Fish and Wildlife Monitoring) and a three-element Yagi antenna to identify locations, habitat use, nesting locations and movements.

3.5.1 Transmitter Attachment

Stainless steel wire was used to secure transmitters (SI-2F or AI-2F Holohil Systems Ltd. Transmitter, Ontario Canada) to the posterior of the carapace. Small holes were drilled along the marginal scutes (usually scutes nine and eleven on the left side of the carapace to minimize interference with breeding) with a cordless power drill (Grayson and Dorcas 2004). Due to the variability in turtle weight, size, age and the unknown demographics of the population within the reservoir, three sizes of transmitters were used to accommodate a range of animal size. As per guidelines set forth by the Canadian Council on Animal Care (CCAC) (2003), the entire transmitter package did not exceed 5% of body weight. Epoxy putty was used to streamline the edges of the attachment to prevent snagging on vegetation (Edge *et al*. 2009; J. Litzgus, pers. comm. 2009).

3.6 Habitat Data Collection

A site assessment was conducted for each turtle identified through telemetry, systematic searches, or incidental observations. This assessment consisted of a circular vegetation (aquatic and or terrestrial) plot (5.64 m radius) to evaluate the percentage of emergent, submergent, floating-leaved vegetation, shrubs, forest, grass and herb, coarse woody debris (CWD) >5 cm, and CWD <5 cm. Other variables measured included: location using the Universal Transverse Mercator (UTM: marked with Garmin® GPSmap76CSX; accuracy less than three meters), time, date, water depth, water temperature (taken approximately 10 cm from the surface of the water) and air temperature at turtle location, elevation, precipitation, wind, cloud cover, (using a Kestral 3000 wind meter) distance to water/shore, activity of the turtle, and habitat type (Inundated, Dry Land, Marsh, Floating Island, Nesting, Open Water, Pond, Shoreline, Shoreline Due to Inundation; Table 1) (Resource Inventory Standards 1998; Marchand and Litvaitis 2004). In 2011 the average wind speed (mph), dew point, heat stress, wind chill and humidity were collected.

Table 1 Description of habitat types used to characterize turtle habitat within Revelstoke Reach, Upper Arrow Lakes Reservoir.

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 characterised 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.

3.7 Temperature Data Loggers

3.7.1 Nesting sites

Temperature data loggers were used to augment the information collected on the nesting of the turtles during 2011. Six iButton® temperature data loggers (Maxim Innovation Inc.) were buried in the ground at Red Devil Hill, three in a shaded area, and three in the non-shaded area where a number of turtles nested. The data loggers were set to record temperature (°C) every four hours. (Hughes 2009; P. Govindarajulu pers. comm. 2010). The majority of data loggers used in 2010 failed due to water damage therefore, each data logger in 2011 was placed in a plastic bottle to avoid damage and buried at a depth of 11 cm, the approximate depth of a turtle's nest. A small wooden stake was placed beside each iButton® and UTM coordinates taken at each nest to facilitate site location and collection of data loggers the following season.

4.0 Data Analyses

Statistical analyses were performed using R: A Language and Environment for Statistical Computing (R Development Core Team 2008) and Minitab 16 Statistical Software (2010). All significant levels were reported at significance level of $\alpha = 0.05$.

Survey effort was calculated as the numbers of sightings or captures (not including telemetry locations) per person hour by each site and month. Analysis included Turtle Pond (TP) only in the survey effort as during the 2011 season TP was not considered a primary site.

The data points were considered independent from one another if separated by a 24 hour period (Compton *et al*. 2002).

Due to the limited number of turtle captures and recaptures, we combined capture data over each active season (2010 and 2011) into two capture periods for the purpose of population estimation. We therefore used the Lincoln-Peterson model, following (Carriére, 2007; Pollock, 1991); i.e.:

estimate of N= $((n_1+1)(n_2+1)/(m+1))-1)$, where

n_1 = total number of animals captured in first season,

n_2 = total number of animals captured in second season, and

m = the number of animals re-captured in the second season that were originally marked in the first.

Note that counts of neonates were not factored into this calculation.

A longer-term data base should enable more elaborate methods of population estimation to be conducted, such as application of Jolly-Seber methods that estimates abundance, survival, and recruitment rates (Krebs 1999) or Bayesian estimators (Gazey and Staley 1986).

Data sets often did not conform to the assumption of normality (e.g. movement distances, plastron lengths) even after attempts at transformation; in these cases we used non-parametric statistics such as the Kruskal Wallis or Mann Whitney ‘U’ test. The Scheffe Method was used as a post-hoc test to determine where differences lied between means.

5.0 Results

5.1 Survey Effort

Our efforts at sighting turtles through systematic surveys, and while conducting telemetry increased in our second year of study (541 person hours in 2010, versus 954 person hours in 2011). This produced in 2011 a total of 252 turtle sightings (excluding telemetry locations) over six months, or 0.26 sightings/hour across all sites (AP, MS and TP), although this was considerably lower than in 2010 (2.46 sightings/hour). The bulk of turtle sightings occurred in August, which differed from the 2010 season when turtles were most often sighted in May. Turtles were sighted from April to September and only detected by telemetry thereafter. The number of turtle detections differed significantly among months in 2011 (X^2 = *58.9*; df = 5; P < 0.01 (Figure 8, 9 and 10), which is similar to 2010 where sightings differed among months ((X^2 = *43.5*; df = 5; P<0.01).

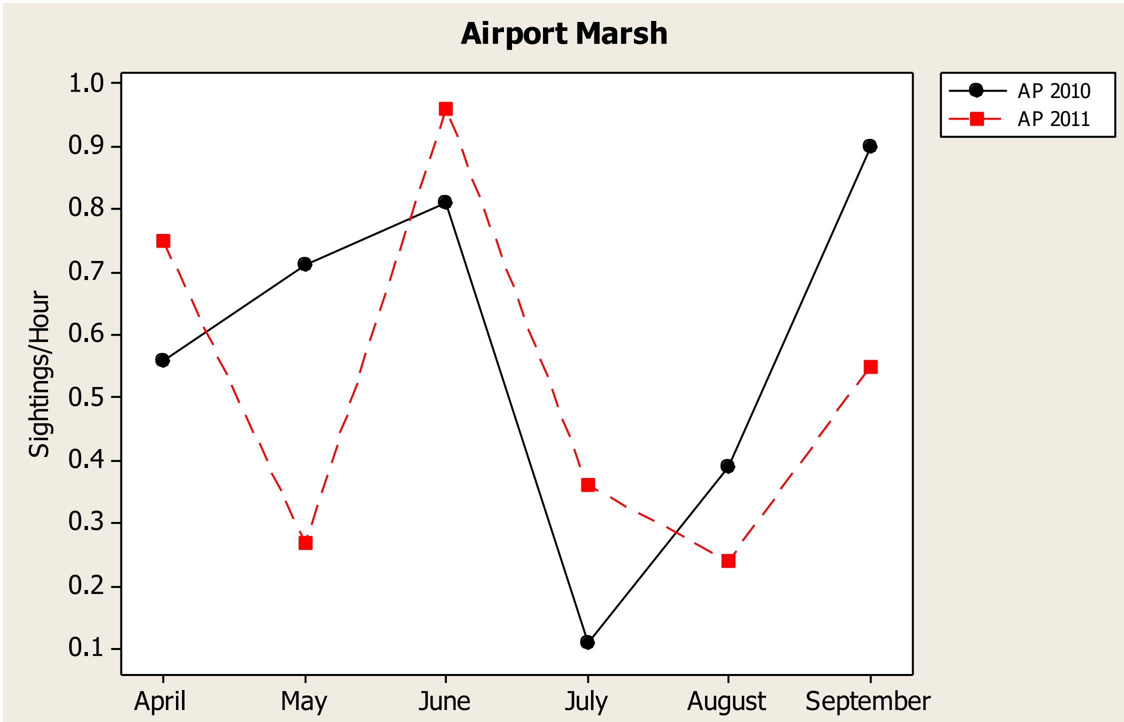

Figure 8 Survey effort (sightings/hour) for Airport Marsh based on year and month.

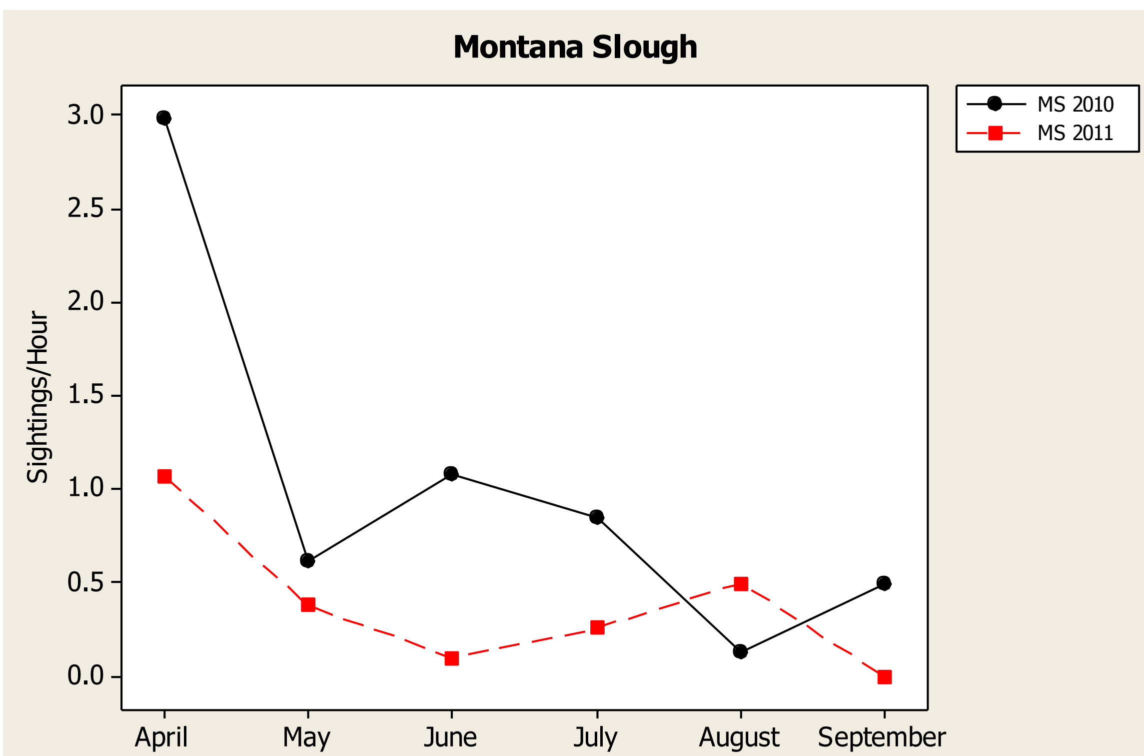

Figure 9 Survey effort (sightings/hour) for Montana Slough based on year and month.

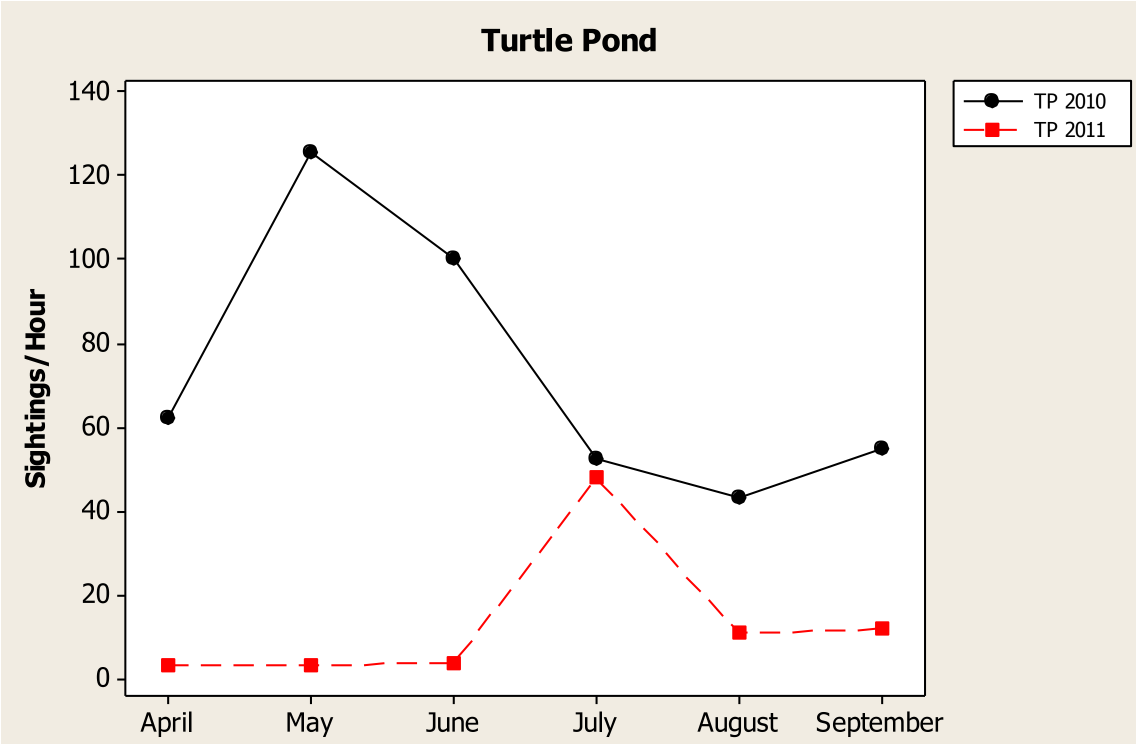

Figure 10 Survey effort (sightings/hour) for Turtle Pond based on year and month.

5.2 Population Assessment

A total of 203 individual turtles (all age classes and sizes) were captured alive during the pilot project (Table 2). This number includes a large proportion of neonates that were captured as they emerged from nests. Adult females were over-represented in our samples, both in 2010 and 2011 and neonates in 2010 (Figure 11).

Table 2 Summary of age class and sex for each turtle captured alive by site and year of the primary sites over the course of the pilot study.

By Sites	Neonates	Juvenile Unknown	Juvenile Female	Juvenile Male	Adult Female	Adult Male	Adult Unknown	Total
	2010							
AP	57	14	2	0	46	3	0	122
MS	0	1	1	0	5	0	0	7
TP	0	0	0	0	3	0	0	3
total	57	16	3	0	54	3	0	**133**
	2011							
AP	15	9	0	0	22	3	0	49
MS	0	4	1	0	8	7	0	20
TP	0	0	0	0	2	1	0	3
Total	15	13	1	0	32	11	0	**72**

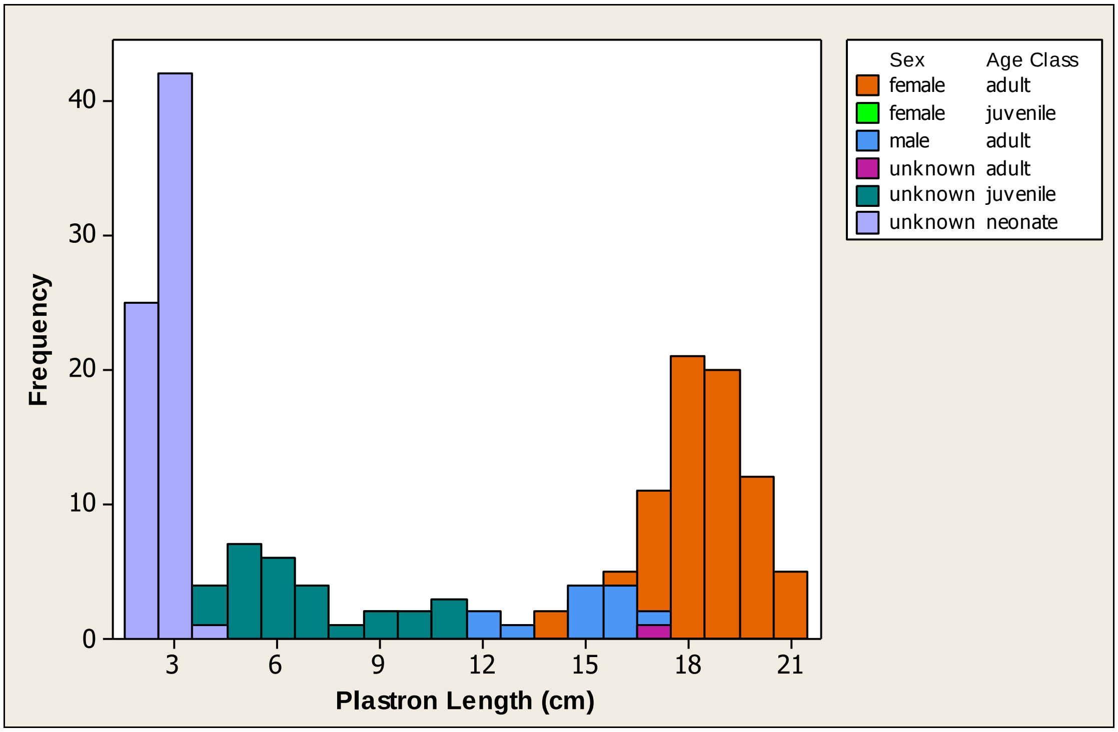

Figure 11 Stacked size frequency histogram of the straight-line plastron length (cm) of captured turtles residing in the Upper Arrow Lakes Reservoir, B.C. during the 2010 and 2011 field seasons. * 99 percent of all neonates were captured at the nesting sites and not within the reservoir.

Our data provided a population estimate of 242 turtles in our study area n_1= 73, n_2 = 55, m= 16, ±SE = 42.1, 95%CI = 160, 325).

5.21 Sex Ratio

A total of 81 female and 13 male turtles were captured in the reservoir, although less turtles were captured in 2011 then 2010, more males were captured in 2011. The ratio of adult captures was not significantly different between years, (χ^2 = *1.96*, df = 1, P = 0.16; Table 2), however evidence exists for the difference (χ^2, df = 1, P = 0.004) between gender captured across years that may be related to trapping methods or that male and female turtles utilize different habitat at different times of the year (Appendix 3; Map 1 and 2 and Appendix 4 and 5). Assuming our sample is representative of the population, a significant sex bias is present (χ^2 = 49.2, df = 1, P<0.001) with females outnumbering males 6:1.

5.3 Morphometrics

Using data pooled across years, average size for neonates, juveniles, adult males, and adult females was 2.5 cm (±SE = 0.04, n = 70), 6.9 cm (±SE = 0.44, n = 30), 13.2 cm (±SE = 0.7, n=14), and 17.1 cm (±SE = 0.3; n = 88, Figure 12). Female adult turtles were on average larger than males (t = 5.4, df = 16, P < 0.01). This is consistent with other turtle populations where females are larger than males.

