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Identification and Protection of Critical Breeding Habitat for Red-legged Frogs (*Rana aurora*) in the Stave River Watershed

B.C. Hydro B.C.R.P. Project ID – 10.W.SFN.02

for:

B.C. Hydro Bridge Coastal Restoration Program (B.C.R.P)
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by:

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EXECUTIVE SUMMARY

Through B.C. Hydro Bridge Coastal Restoration Program (BCRP) funding, Madrone Environmental Services