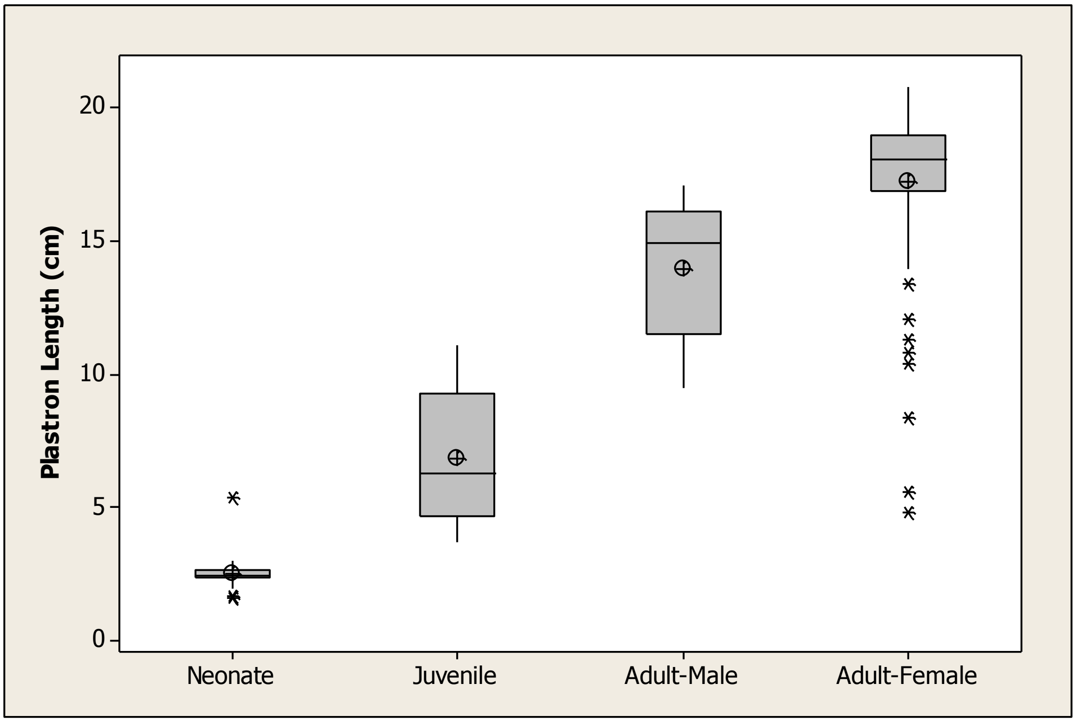

Figure 12 Mean plastron length (cm) of male and female adults, juveniles, and neonate turtles captured within the reservoir. ○ indicate outliers within the data.

5.4 Turtle Captures

In 2010, we used three main methods to capture turtles: basking traps, hand/dip net capturing, and capturing of nesting females on land. In 2011, we added the use of hoop traps as an additional method. Table 3 shows the actual number of turtles captured using these techniques, both within years, and pooled across years. Hoop traps were more successful than basking traps and, hand captures were the most successful next to capturing females after nesting for both years.

Although opportunistically capturing females at the nest sites was relatively productive, there are two important drawbacks of this method, namely (1) a bias in the sex ratio of sampled animals, and (2) the potential for nest abandonment. Capturing turtles directly (by hand, or dip net) has the advantage of allowing other data to be simultaneously collected, including habitat use. However, both of these methods are very labour intensive and their success depends on the number of field personnel and days in the field, size of the study sites, access to and within the sites, character of the habitat (vegetation, water depth, and reservoir levels), sample size requirement, and size of the turtle population. The success rate differed between the two pilot years of study, and may be a result of surveyor bias, although fluctuating water levels within the reservoir also had an effect. Nonetheless, in comparison to other methods, the active capture approach appeared to be the most effective

Compared to active capture methods, the use of basking traps was quite unsuccessful, despite the fact that these traps have been used successfully elsewhere on painted turtles (Gamble 2006; P. Ballin, pers. comm., 2011). For this reason, the use of hoop traps was tested in the 2011 field season. Although the catch per unit effort (CPUE) for basking traps was higher overall than for hoop traps (Table 3), the latter proved more favorable and effective in capturing a broader range of age and sex classes. Using hoop traps, we captured all age and sex classes in all seasons, whereas basking traps were successful in capturing juvenile turtles in the early spring season only.

Part of the efficacy of hoop traps relates to the relative ease with which they can be deployed. During the pilot study, hoop traps were set throughout the day and the night, and checked every 12 hours. Basking traps were set only during daylight hours on warm sunny days, and the mesh netting used to set the traps were pulled at the end of each day. This increases the effort to maintain and monitor basking traps, resulting in less trapping time in comparison to hoop traps. Trap maintenance and setup was not accounted for in the CPUE in Table 3.

Table 3 Caught per unit of effort (CPUE) for each capture method used during the pilot season

Capture Method	Turtles/Hour	Projected Turtles Captured/100 hours	Actual Turtles Captured Over study
Active Methods			
Nest Site Patrolling 2011	0.7	68	23
Nest Site Patrolling 2010	2.6	257	32
Nest Site Patrolling 2010 & 2011	1.2	118	55
Hand/Dip Net/Boat/Public 2011	0.7	67	25
Hand/Dip Net/Boat/Public 2010	0.08	8	44
Hand/Dip Net/Boat/Public 2010 & 2011	0.005	0.5	69
Passive Methods			
Hoop Traps 2011	0.008	0.008	21
Basking Traps 2010	0.05	5	2
Basking Traps 2011	0.02	2	2
Basking Traps 2010 & 2011	0.03	3	4

Hoop traps were introduced in 2011 in an effort to determine if the highly skewed female sex bias in our 2010 sample (see section 5.2.1 above) could be attributed to trapping methods (Ream and Ream 1966; Gamble 2006). It appears that hoop traps do not have a sex capture bias ($\chi^2 = 0.53$, df = 17; P = 0.46), however hand captures are biased towards females ($\chi^2 = 23.17$, df = 1; P <0.001). In addition, the sex ratio in our 2011 hand capture sample was significantly different from that of the first year ($\chi^2 =$ 4.9, df = 1; P = 0.03), which may be attributed to a lower capture rate in 2011 than in 2010.

5.5 Mortality & Observations Of Natural Predators

Excluding neonate deaths near or in the nests, we detected a total of 12 mortalities of turtles over the two years of this study (three in 2010, nine in 2011). This sample included four juveniles found dead atop vegetation (May 02 to May 05), with no obvious sign of cause of death. How these animals died is unclear, although the lack of predation signs suggests they may have emerged from hibernation and died shortly thereafter. Also among the mortalities detected three adult turtles were killed on the road, paralleling the reservoir, during the nesting season. Only one of these animals was determined to be a gravid female at the time of death (a telemetered individual). Another adult turtle (telemetered male) was found dead in the water, with some aquatic vegetation entangled on his transmitter's antenna. Whether this entanglement had been sufficient to cause the death of the animal was not readily apparent. Finally, two turtles (one adult and one juvenile) were found dead, simply floating in MS in late summer (August 28th). As per the animals found dead on land, there was no outward sign of the cause of these mortalities.

Over the course of the study, the remains of 22 neonates were detected at the nesting sites (3 in 2010, 19 in 2011). We attributed most of these deaths to birds, because corvids were seen eating objects at the nest sites and the remains of the neonates had pierce marks through their shells. It is quite possible that additional neonates and/or nests were predated on but went undetected, as birds (e.g. corvids) for example, could remove the animals before consuming them.

Within the Revelstoke area, potential mammalian predators for adult and juvenile turtles are coyotes, black bears and some of the mustelids, particularly the river otter which also prey on overwintering turtles (Brooks *et al*. 1991; COSEWIC 2006). Beside Winter Pond, where a number of turtles hibernate, is an otter kill-site. These otters are sited during all seasons. On November 23rd five otters were observed on the ice at Winter Pond (Appendix 1: Photo 7). During the summer of 2011, a resident at a pond outside of the reservoir, observed an otter pick up an adult painted turtle, throw the turtle into the pond and then proceeded after it. Another resident a few years back, discovered an adult turtle along the roadside with claw marks though the shell, evidence that the turtle had an encounter with a bear.

No incidents of mortality to turtles could be attributed to the reservoir operation, but again, our sample of telemetered turtles (those animals most likely to allow detection of mortality) is relatively small and of short duration.

5.6 Nesting

Six nesting sites were identified: Red Devil Hill, Airport-Firebase (between the aviation club property and the wildfire firebase), Turtle Pond, Nichol Road, Williamson Lake and Montana Slough (Figure 13). Of these sites Turtle Pond and Williamson Lakes lie adjacent to other water bodies outside of the reservoir. All identified sites were situated above the influence of fluctuating reservoir water levels and all are anthropogenic in origin or have been highly modified. Two of the nesting sites, Airport/Firebase site and Red Devil Hill, appear to be significant for the population of turtles inhabiting the reservoir. Although these sites are not directly influenced by reservoir operations, each site faces threats due to road infrastructure, construction, and land use. Multiple nest sites for the turtles found in Montana Slough have yet to be documented as only one was discovered in 2010 along the shoulder of the road. For each year 2010 and 2011, over 30 nests were detected at Red Devil Hill and the Airport/Firebase sites, with more nests located at Red Devil Hill than Airport Firebase.

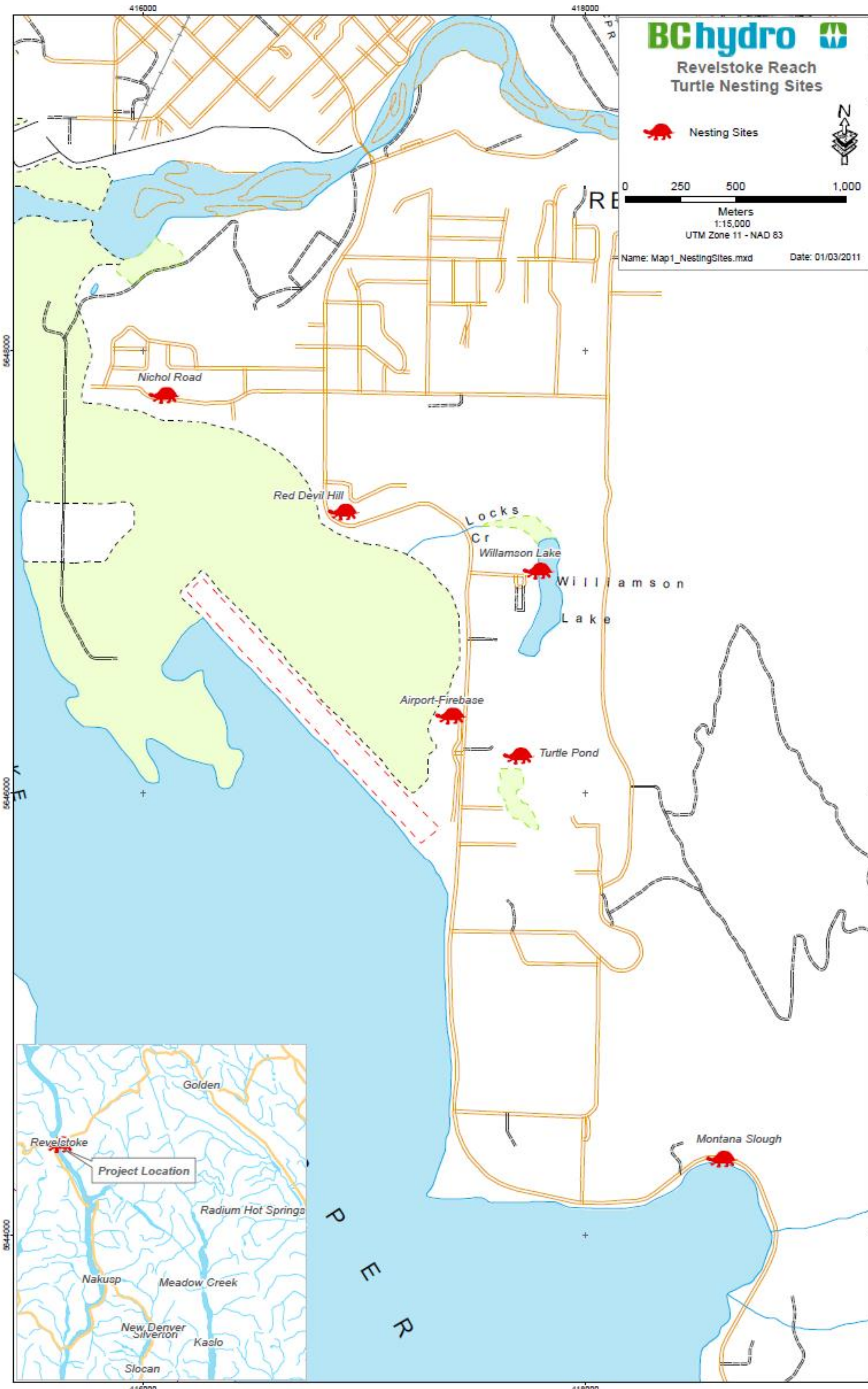

Figure 13 Nesting sites identified within Revelstoke Reach, Upper Arrow Lakes, Revelstoke B.C., Canada (Galdamez 2011).

Turtles not within the vicinty of the two major nesting sites nest elsewhere. These areas may be less optimal and may decrease the survival of both the adult and neonate turtles. Two study animals were dicovered nesting along roadways. One turtle was discovered nesting alongside a residental road (Nichol Road), where, if the nest survives, the neonates not only have a road to cross, but also a 70 degree slope of vegeation and shrubs to traverse to access the reservoir. A second turtle was discovered nesting along the shoulder of Airport Way at Montana Slough who was killed the following year, likely while looking for a nesting site as she was still gravid and found in the same area as her nest site the previous year.

5.6.1 Nesting Data Loggers

Data loggers placed at Red Devil Hill showed that the mean temperature of the non-shaded nesting area was 20.74 ºC (±SE = 0.8, n = 3512), significantly higher than the average of 16.6 ºC recorded in the adjacent shaded areas (U = 7539557, 95%CI: -4.1, -3.7, P<0.001) at 16.60 ºC (±SE = 0.06, n = 3146).

5.7 Telemetry

Forty one turtles (29 female, 10 males, 1 female juvenile, and 1 unknown juvenile) were outfitted with VHF radio transmitters throughout the course of the pilot study within AP and MS. On average, each turtle was located 11 times during 2010 and 15 times during 2011.

Telemetry revealed that turtles moved between our two principal study sites in the reservoir (AP and MS), and between ponds upland of the reservoir. Telemetry also showed that at least one turtle from MS moved as far south as 12-Mile, and along the west side of the reservoir. In the opposite direction, public sightings suggest that turtles can on occasion be found as far north as the town of Revelstoke.

5.7.1 Movement

In general, turtle movements patterns in 2011 were similar to 2010. These movements are summarized as follows:

- During April, turtle sightings and locations of radio tagged turtles were found in proximity to overwintering locations. Turtles were often spotted basking along the shoreline of Winter Pond with as many as fourteen turtles sighted at one time. The high number of turtles detected at this pond in April suggests this may be an important overwintering location (Appendix 4: Map 5; Appendix 5: Map 11).

- Through May and June, turtles, both from AP and MS began to disperse from one another and their initial locations. Females tended to move along the shoreline towards the nesting sites at Red Devil Hill, Airport/Firebase and along the road at MS. Peak detections of female turtles at known nesting location occurred in June (Appendix 4: Map 6 and 7; Appendix: Map 12 and 13).

- From June to the beginning of July, the majority of females remained close to shore in AP and MS, while males tended to move away from the mainland shorelines into pond type habitat and open water areas (Appendix 4: Map 7 and 8; Appendix 5: Map13 and 14).

- Movements between July and August appeared to be localized within AP (Appendix 4: Map 8 and 9). In Montana Slough, where there is greater exposure to the main channel of the river, turtles moved eastward closer to the shoreline and remained in emergent vegetation as water levels rose. (Appendix 5: Map 14 and 15). However, movements to different habitats were variable as there were a four turtles from both sites that moved either north or south into areas that had become inundated as the water levels rose.

- During September, turtles that had moved large distances and were located outside of the primary sites returned to the original capture areas in AP or MS. In addition, turtles that were captured in early spring and retained their transmitters returned to their original capture locations in the fall, primarily Winter Pond, suggesting that turtles are moving towards over-wintering sites (Appendix 4: Map 10).

Overall, the majority of movements detected through telemetry were localized within each of our two principal sites and averaged 59 m/day (±SE = 4.1, n=620). No differences in turtle movements/day (m) were detected between years (U = 47113, 95% CI: 4.9, -3.10, P = 0.68) or when separated by site for combined years (U = 84229.4, 95% CI: 0.92, 6.81, P=0.15). However when the sites (MS, AP) were separated by year a significant difference was detected in both years (2010: U = 6887.0, 95% CI: 0.90, 20.32, P = 0.03; 2011: U = 43261.5, 95% CI: 2.53, 14.56, P = 0.001). During 2010, turtles occupying MS moved larger distances on average ($\bar{x}$= 101.2, SE=21.9; n=65, Figure 14) than AP ($\bar{x}$=59.7, SE=23.2, n=94). In contrast, movements in 2011 where larger in AP (n=193, $\bar{x}$=70.46, ±SE = 7.3) than in MS ($\bar{x}$ = 48.98, ±SE = 5.93; n = 215, Figure 15).

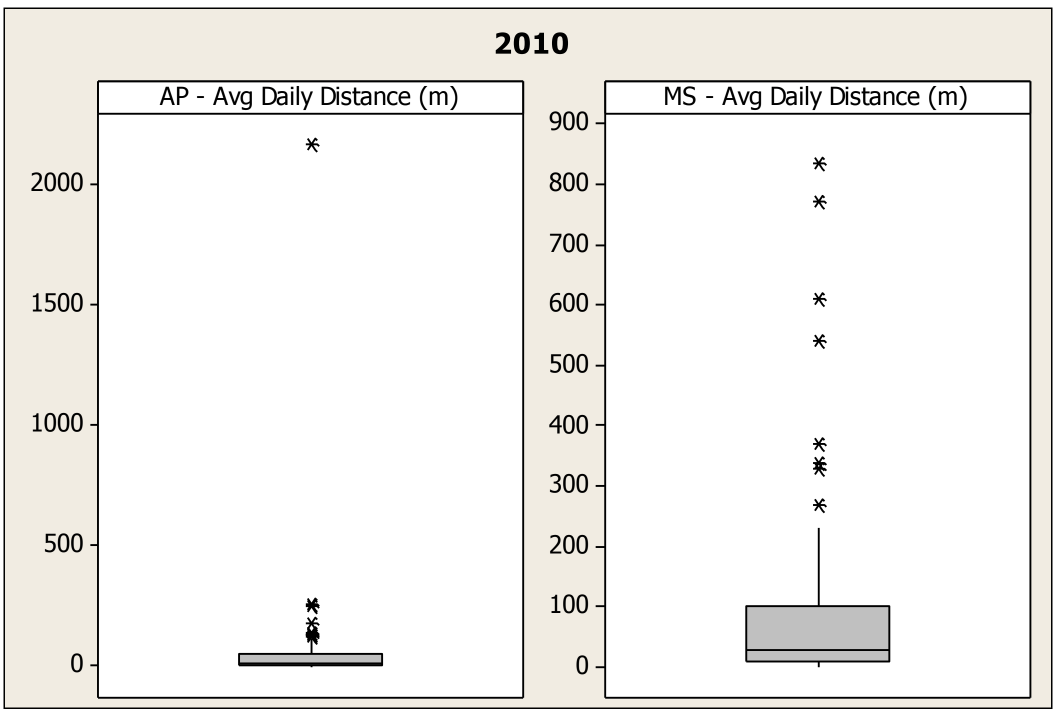

Figure 14 Average (Avg) daily distance (m) moved by turtles at each site (MS: Montana Slough, AP: Airport Marsh) during the 2010 field season. Upper Arrow Lakes Reservoir, Revelstoke B.C. * Indicate outliers.

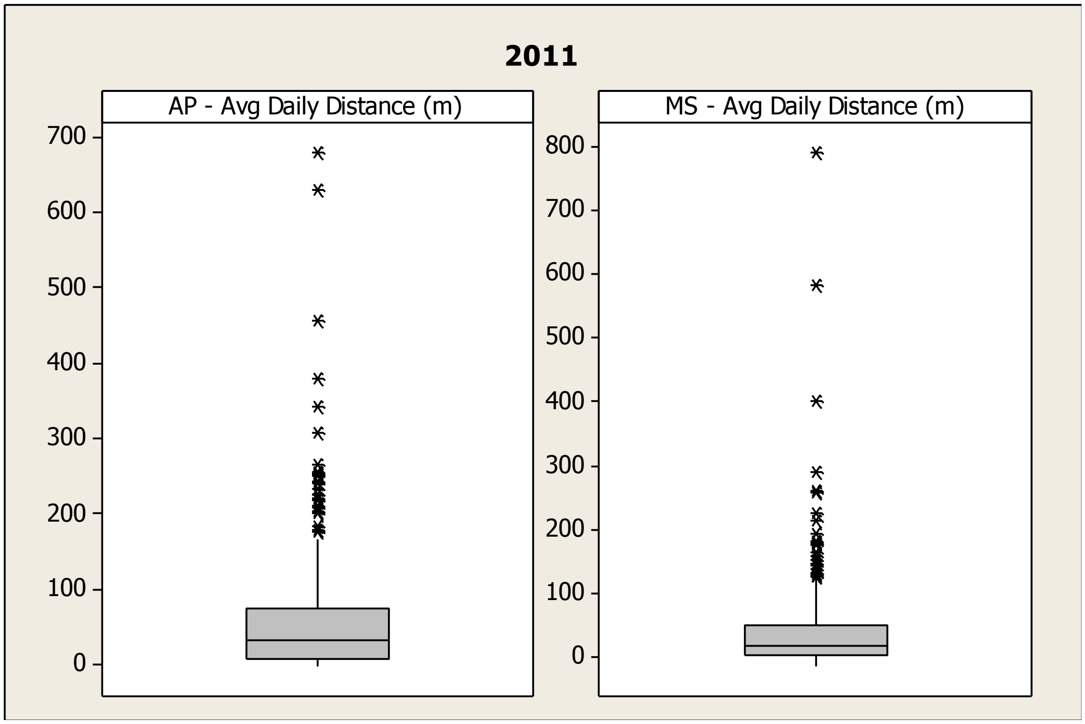

Figure 15 Average (Avg) daily distance (m) moved by turtles at each site (MS: Montana Slough, AP: Airport Marsh) during the 2011 field season. Upper Arrow Lakes Reservoir, Revelstoke B.C. * Indicate outliers.

Only two juvenile turtles were outfitted with transmitters during the course of this study (both in 2011). The average movements made by these animals ($\bar{x}$ = 21.62, ±SE = 6.1, n = 21) were significantly less than that made by adults during the same time period ($\bar{x}$ = 64.59, ±SE = 7.2; n = 287: U = 40317, CI: 0.09, 24.42 P = 0.046: Appendix 3; Map 3 and 4) Conversely, movements demonstrated by adult males and females were not significantly different from one another (U = 125230.5, CI: 0.68, 11.54, P = 0.10). However, some individual turtles, both male and female, made large distance movements outside of the primary sites (Appendix 3, 4 and 5)

Differences in movement/day were significant by month within each year (2010: H = 14.84, df = 5, P = 0.01: Figure 16; 2011: H = 34.59, df=5, P = 0.006: Figure 17). In addition, the average water levels (elevation (m)) per month differed significantly by year (2010: H = 151.9, df = 5, P<0.001: Figure 18; 2011: H = 362.4, df = 5, P<0.001: Figure 19). The Scheffe post hoc test failed to reveal where the differences lie in daily movements by month during 2010. However, the test did detect where the differences lie in the daily movements by month for 2011 and the elevations levels for both years. This discrepancy may be due to a limited amount of data to detect differences in the non-normally distributed data. Differences in water levels and movements are summarized in Table 4. For both years, the greatest variation in water levels was seen in June while the peak water levels were in July. However, 2010 had a gradual increase in water levels in comparison to 2011 and a faster decrease in levels during September and October.

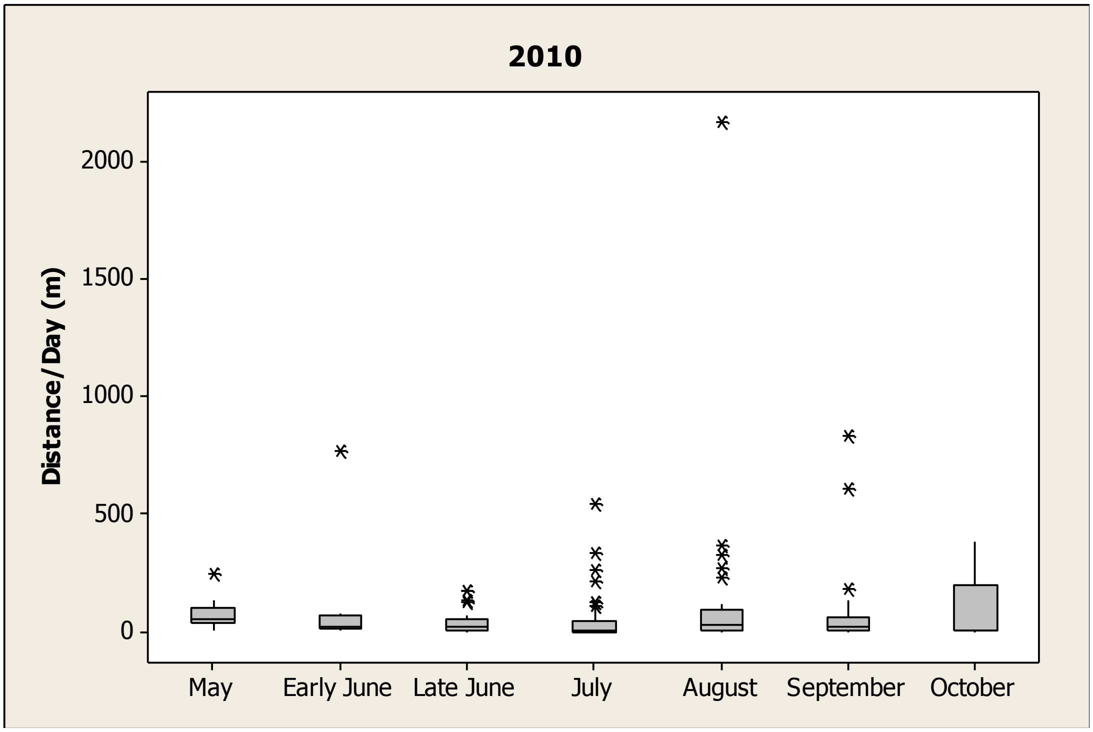

Figure 16 Average turtle distance/day during 2010 of telemetered turtles (all age and sex classes) within Revelstoke Reach, Upper Arrow Lakes Reservoir, B.C. * indicate outliers.

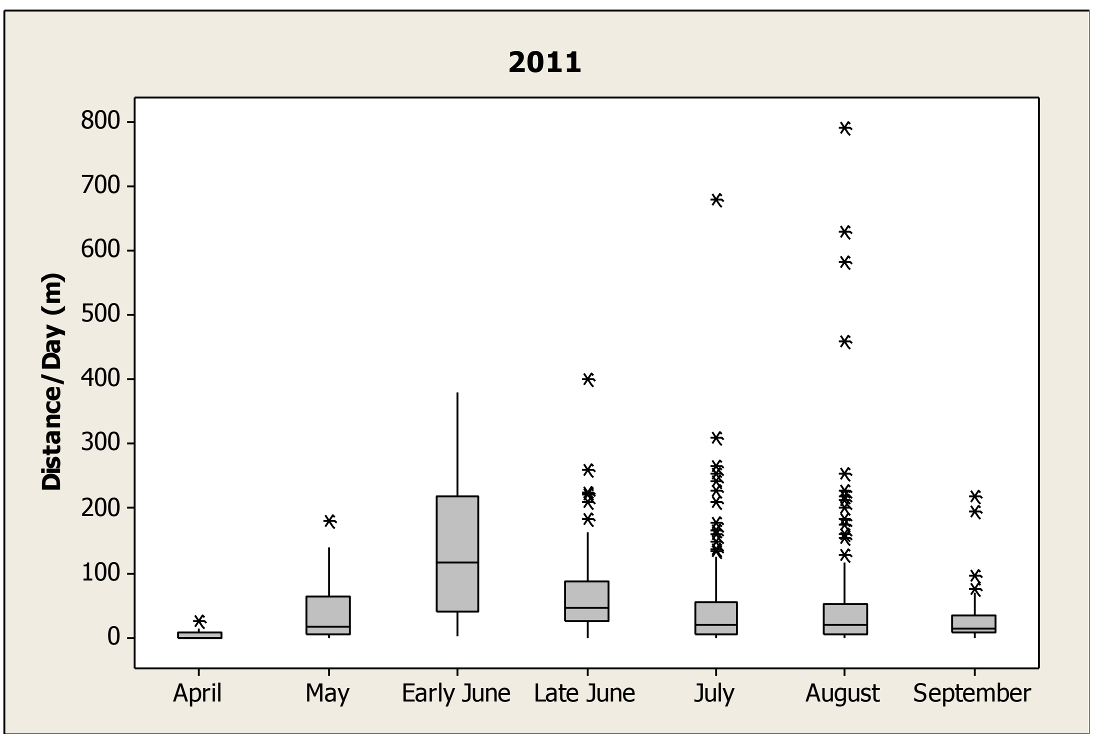

Figure 17 Average turtle distance/day during 2011 of telemetered turtles (all age and sex classes) within Revelstoke Reach, Upper Arrow Lakes Reservoir, B.C. * indicate outliers.

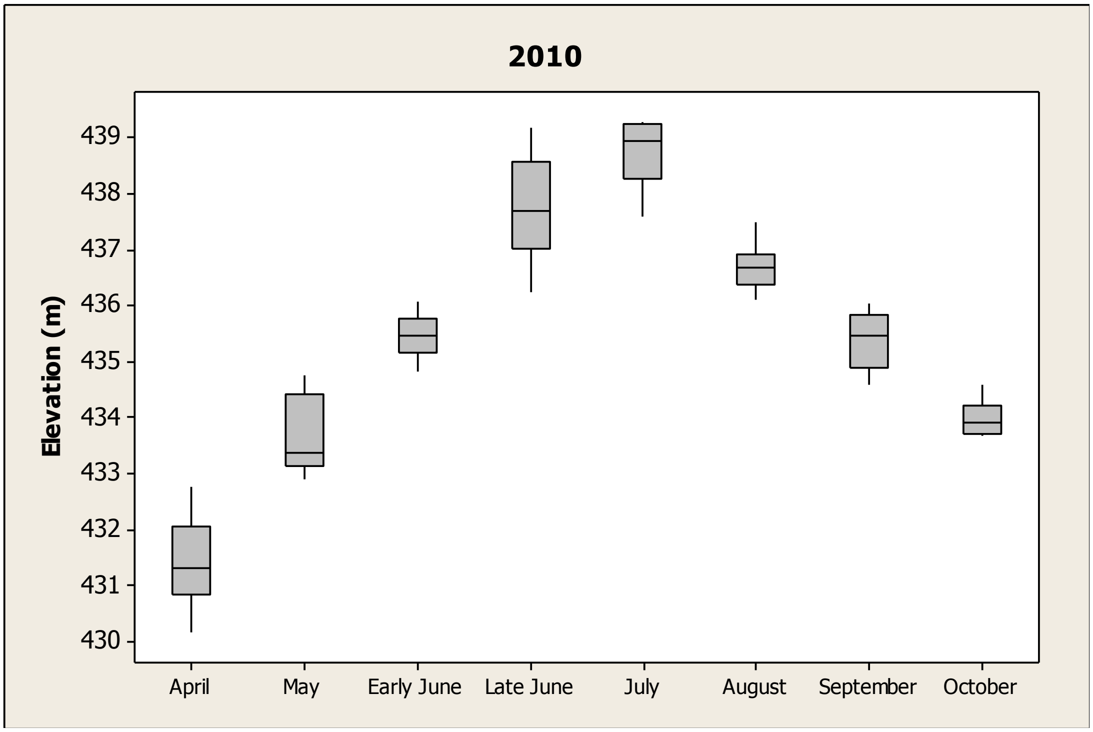

Figure 18 Water levels (elevation (m)) experienced by the Upper Arrow Lakes Reservoir in 2010. Hydromet data provided by the "NAK" Hydromet station at Nakusp B.C. Hydro (2012).

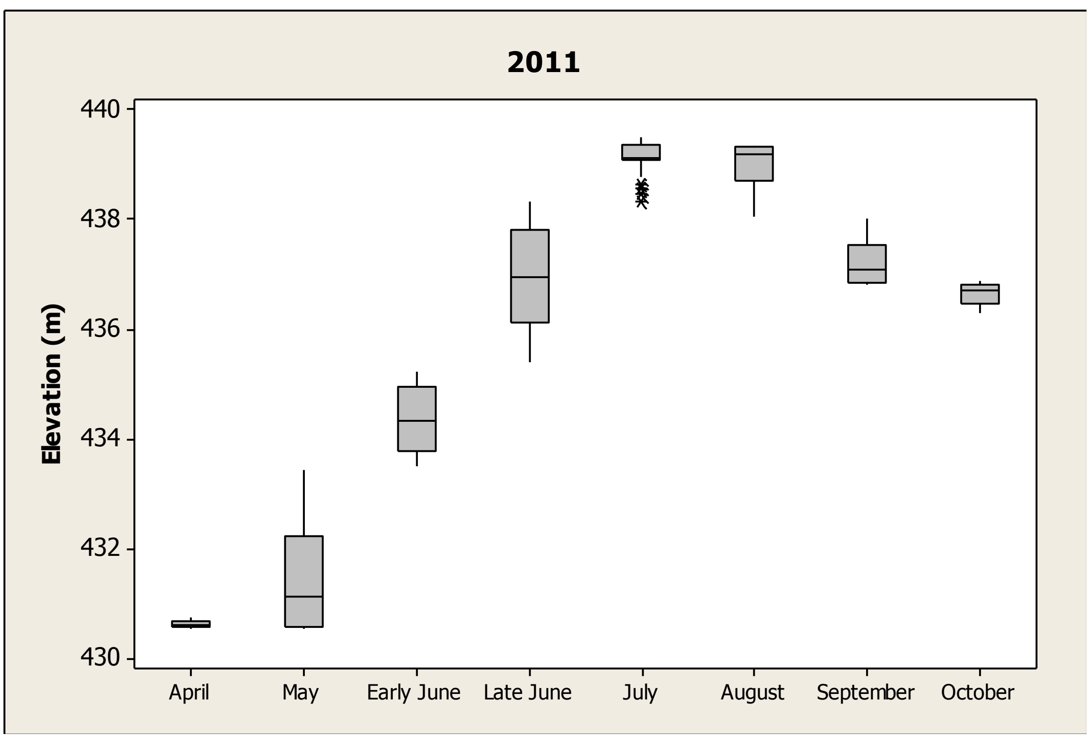

Figure 19 Water levels (elevation (m)) experienced by the Upper Arrow Lakes Reservoir, in 2011. Hydromet data provided by the "NAK" Hydromet station at Nakusp BC Hydro (2012).

Table 4 Descriptive statistics for the average distances moved (elevation in meters) per month by radio tagged turtles in Revelstoke Reach during the pilot study.

2010					2011			
	Average Daily Movements (m)		Average Elevation (m)		Average Daily Movements (m)		Average Elevation (m)	
Month	**N**	**Mean ±SE**	**N**	**Mean ±SE**	**N**	**Mean ±SE**	**N**	**Mean ±SE**
April	Na	na	30	431.4 ±0.1	9	4.8 ±2.9	30	430.6 ± 0.01
May	13	74.6 ±17.1	22	433.8 ±0.1	9	38.4 ±6.0	31	431.5 ±0.2
Early June	13	90.1 ±57.2	11	435.5 ±0.1	29	136.0 ±19.4	11	434.3 ±0.2
Late June	24	46.0 ±11.0	19	437.8 ±0.2	65	68.8 ±9.0	19	436.9 ±0.2
July	55	47.8 ±12.9	31	438.7 ±0.1	94	57.5 ±10.3	31	439.1 ±0.1
August	28	148.7 ±77.1	28	436.7 ±0.1	138	55.2 ±9.5	31	439.0 ±0.1
September	27	88.5 ±36.6	30	435.3 ±0.1	32	33.3 ±9.0	30	437.2 ±0.1

Cursory analysis of water levels and average daily movements shows a statistical correlation (Spearman's rho = -0.12, P = 0.003, n = 573) suggesting that the variation in movements increase, and that larger movements are made when water levels rise (Figure 20). Including the analysis of movements by time (month) as discussed above, there may be an increase in turtle movements when water levels first rise. A more detailed analysis of movements is planned as part of the Schiller thesis.

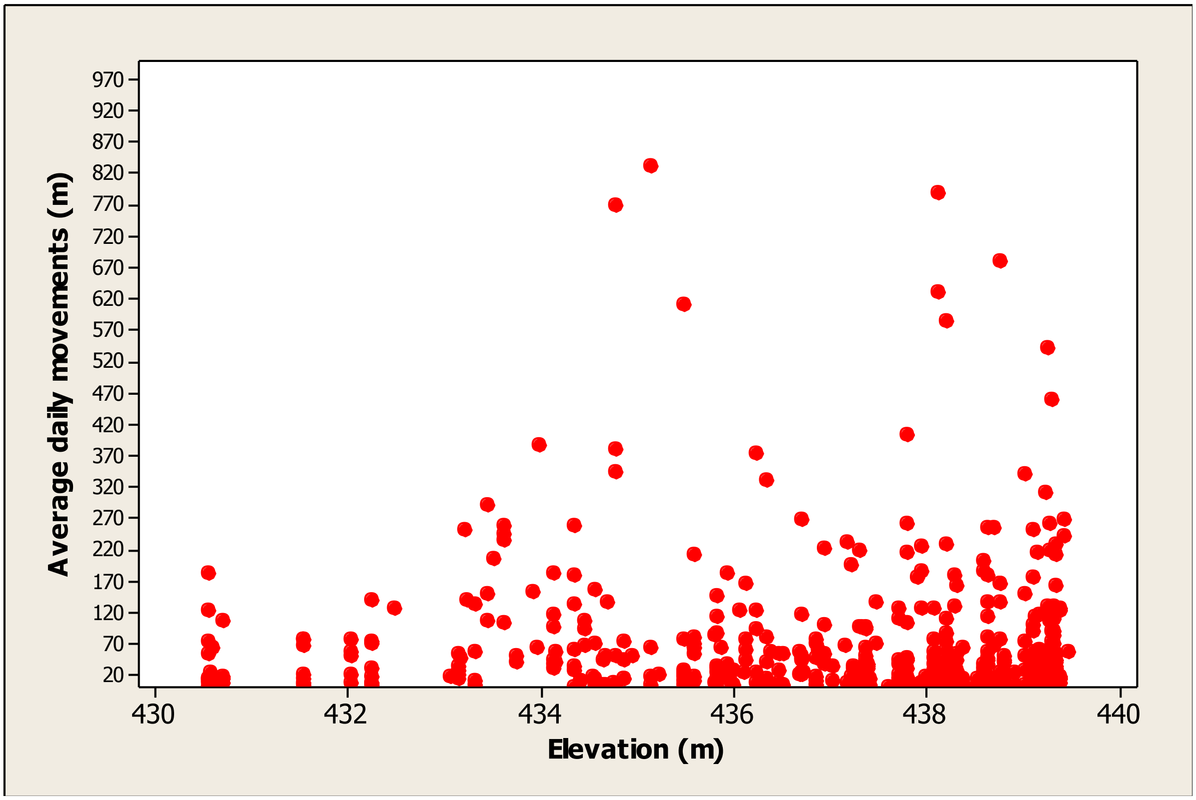

Figure 20 Average daily movements of telemetered turtles in relation to water levels (elevation in meters) in Revelstoke Reach, Upper Arrow Lakes Reservoir, B.C. over the course of the pilot study.

5.8 Spring, Summer, and Fall Habitat

Turtles in the two main study sites appeared to use different habitats to varying degrees, perhaps brought on by inherent differences in the two locations. Compared to AP, MS lies in closer proximity to the main Columbia river channel, and thus has less marshy areas characterized by ponds, bulrushes and cattails in comparison to Airport Marsh. This may explain why MS turtles were most often detected along the shoreline of the mainland or the floating vegetative island, characteristic of MS, followed by pond-type habitats (Figure 21), whereas AP turtles were detected most often in marsh areas, cattail or bulrush islands, or in open water areas close to bulrushes and marshy areas (Figure 22). However, these data should not be taken to indicate habitat *selection* per se; determining selection for these or other habitat features is complicated for this system, given that most detections of turtles were underwater or basking. Clearly, however, the data do suggest that turtles in MS can be found on the shoreline more often, but the reasons for doing so remain to be determined (i.e. shortage of basking sites versus less suitable aquatic habitat).

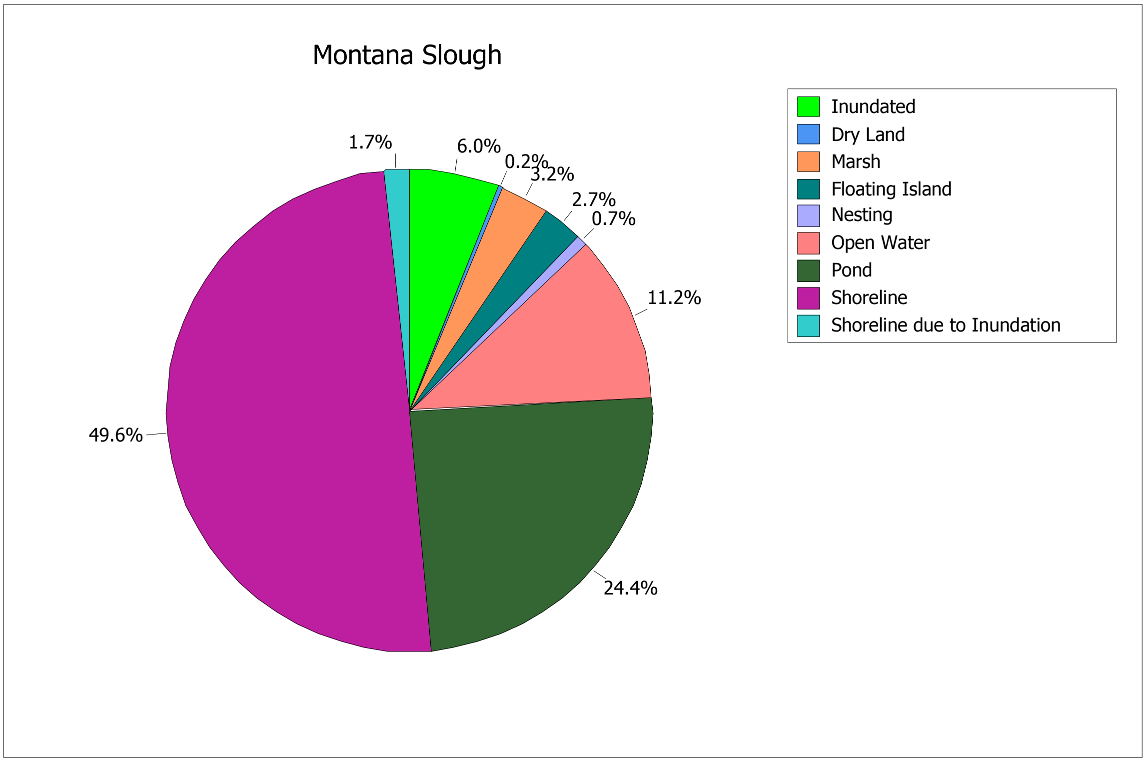

Figure 21 General habitat type of turtles detected during 2010 and 2011 in Montana Slough.

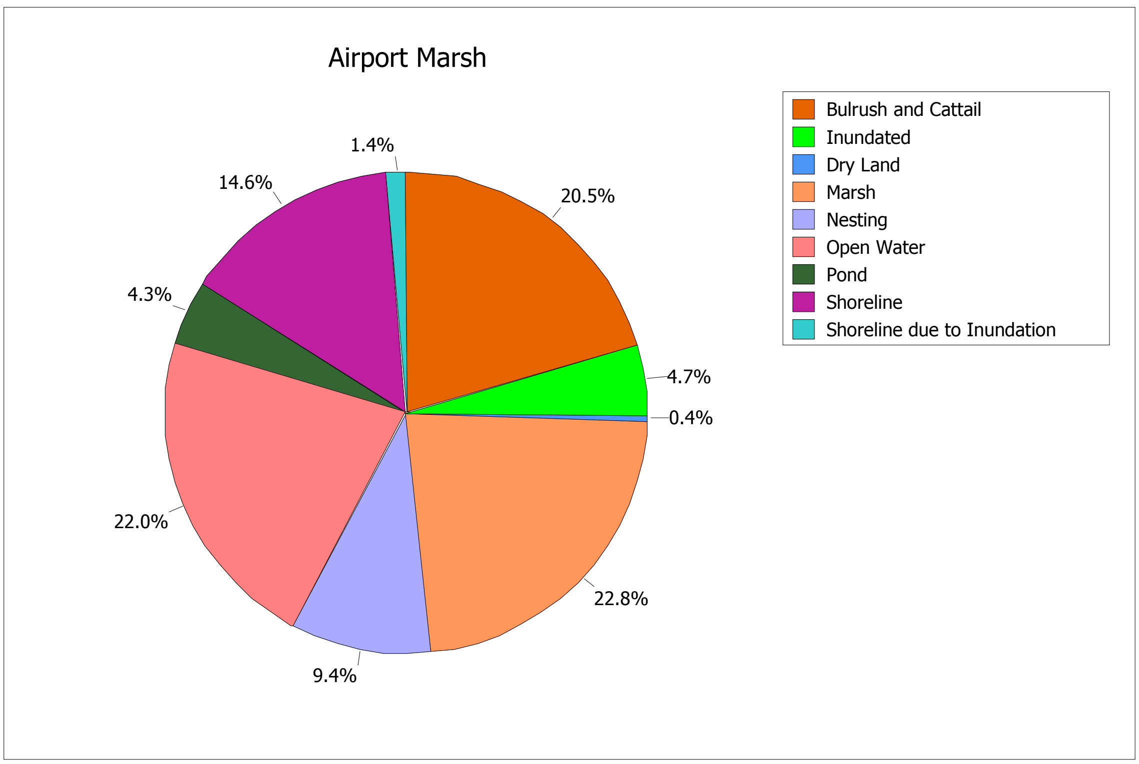

Figure 22 General habitat type of turtles detected during 2010 and 2011 in Airport Marsh.

5.9 Overwinter Locations

A subsample of turtles from both AP and MS were selected to retain their radio transmitters throughout the winter months. A total of four turtles were followed during the winter of 2010, and 16 were tracked in the winter of 2011.

Three overwintering locations were identified in MS over the two winters. One location was along the shoreline of a floating vegetative island, and the other was in a pond (Winter Pond). On November 23rd, 2011, all nine turtles from MS carrying VHF transmitters were located at Winter Pond (Figure 23). On February 20th, 2012 all turtles except for one were located in Winter Pond. It appears that this one animal moved west into another pond type habitat with moving water. We were unable to obtain a signal for two turtles. It is therefore suggested that this area affords an important overwintering habitat, although future work looking at the physical attributes of this site (.e.g. oxygen levels, water temperature, etc.) would be needed to verify the uniqueness of the site.

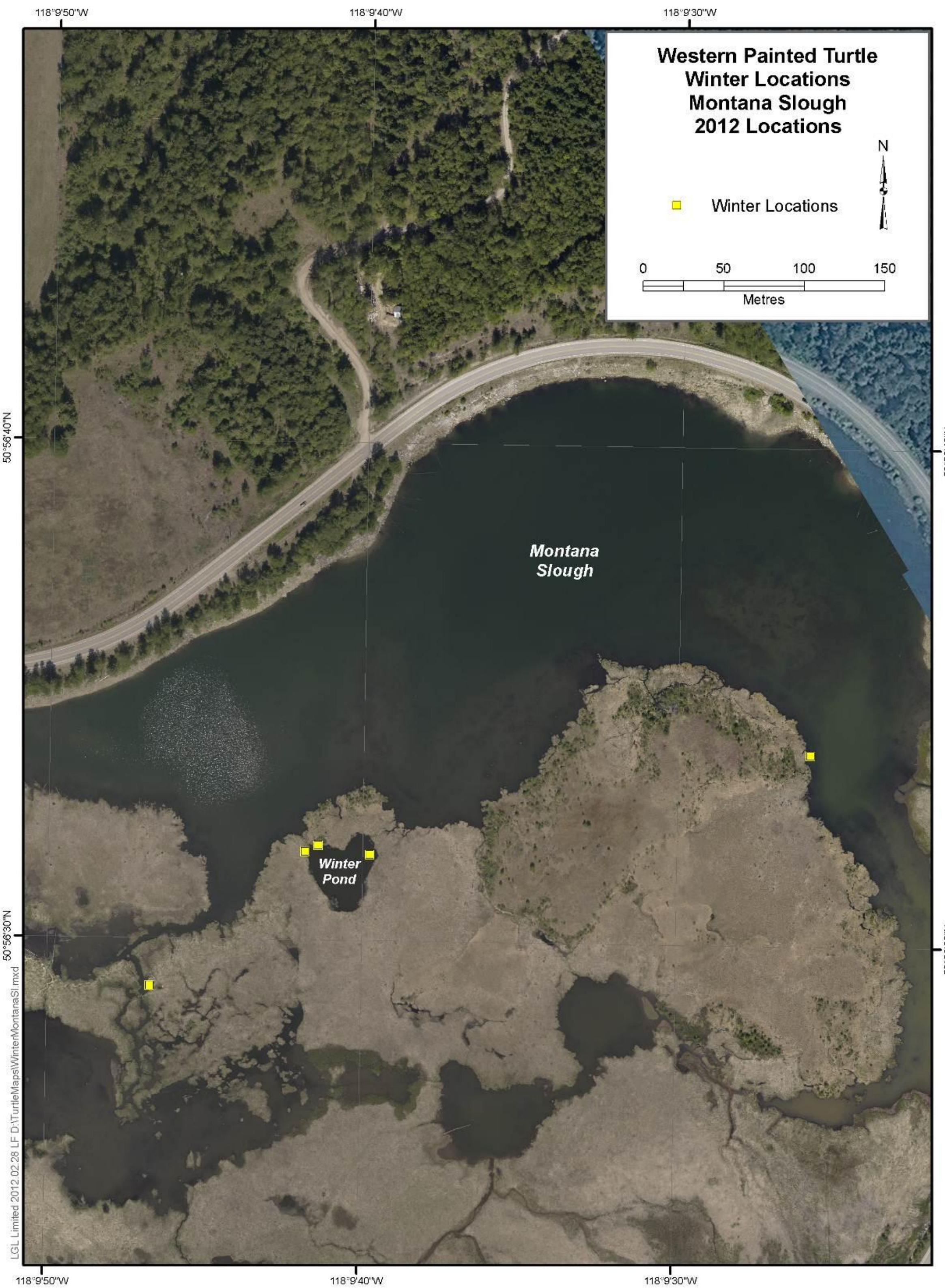

Figure 23 Overwintering locations identified in Montana Slough during the winter of 2010 and 2011. Communal hibernation site is located in Winter Pond, Upper Arrow Lakes Reservoir, Revelstoke B.C. (LGL 2012).

During 2010, one telemetered animal captured in AP overwintered in Williamson Lake (approx. 450 m distant) and moved back into AP in the following spring (this animal did not retain her transmitter for the following winter). On February 21st, 2012 seven turtles were located throughout AP (Figure 24). It appears that AP also affords overwintering habitat for painted turtles in the study area.

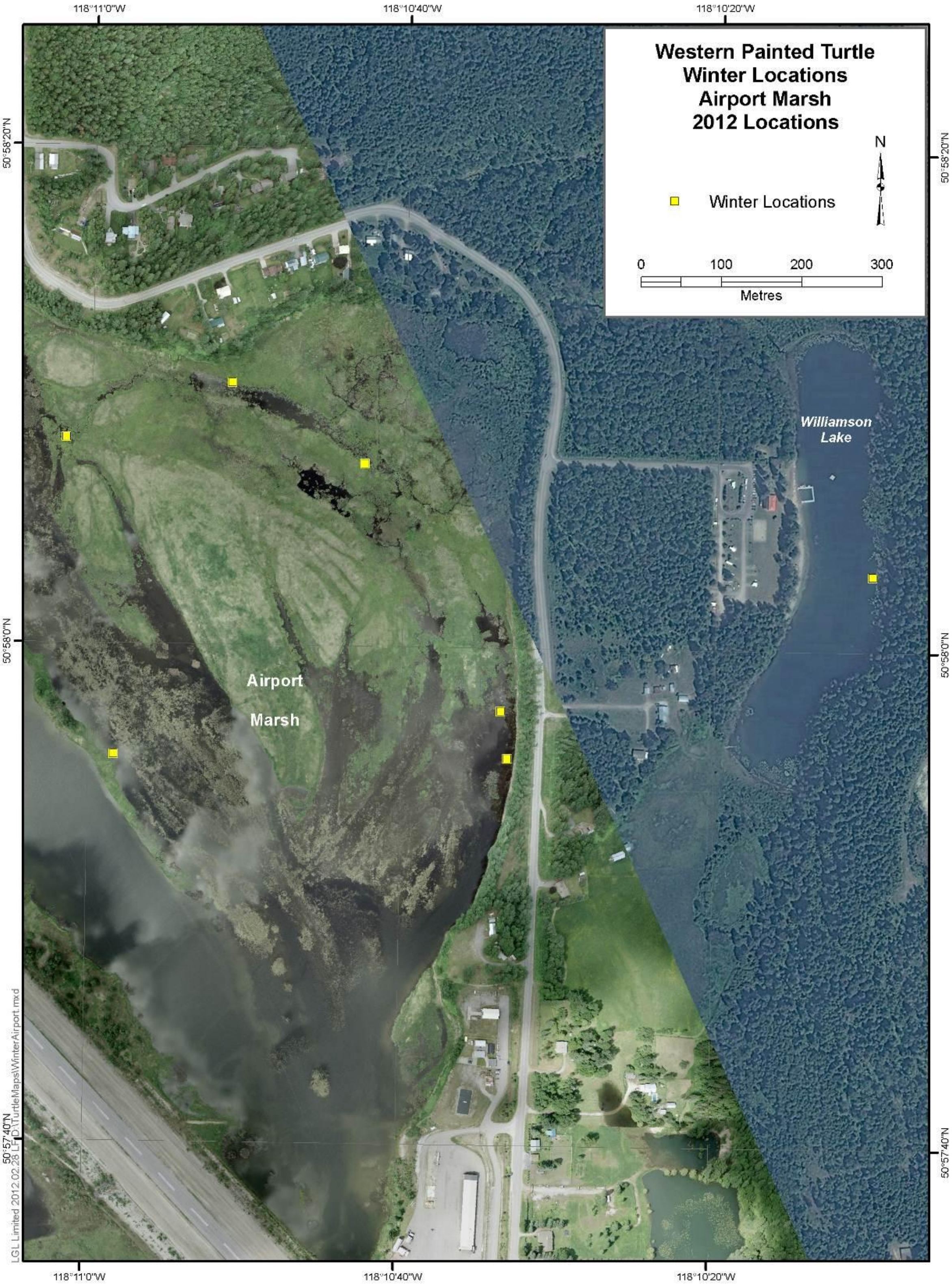

Figure 24 Overwintering locations identified in Airport Marsh during the winter of 2010 and 2011. One turtle left Airport Marsh and overwintered in Williamson Lake during 2010, Upper Arrow Lakes Reservoir, Revelstoke B.C. (LGL 2012).

7.0 Discussion

This preliminary assessment of the painted turtle population began in April 2010 by attaching radio transmitters to turtles, assessing the population demographics (age and sex classes), distribution and nesting and overwintering locations. The first two years of this project used the eight management questions set forth by BC Hydro and the Water Use Committee (CLBMON11B3) as a foundation to develop a long-term monitoring program (Schiller and Larsen 2012) for addressing the management questions posed in section 1.1. Below we summarize information on the results that are pertinent to each management question, and discuss the remaining knowledge gaps, while reviewing the goals set forth by the long-term monitoring program.

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 observations of nesting by turtles occurred primarily in habitat patches *above* the high-water mark of the reservoir, suggesting these sites or the nesting efforts of the female turtles are not threatened by reservoir operations. However, our sample of females radio-tracked to their nesting sites is limited, and therefore we cannot rule out the possibility that at least some animals may be attempting to nest within the drawdown zone, leading to subsequent inundation of the nests. Further, we cannot determine whether a larger selection of nesting sites was available to female turtles prior to the creation of the reservoir.

Telemetry and early spring surveys revealed that adult and juvenile turtles overwinter within the drawdown zone, and it appears that there is a communal hibernating site within a floating mass of vegetation (island) in Montana Slough. However, our sample size here is also limited, and additional work will be needed in order to comment on the exclusivity of these sites for hibernating animals.

Use of the drawdown zone by turtles (outside of nesting behaviour) was clearly established. Both telemetered and other turtles were detected in the drawdown zone during times of high and low water. Turtles located in this zone were primarily in the water (preventing observations on their exact behaviour) or basking on vegetation and/or the shoreline. One may speculate that when submerged, the animals are foraging in the drawdown zone, but this is not clear at this point in time. Overall, the significance of these observations needs to be explored with future work.

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)?

The majority of turtles were located in areas of slow moving water with submergent and emergent vegetation and muddy substrates, followed by open areas of water within the drawdown. These types of habitat are suggested as being preferred by painted turtles, in that they provide cover as well as access to open water for feeding and/or predator avoidance (COSEWIC 1996).

Turtles residing in MS were sighted using ‘pond habitat’ and shorelines within a wetland complex, and grassy areas within the drawdown zone. However, as the water levels increased a large portion of habitat became inundated, causing the turtles to move closer to the shorelines along the mainland and along the floating island of vegetation This Island appears unique as it provides habitat and cover for the turtles when the majority of the area is inundated.

At both sites, basking objects commonly associated with turtles, such as logs, were limited. Instead, turtles were sighted basking within or on islands of bulrush and cattails, or in areas where there were significant amounts of dead organic matter (DOM) in which they could hide while still maintaining a relatively warm temperature.

These data suggest that the changes in water levels affect habitat availability. Areas suitable for basking and foraging in early spring may become lost at one site as water levels rise; whereas in other sites the rising water levels may create more 'usable' habitat. This obviously is a complicated relationship that cannot be clearly understood at this time.

Differences and variations detected in movement data may be related to seasonal activities such as mating, nesting, and or foraging, different sections of the population requiring different habitat (Reese 1996), or spatial differences in habitat types. Some variation in movement may be correlated with changes in water levels, or partly by differences in habitats at the two sites. In particular, the degree that these two sites are affected by fluctuating reservoir levels appears to differ: The AP site (elevation 438 m) is relatively sheltered from the reservoir by the airport runway, flooding at a slower rate and having a larger land base to flood, in comparison to MS (elevation 436 m). These differences potentially could lead to higher energetic costs or risk of predation for those turtles that are changing their movements (Reese 1996; Grayson and Dorcas 2004), but future work would be needed to elucidate this.

Although our observations of turtles provide some insight into habitat use in the drawdown zone, our inability to observe submerged turtles makes it very difficult if not impossible to draw conclusions at this time on more specific habitat use within the drawdown zone. However, more focused work using alternative methods to collect fine scale habitat data may be possible during the long-term monitoring of the population.

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

Given only two sampling sessions in this is the first survey of the population, with no historical data available, we cannot at this time comment on population trends. Given this, the information on age and sex class structure data provides the most useful information for evaluating the status of the population, following similar interpretations by and Macartney and Gregory (1985) and Reese *et al*. (1998). The Revelstoke Reach population consists of a relatively large number of adults and neonates and more specifically, of the adult population there are more reproductive females, which is similar to the Kikomun Creek Provincial Park population found in southern B.C. (Macartney and Gregory 1985) and other turtle populations (Cagle 1954; Carriére 2007 - *Graptemys geographica*). However, reports of turtle population structures vary across North America (male biased, Bayless 1975: Stone 2001; no bias, Gibbons 1968). Differences in the age class structure may be attributed to lower recruitment rates within the reservoir or a sampling bias where juveniles and neonates are small, cryptic and harder to find (Ream and Ream, 1966; Reese and Welsh, 1998; Gamble, 2006). Potential factors causing lower neonate and juvenile survival can include the fact that younger turtles are more susceptible to predation, and overwintering mortality, and changes in habitat due to fluctuations in water levels can eliminate shallow shoreline microhabitat sites that young turtles require. Changes in water levels can also alter the temperature regime of the habitat, decreasing growth and thus increasing exposure to predators and energy requirements of small sized turtles (Reese and Welsh 1998).

The pilot study described herein provides the first actual estimates of population size for the turtles in this portion of the Arrow Lakes Reservoir. Although this estimate (>200 turtles) suggests reasonable numbers of animals, it does not reveal whether the population is stable, increasing, or decreasing, and/or whether the population is significantly augmented by animals dispersing from nearby water bodies. The inability to monitor the survival of neonates and/or other younger turtles further constrains our ability to extrapolate a population trajectory from these preliminary data. Only a series of population estimates from a longer monitoring period will be able to answer this question, as well as provide for narrower confidence limits around the estimates.

The reason(s) for the strong female bias in the adult sex ratio is not clear at this time. The main method of capture, hand or dip net captures may be more effective in capturing females, particularly as females move and come to shore to nest. Another possible explanation may be that male turtles are utilizing habitats at different times or other habitats within the drawdown zone and are therefore not as easily detected.

A large number of reproductive females may be a good indicator that the population is recruiting. This is particularly important in a species that has high rates of juvenile mortality such as is assumed for WPT populations (COSEWIC 2006). Female-bias has been detected in other turtle populations at the northern extent of their range, such as for painted turtles in southern B.C. (ratios of 1:1.8,1:1.3, and 1:1.8 at three different lakes - Macartney and Gregory 1985), and for stinkpot turtles (1:0.6) and common map turtles (2:1) in the St. Lawrence Islands National Park in Ontario, Canada (Carriére 2007).

Although large numbers of adult females is obviously important to the long-term persistence of turtle populations, a low number of male turtles may contribute to a depressed reproductive rate or low genetic diversity within the population (Parker and Whiteman 1993). Further research is required to determine whether the bias observed in our sample is influenced by trapping methods or differential behaviour on the part of the males. If a female bias truly exists, future studies may wish to look into the mechanisms responsible for the bias.

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?

The data from this pilot study suggest nest inundation as a result of reservoir operations is not a significant threat to the animals, simply because the two major nest sites we detected lay above the high-water mark. Similarly, no incidents of mortality to turtles could be attributed to the reservoir operation, but again, our sample of telemetered turtles (those animals most likely to allow detection of mortality) is relatively small and of short duration. However, the predominant use of two anthropogenic nesting sites (albeit above the high-water mark) by females in this population may or may not reflect a shortage of alternative sites brought on by the creation of the reservoir and its operations. Certainly, a situation exists where alteration, deterioration, or detection by predators of these unprotected nesting sites could impact reproduction in this population over time. Determining the exclusivity of the current two nesting sites, and working with other agencies/land owners to protect and maintain identified nesting sites such as, maintaining adequate solar radiation as revealed by the temperature data loggers at Red Devil Hill, may lead to the creation of new nesting sites.

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

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

At present, the information collected during this pilot study on the Upper Arrow Lakes Reservoir turtles does not provide an argument for making either minor adjustments to reservoir operations or creating physical works projects designed to mitigate impacts to the turtles. However, nor does this information rule out the need for such management actions. As has been repeatedly stated, the data collected to date should be considered preliminary, in keeping with a ‘pilot study’. A longer-term program of baseline monitoring coupled with more-focused research projects such as, a study designed to look at the fine-scale habitat use of the turtles within the drawdown zone would address the direction of impact, is needed to address questions and mitigation options.

Q7. Does re-vegetating 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?

Answer(s) to Q2 are needed to predict whether re-vegetation and/or physical changes to the drawdown zone will positively or negatively affect the turtles in the reservoir. Comments on how alterations to vegetation in the drawdown zone (both emergent and submerged) would influence turtle foraging, predation, or other aspects of the ecology of these animals would be presumptuous at this time. However, with techniques and knowledge gained through the continuation of this pilot study, more insight in this direction should be forthcoming.

In addition to empirical data, small-scale management experiments are one possible tool that might provide insight into the response of the turtles to habitat manipulations. Monitoring the response of turtles to submerged vegetation will be difficult, but the use of experimental, emergent plots of vegetation could be assessed (i.e. use for basking, as seen in this study with turtles using bulrushes in this fashion). The provision of more conventional basking sites (e.g. logs, or artificial islands) could also be done using an experimental design and in theory provide supplementation basking sites and habitat that would rise and fall with water levels. However, there appeared to be no short-term response of turtles during this study to new basking sites (i.e. the basking traps), so longer term monitoring may be prudent if such habitat manipulations are effected.

8.0 Conclusion

The Revelstoke western painted turtles not only face the challenges of living in one of the most northerly locations for the species, but also in an environment that is constantly changing due to the hydroelectric operations of the reservoir. To identify direct and indirect impacts of these operations on the turtles, a combination of methods likely will be needed to monitor population demographics, habitat use, overwintering and nesting locations, and the presence of critical habitat within the reservoir over time. These directions are described in more detail in a companion report entitled “Arrow Lakes Reservoir, Revelstoke Reach Western Painted Turtle (*Chrysemys picta bellii*) Monitoring Strategy (2012-2019)” (Schiller and Larsen 2012). The continuation of a turtle monitoring and research program in the reservoir will provide the detailed data needed to answer the management hypotheses and questions set forth by BC Hydro and the Water Use Plan (BC Hydro 2005; BC Hydro 2009) for the western painted turtles inhabiting the Revelstoke Reach of the Arrow Lakes Reservoir.

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Appendix 1. Photos of Study Sites

Photo 1 Turtle Pond, Revelstoke B.C. (Schiller 2011).

Photo 2 Turtle Pond, Revelstoke B.C. (Schiller 2011).

Photo 3 Airport Marsh, Upper Arrow Lakes Reservoir, Revelstoke B.C. (Schiller 2010).

Photo 4 Airport Marsh seen from Red Devil Hill, Upper Arrow Lakes Reservoir, Revelstoke B.C. (Schiller 2011).

Photo 5 Montana Slough Upper Arrow Lakes Reservoir, Revelstoke B.C. (Schiller 2010).

Photo 6 Montana Slough, shoreline of the floating Fen Island, Upper Arrow Lakes Reservoir, Revelstoke B.C. (Schiller 2010).

Photo 7 Nesting western painted turtle at the Airport/Firebase nesting site, Upper Arrow Lakes Reservoir, Revelstoke B.C. (Schiller 2011)

Photo 8 Airport/Firebase nesting site, Upper Arrow Lakes Reservoir, Revelstoke B.C. (Schiller 2011).

Photo 9 Nesting western painted turtles at Red Devil Hill, Upper Arrow Lakes Reservoir, Revelstoke B.C. (Schiller 2010)

Photo 10 Nesting site at Red Devil Hill, located between the shoulder of a road and Airport Marsh. Each blue flag represents a western painted turtle nest. Upper Arrow Lakes Reservoir, Revelstoke B.C. (Schiller 2010).

Photo 11 Marking of a western painted turtle by notching the marginal scutes of the carapace. Upper Arrow Lakes Reservoir, Revelstoke B.C. (Schiller 2011).

Photo 12 River otters seen at Winter Pond in Montana Slough, November 23, 2011. Upper Arrow Lakes Reservoir, Revelstoke B.C. (Schiller 2011).

Photo 13 Winter Pond, located at Montana Slough, Upper Arrow Lakes Reservoir, Revelstoke B.C. (Schiller 2011)

Photo 14 Winter telemetry on ice February 21st, 2012, Airport Marsh Upper Arrow Lakes Reservoir, Revelstoke B.C. (D. Schiller 2012)

Photo 15 Road mortality, Upper Arrow Lakes Reservoir, Revelstoke B.C. (Schiller 2011)

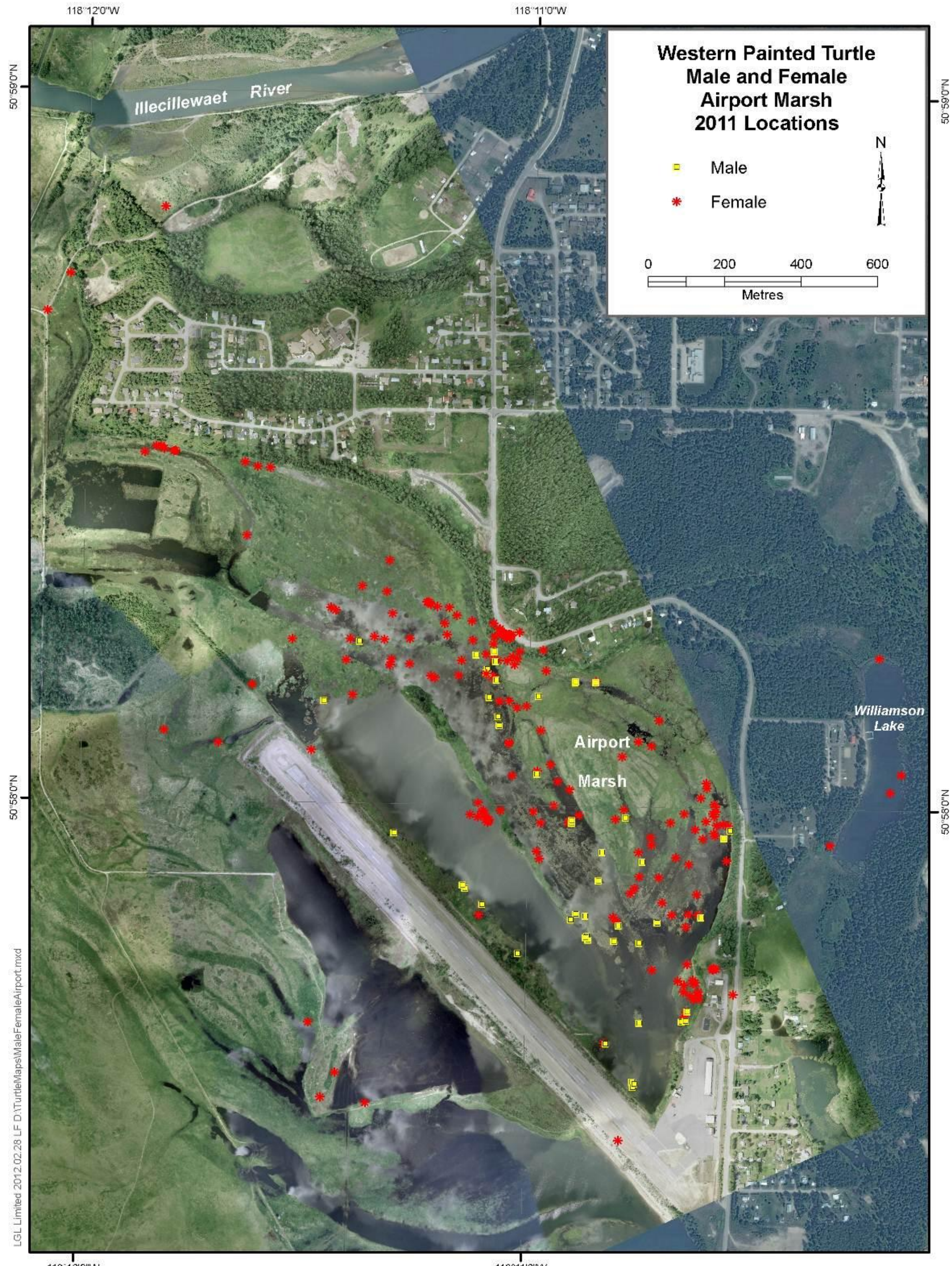
Appendix 2. Turtle Movements

Table 5. Summary of radio-tagged western painted turtle (*Chrysemys picta bellii*) with more than one location, in Revelstoke Reach of the Upper Arrow Lakes, British Columbia.

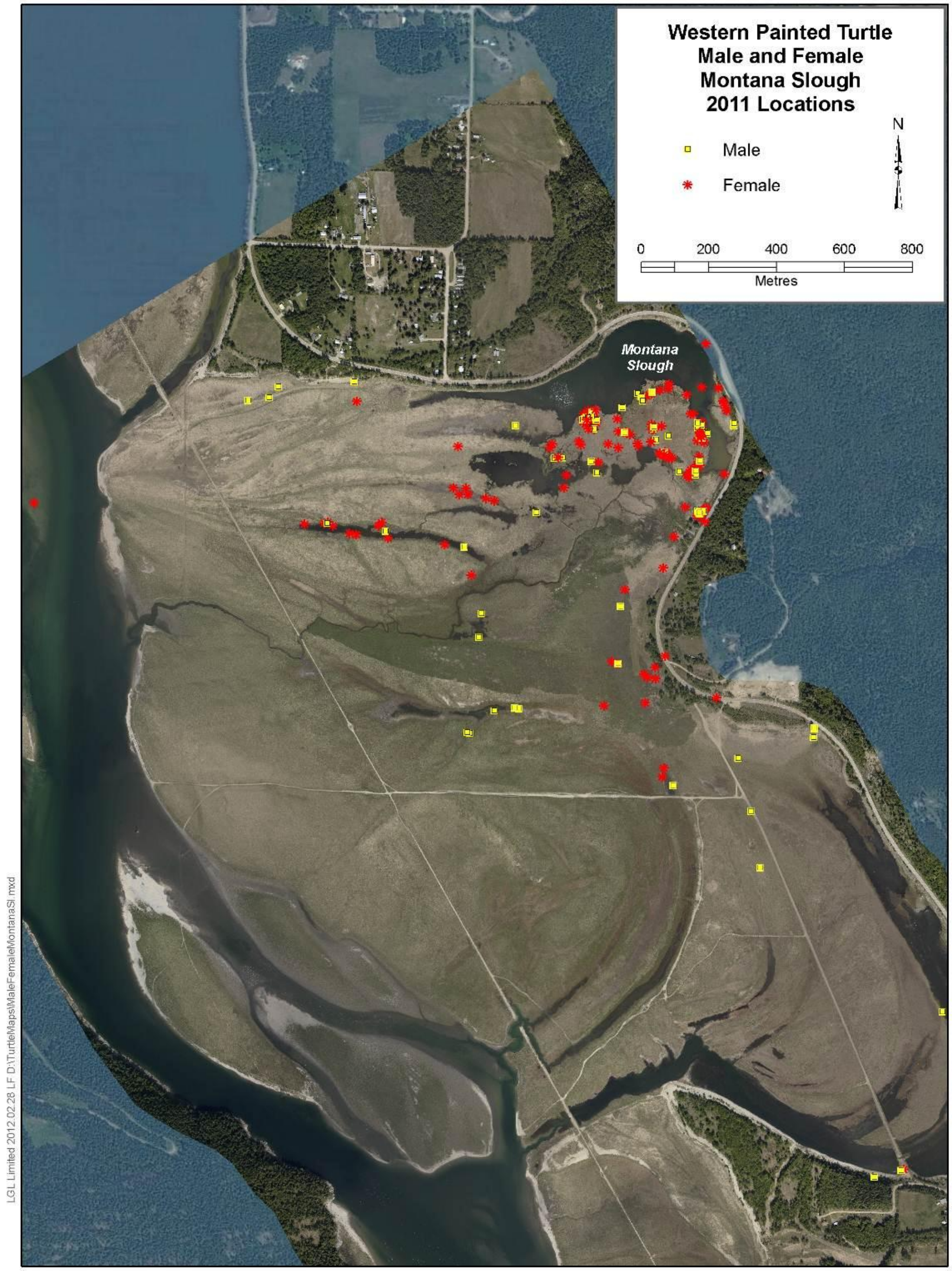
Turtle Name	Number of Locations	Mean	±SE	Distance Travel based on Locations (m)	Minimum (m)	Maximum (m)
T2	11	141	76.6	1409.6	2.2	627.9
T3	11	553	147	5526	58	1299
T4	12	187.9	96.7	2066.4	4.5	1105
T5	14	158.6	44.9	2061.8	16.2	559.3
T6	10	141.6	54.4	1416.3	1	438
T7	14	339.5	65.1	4073.9	51.9	660.5
T11	9	83	23.7	664	1	215.6
T12	7	136.6	99.1	819.6	7.1	627.4
T13	6	473	278	2367	8	1474
T32	29	354	104	9555	1	2445
T43	14	177.7	53.1	2310.3	5.1	483.4
T47	17	527	220	8425	2	2712
T61	36	303.8	98.9	10329.7	3.6	2601
T64	37	489	194	17116	1	4998
T65	11	1174	500	11740	32	4634
T74	28	217.2	35.5	5864.6	0	749.7
T79	5	110.8	56.6	443	1	269.5
T80	17	377.4	92.3	6038.7	12	1273.3
T81	17	285.3	66	4565.4	24.3	900.9
T82	11	286	114	2860	4	997
T84	20	309.9	95.5	5888.1	3.2	1415.7
T85	19	120.4	32.3	2168	6.7	508.2
T86	19	455.5	93.2	8199.4	8.2	1203.4
T87	18	370.7	96.8	6302.5	3	1304.9
T88	20	281.8	83.2	5354.5	1.4	1254.5
T90	16	623	229	9350	2	2921
T91	18	729	259	12400	6	3948
T97	17	240.8	59.6	3853	4	903.7
T98	8	552	338	4413	11	2887
T99	21	459	107	9182	61	1755
T104	15	141.9	44.8	1987.1	3	591.3
T106	14	301	111	3913	17	1270
T107	16	152.8	62.5	2292.4	5.4	679
T110	15	507.6	89.5	7106	47.9	1178.5
T111	13	289	70.1	3468	48.5	917.1

Turtle Name	Number of Locations	Mean	±SE	Distance Travel based on Locations (m)	Minimum (m)	Maximum (m)
T114	12	415	117	4983	13	1217
T116	14	267.9	67.8	3482.2	28.3	921.4
T117	12	307.2	85.4	3379.2	12.2	818
T120	11	124.1	26.8	1241.4	18	267.4
T129	6	54.3	36.1	271.7	8.2	197.6

Appendix 3 Age and Sex Class Mapping of Turtle Locations

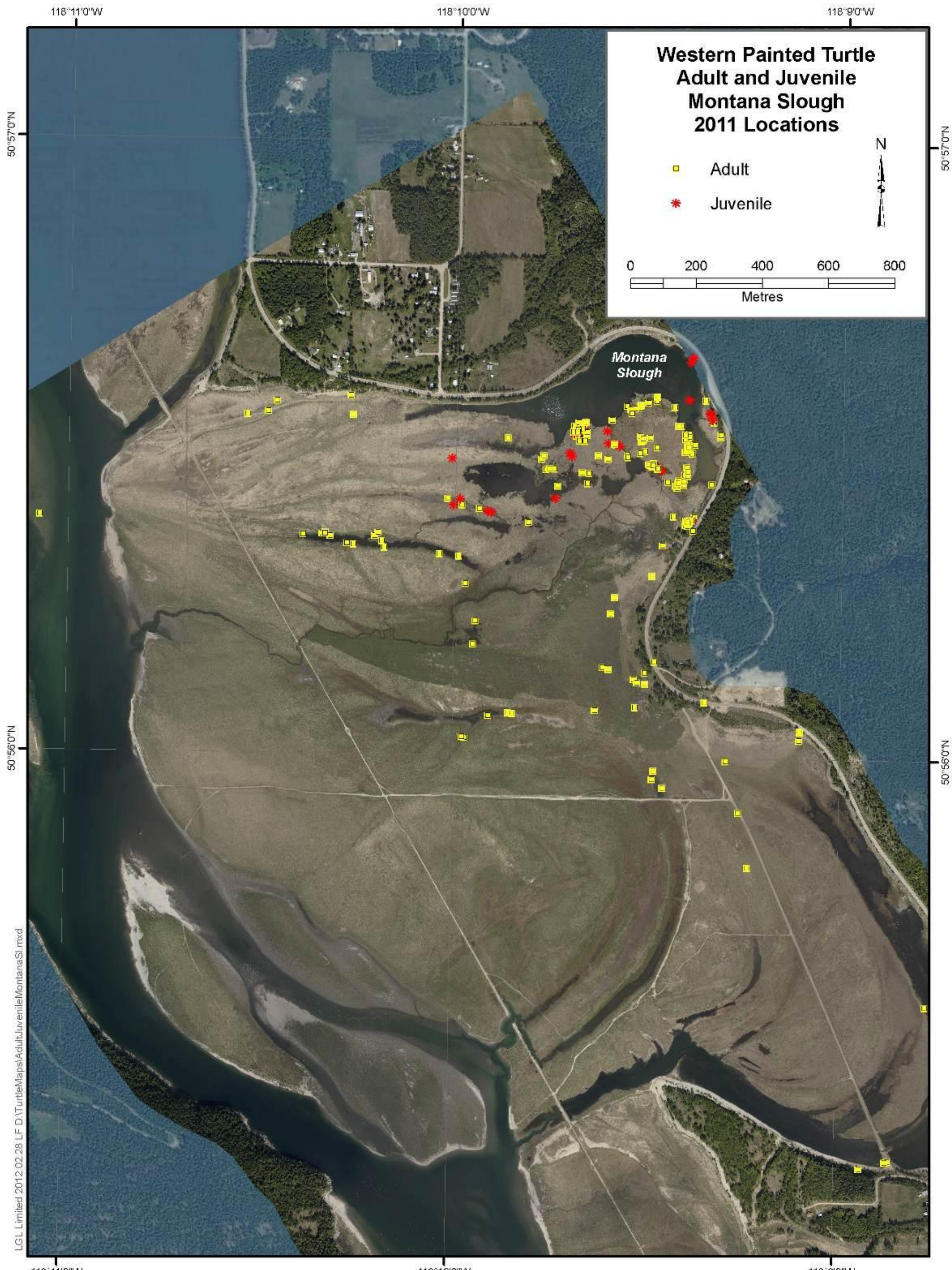


Map 1 Female and Male turtle locations in Airport Marsh during 2011 (April to September), Upper Arrow Lakes Reservoir, Revelstoke, B.C. (LGL 2012)



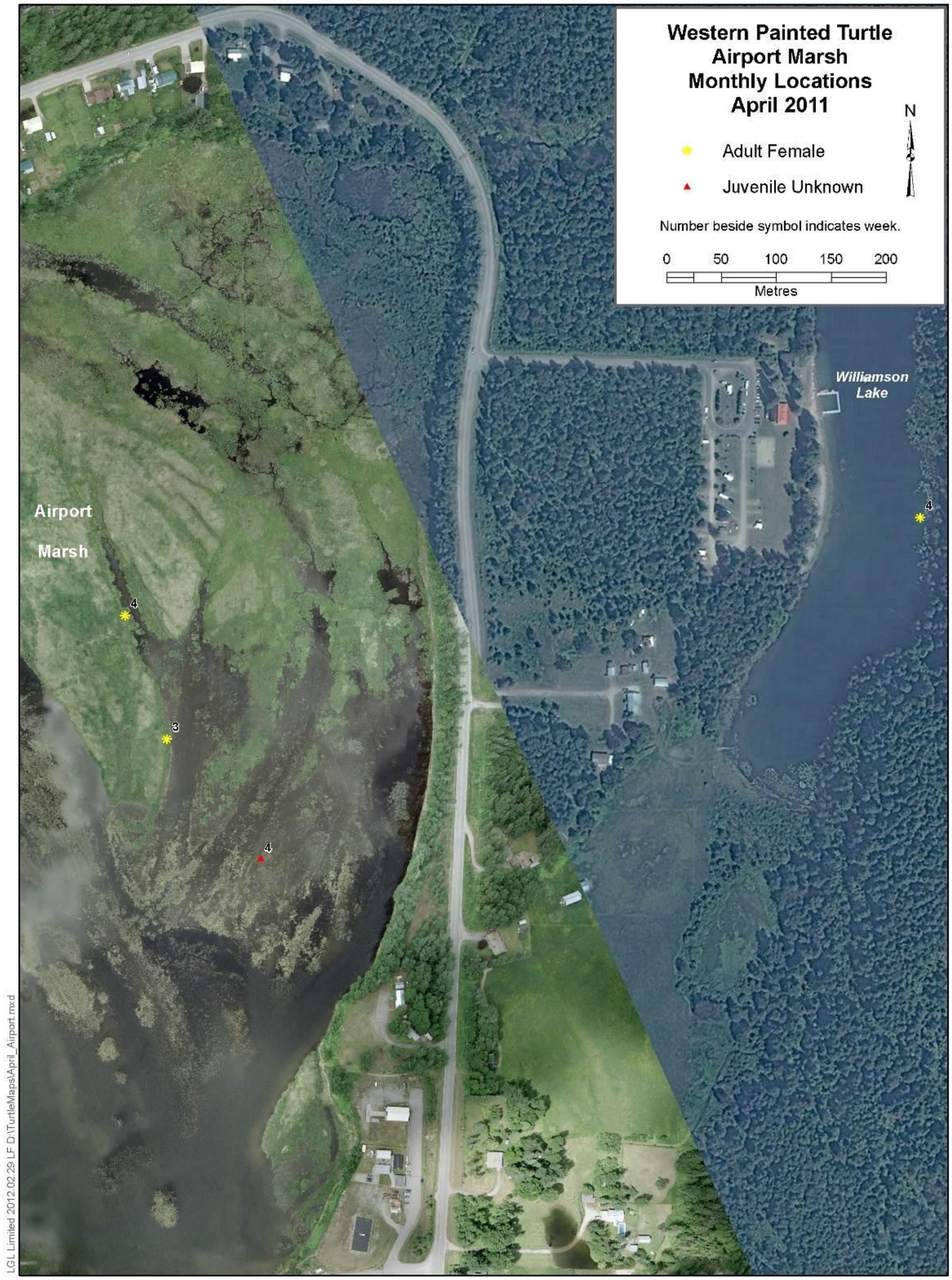
Map 2 Female and Male turtle locations in Montana Slough during 2011 (April to September), Upper Arrow Lakes Reservoir, Revelstoke, B.C. (LGL 2012).

Map 3 Adult and juvenile turtle locations in Airport Marsh during 2011 (April to September), Upper Arrow Lakes Reservoir, Revelstoke, B.C. (LGL 2012)



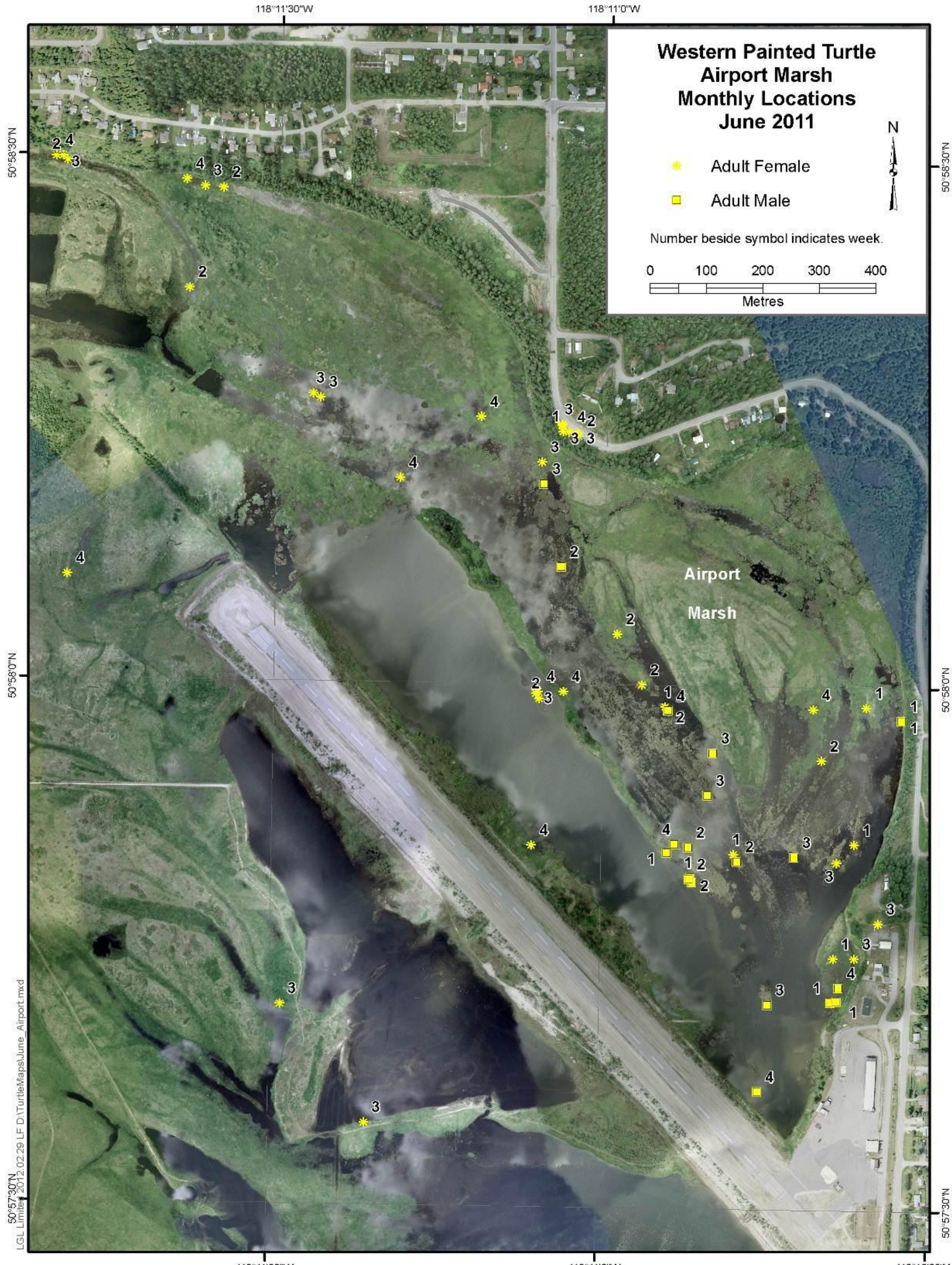
Map 4 Adult and juvenile turtle locations in Montana Slough during 2011 (April to September), Upper Arrow Lakes Reservoir, Revelstoke, B.C. (LGL 2012)

Appendix 4. Monthly Telemetry Locations for Turtles in Airport Marsh

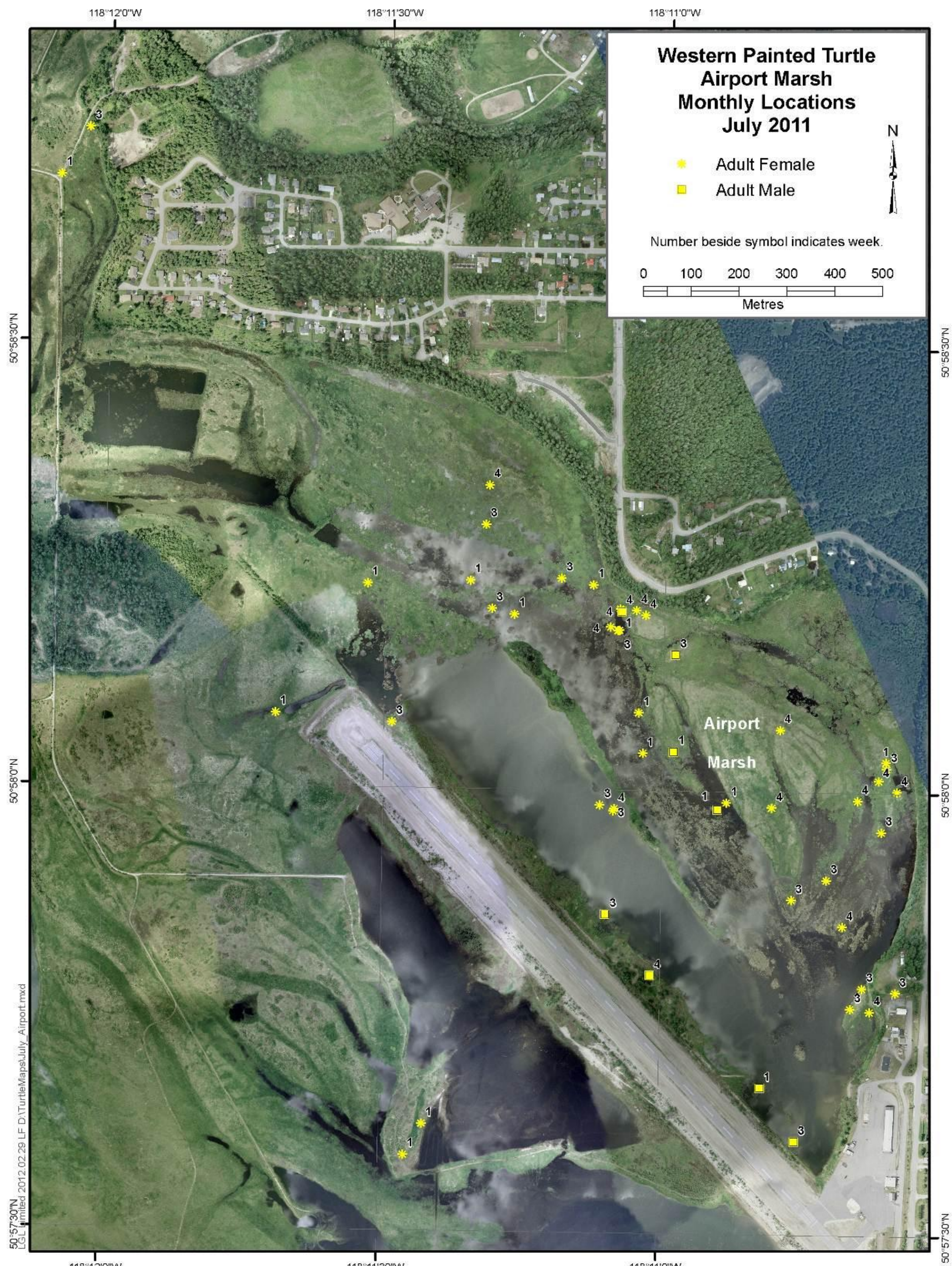


Map 5 Turtle telemetry locations during the month of April in Airport Marsh, Upper Arrow Lakes, Revelstoke, B.C. Numbers represent the weeks of the month (LGL 2012).

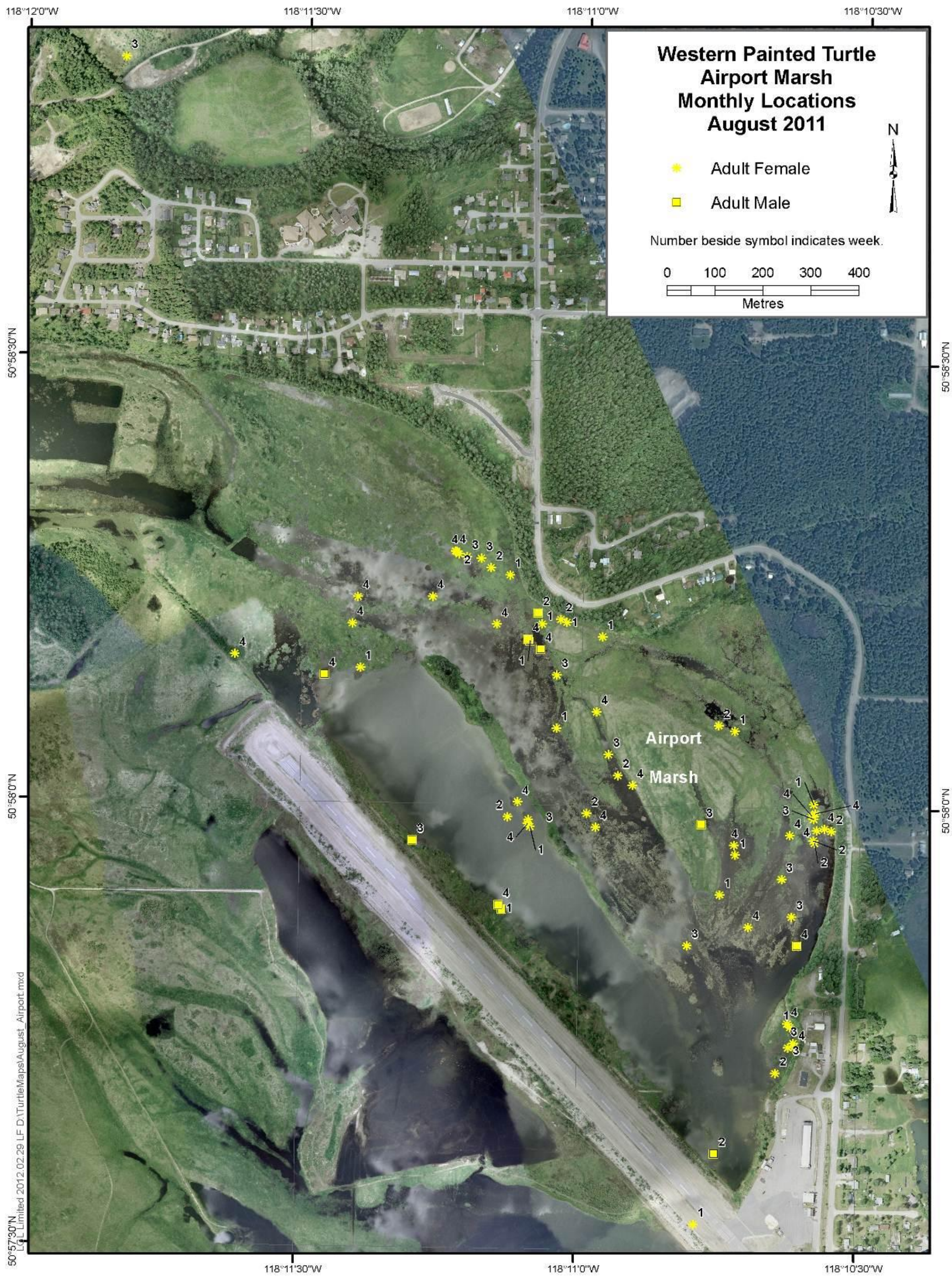
Map 6 Turtle telemetry locations during the month of May in Airport Marsh, Upper Arrow Lakes, Revelstoke, B.C. Numbers represent the weeks of the month (LGL 2012).



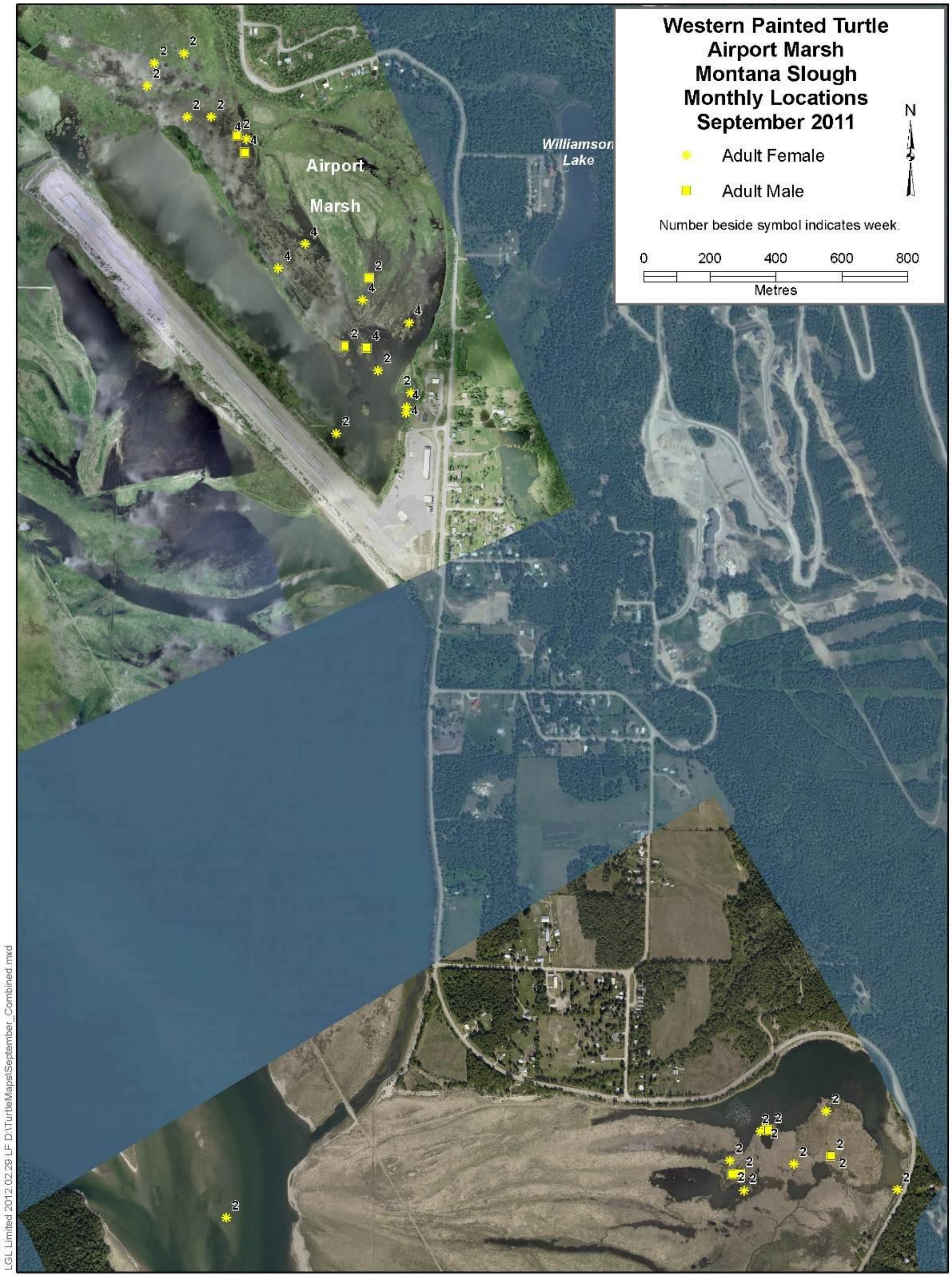
Map 7 Turtle telemetry locations during the month of June in Airport Marsh, Upper Arrow Lakes, Revelstoke, B.C. Numbers represent the weeks of the month (LGL 2012).



Map 8 Turtle telemetry locations during the month of July in Airport Marsh, Upper Arrow Lakes, Revelstoke, B.C. Numbers represent the weeks of the month (LGL 2012).

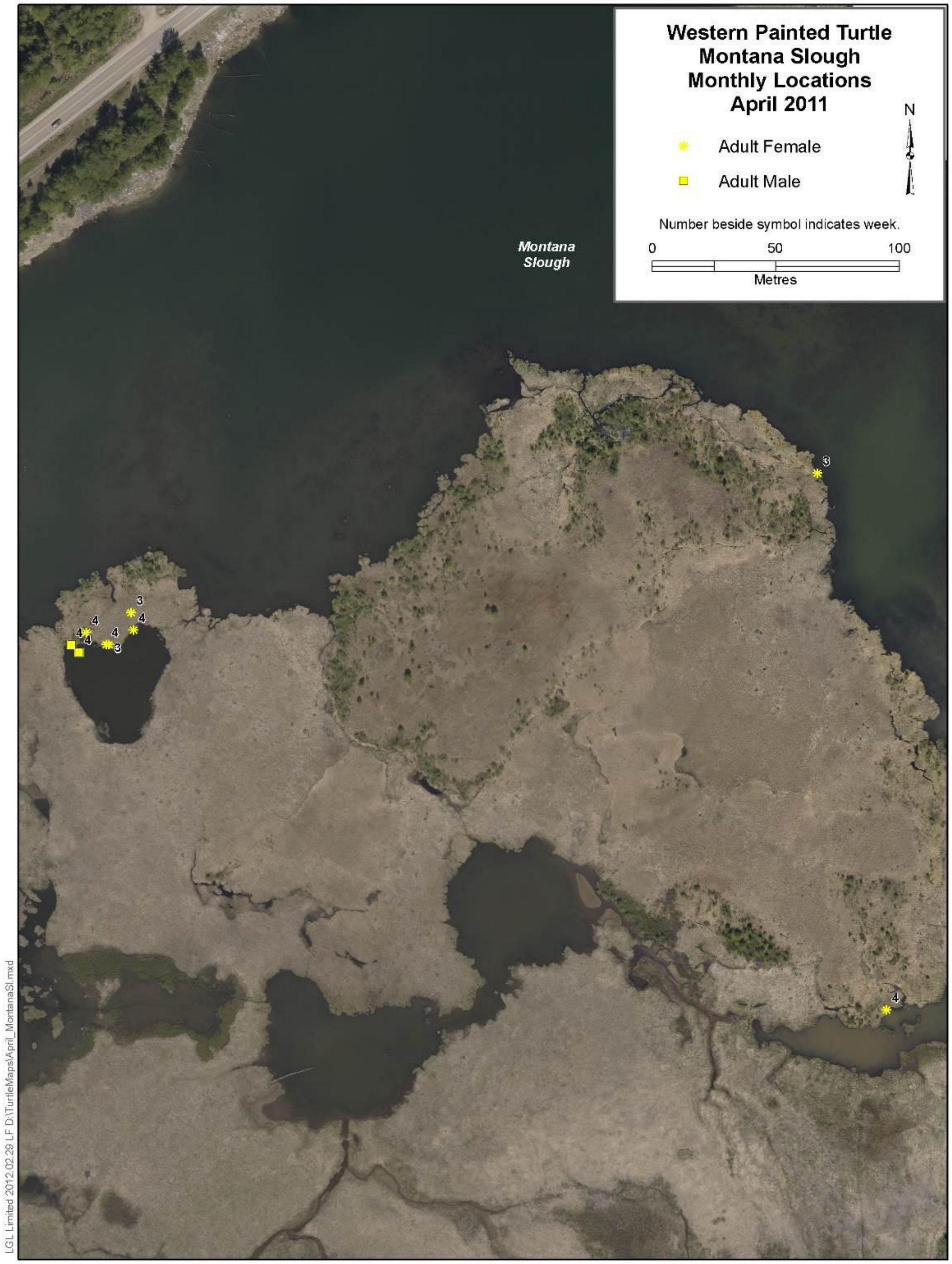


Map 9 Turtle telemetry locations during the month of August in Airport Marsh, Upper Arrow Lakes, Revelstoke, B.C. Numbers represent the weeks of the month (LGL 2012).

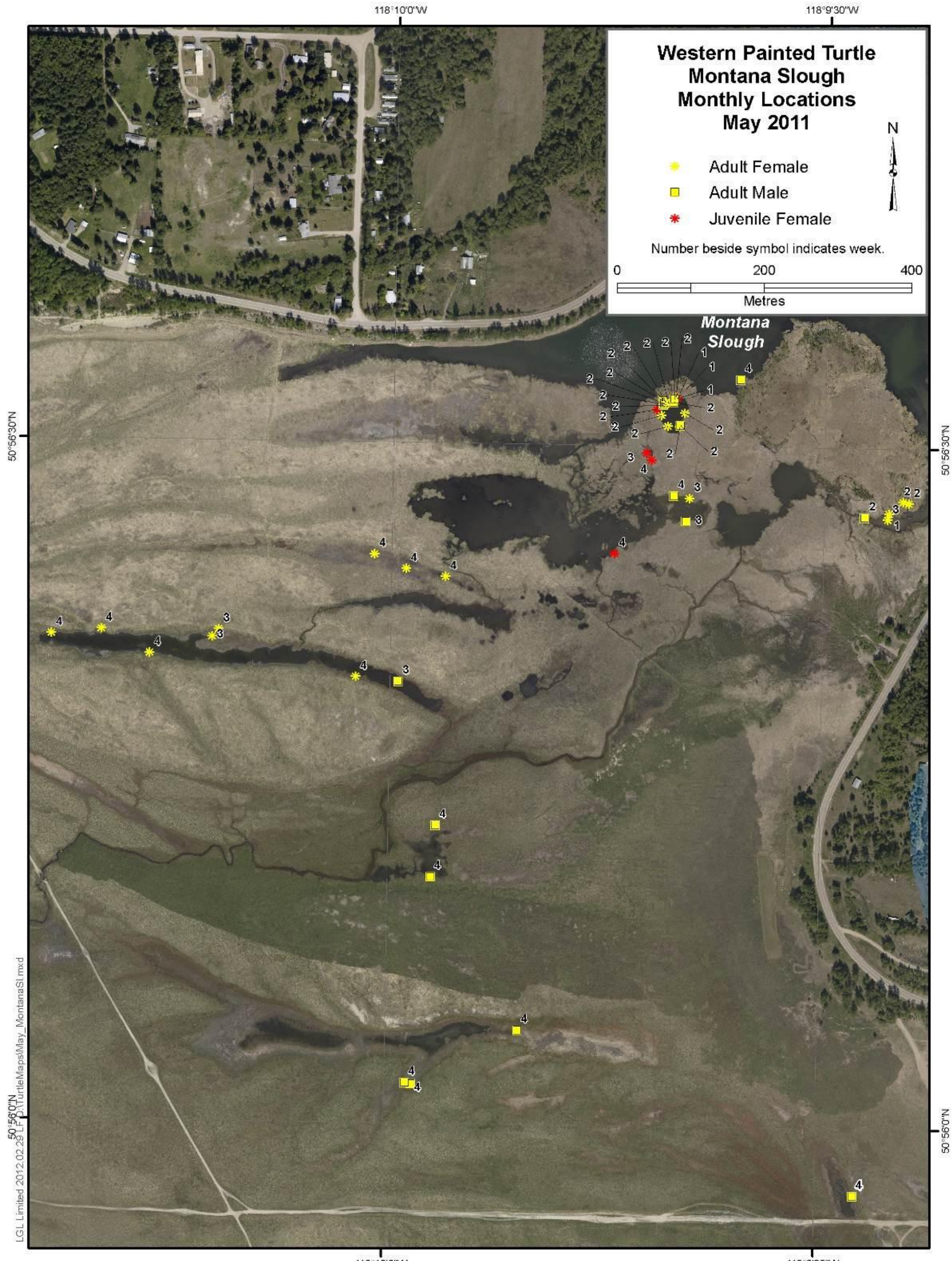


Map 10 Turtle telemetry locations during the month of September in Airport Marsh and Montana Slough, Upper Arrow Lakes, Revelstoke, B.C. Numbers represent the weeks of the month (LGL 2012).

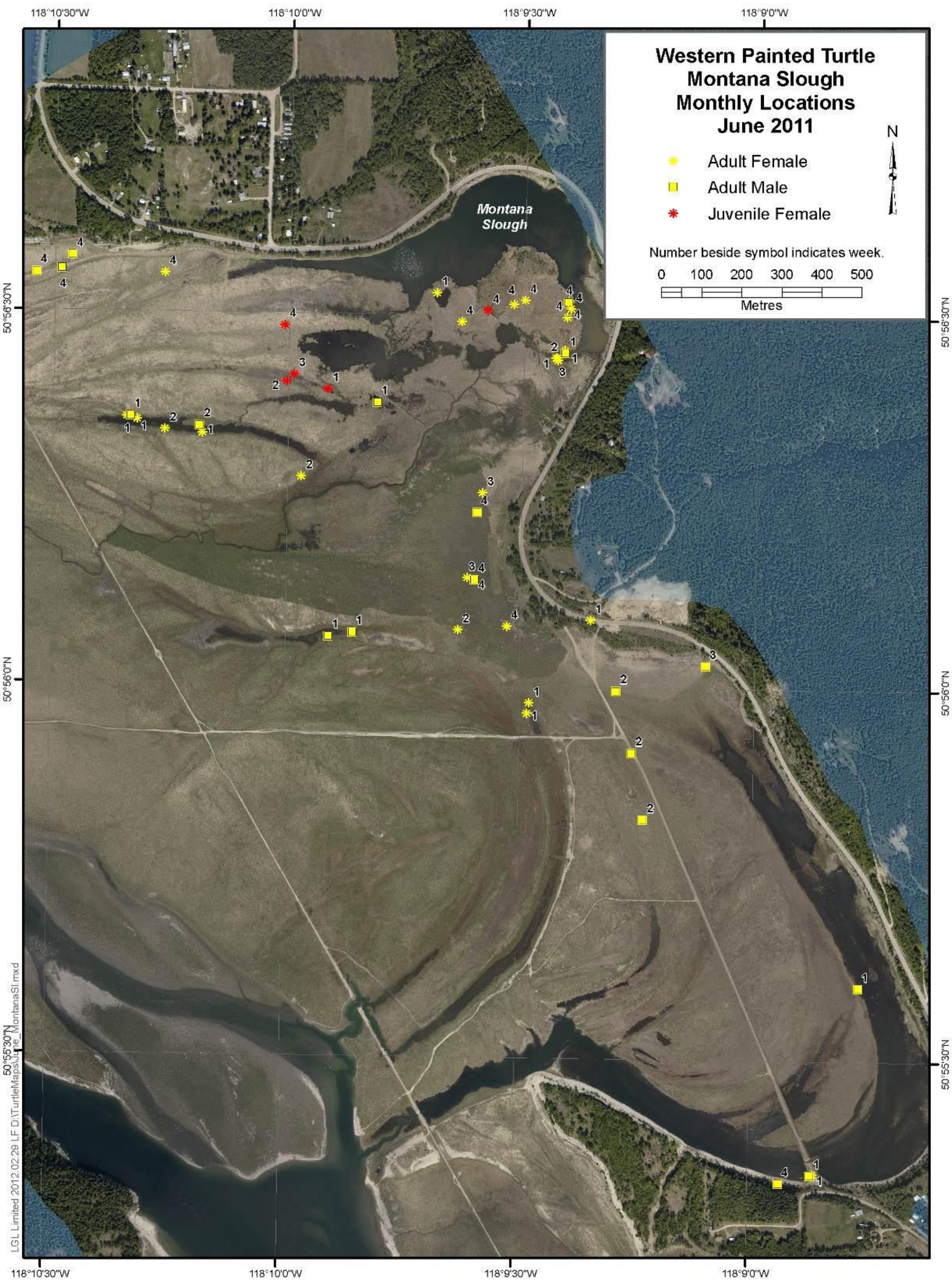
Appendix 5 Monthly Telemetry Locations for Turtles in Montana Slough



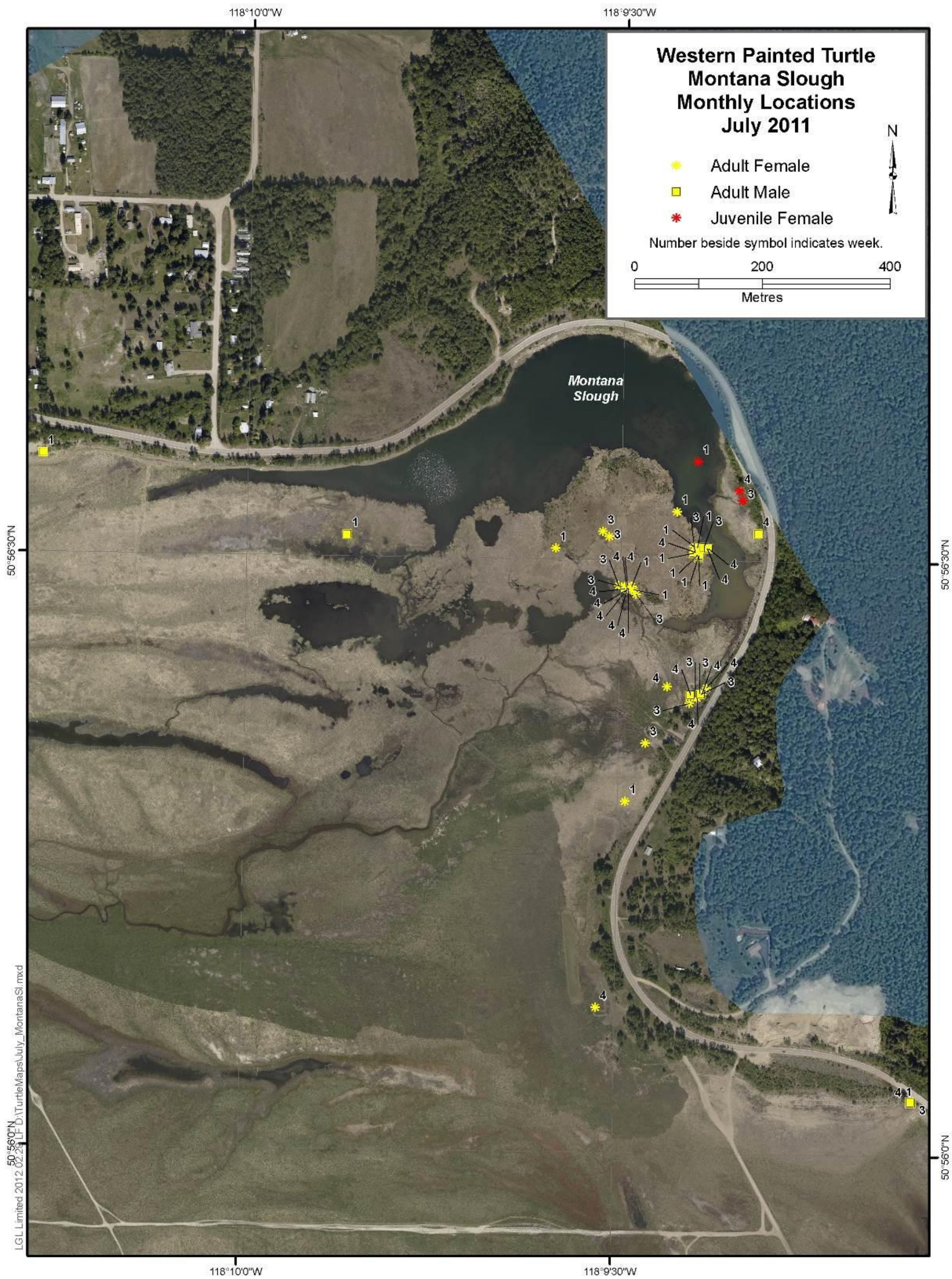
Map 11 Turtle telemetry locations during the month of April in Montana Slough, Upper Arrow Lakes, Revelstoke, B.C. Numbers represent the weeks of the month (LGL 2012).



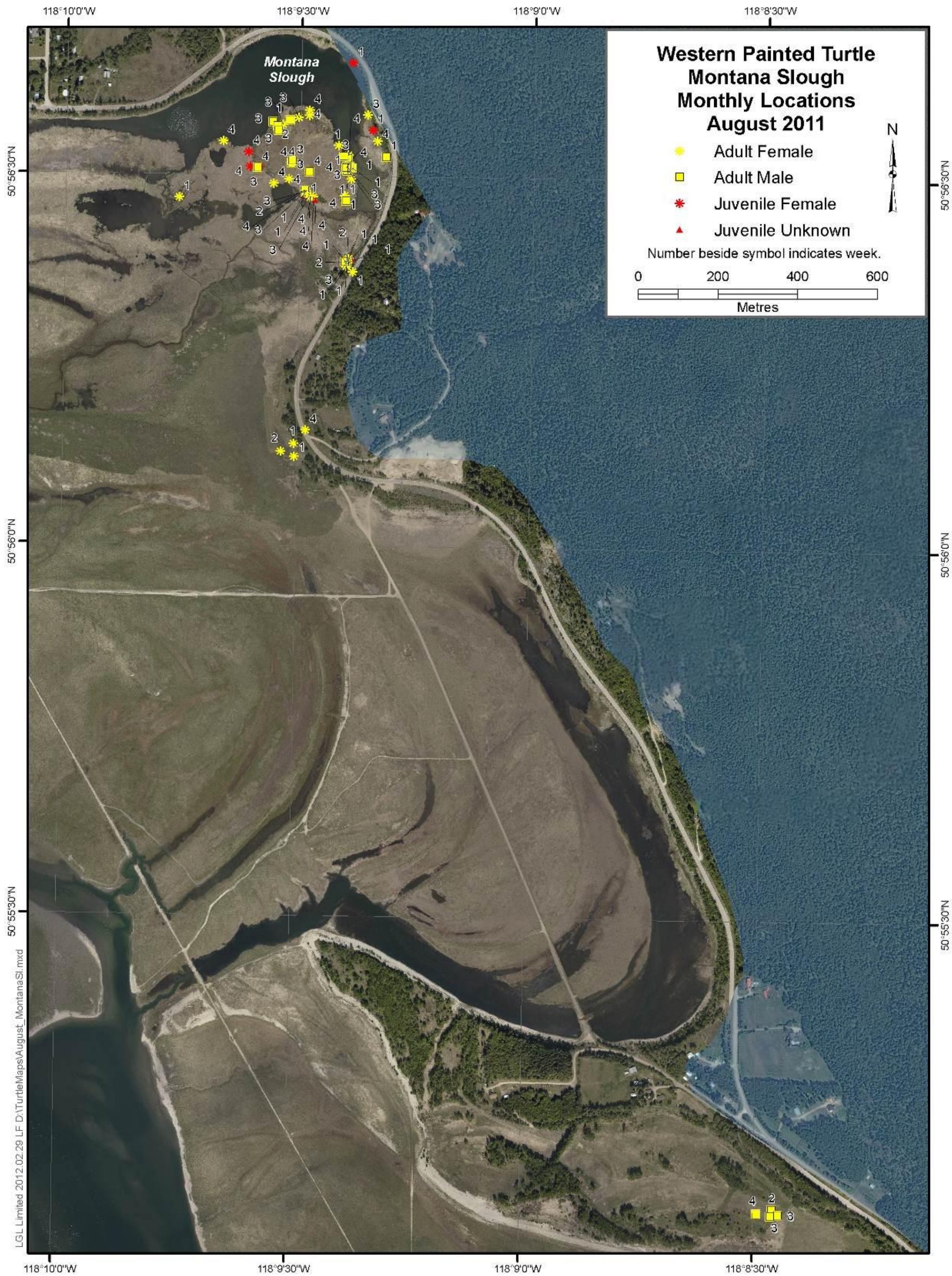
Map 12 Turtle telemetry locations during the month of May in Montana Slough, Upper Arrow Lakes, Revelstoke, B.C. Numbers represent the weeks of the month (LGL 2012).



Map 13 Turtle telemetry locations during the month of June in Montana Slough, Upper Arrow Lakes, Revelstoke, B.C. Numbers represent the weeks of the month (LGL 2012).



Map 14 Turtle telemetry locations during the month of July in Montana Slough, Upper Arrow Lakes, Revelstoke, B.C. Numbers represent the weeks of the month (LGL 2012).



Map 15 Turtle telemetry locations during the month of August in Montana Slough, Upper Arrow Lakes, Revelstoke, B.C. Numbers represent the weeks of the month (LGL 2012).

Appendix 6 A Table Outlining the Management Objectives, Questions, and Hypotheses of CLBMON 11B3

Table 6 Management Objectives, Questions, and Hypotheses of CLBMON 11B3 outlined .

Objectives	Management Questions	Management Hypotheses	Approaches	Year Two (2011) Status	Report Section
Identify nesting and overwintering habitat within the drawdown zone.	1) During what portion of their life history (e.g., nesting, foraging, and overwintering) do painted turtles utilize the drawdown zone in Revelstoke Reach?	HO $_1$: Painted turtles are not dependent on habitats in the drawdown zone of Arrow Lakes Reservoir	Visual Encounter Surveys Radio Telemetry	Pilot study completed. Future research recommended	5.6 and 5.9 & 7.0: Q1
Determine the effects and impact of reservoir operations on habitat that painted turtles are utilizing within the drawdown zone	2) 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)?	HO $_1$: Painted turtles are not dependent on habitats in the drawdown zone of Arrow Lakes Reservoir HO $_2$: The operations of the Arrow Lakes Reservoir do not affect painted turtle survival or productivity	Visual Encounter Surveys Radio Telemetry	Pilot study completed. Future research required	5.6, 5.7, 5.8, and 5.9 & 7.0: Q2
Capture - Mark and Recapture the majority or all of the turtles within the drawdown zone.	3) What is the abundance and productivity of painted turtles in Revelstoke Reach and how do these vary across years?	HO $_2$: The operations of the Arrow Lakes Reservoir do not affect painted turtle survival or productivity.	Visual Encounter Surveys Radio Telemetry Mark-Recapture	Pilot study completed. Future research required	5.2 &70: Q3
Identify potential threats to the painted turtle population	4) Does the operation of the Arrow Lakes Reservoir negatively impact painted turtles directly or indirectly (e.g., mortality, nest inundation, predation, and habitat change)?	HO $_1$: Painted turtles are not dependent on habitats in the drawdown zone of Arrow Lakes Reservoir HO $_2$: The operations of the Arrow Lakes Reservoir do not affect painted turtle survival or productivity. HO $_3$: Habitat enhancement through revegetation or physical works does not mitigate the effects of reservoir operations on painted turtles. More specifically, wildlife physical works and revegetation projects do not change the utilization of the drawdown zone habitats by painted turtles in Revelstoke Reach	Visual Encounter Surveys Radio Telemetry Mark-Recapture	Pilot study completed. Future research required	5.5, 5.6, 5.7 & 7.0: Q4
Determine the effects of reservoir operations on the productivity of the turtle population	5) Can minor adjustments be made to reservoir operations to minimize the impact on painted turtles?	HO $_1$: Painted turtles are not dependent on habitats in the drawdown zone of Arrow Lakes Reservoir HO $_2$: The operations of the Arrow Lakes Reservoir do not affect painted turtle survival or productivity. HO $_3$: Habitat enhancement through revegetation or physical works does not mitigate the effects of reservoir operations on painted turtles. More specifically, wildlife physical works and revegetation projects do not change the utilization of the drawdown zone habitats by painted turtles in Revelstoke Reach	Visual Encounter Surveys Radio Telemetry Mark-Recapture	Pilot study completed. Future research required	7.0: Q5 & Q6
Provide recommendations for physical works, revegetation or reservoir operations to minimize the impact of reservoir operations on the painted turtle	6) Can physical works be designed to mitigate the impacts of reservoir operations on painted turtles?	HO $_3$: Habitat enhancement through revegetation or physical works does not mitigate the effects of reservoir operations on painted turtles. More specifically, wildlife physical works and revegetation projects do not change the utilization of the drawdown zone habitats by painted turtles in Revelstoke Reach	Visual Encounter Surveys Radio Telemetry	Pilot study completed with baseline data. Future research required	7.0: Q5 & Q6
Evaluate the effectiveness of physical works, revegetation and or reservoir operations at minimizing the impact on painted turtles	7) Does revegetating the drawdown zone affect the availability and use of habitat by painted turtles?	HO $_1$: Painted turtles are not dependent on habitats in the drawdown zone of Arrow Lakes Reservoir HO $_2$: The operations of the Arrow Lakes Reservoir do not affect painted turtle survival or productivity. HO $_3$: Habitat enhancement through revegetation or physical works does not mitigate the effects of reservoir operations on painted turtles. More specifically, wildlife physical works and revegetation projects do not change the utilization of the drawdown zone habitats by painted turtles in Revelstoke Reach	Visual Encounter Surveys Radio Telemetry	Pilot study completed with baseline data. Future research required	7.0: Q7 & Q8
Evaluate the effectiveness of physical works and revegetation at affecting the availability and use of habitat in the drawdown zone by painted turtles	8) Do wildlife physical works (e.g. habitat enhancement) affect the availability and use of habitat in the drawdown zone by painted turtles?	HO $_1$: Painted turtles are not dependent on habitats in the drawdown zone of Arrow Lakes Reservoir HO $_2$: The operations of the Arrow Lakes Reservoir do not affect painted turtle survival or productivity. HO $_3$: Habitat enhancement through revegetation or physical works does not mitigate the effects of reservoir operations on painted turtles. More specifically, wildlife physical works and revegetation projects do not change the utilization of the drawdown zone habitats by painted turtles in Revelstoke Reach	Visual Encounter Surveys Radio Telemetry	Pilot study completed with baseline data. Future research required	7.0: Q7 & Q8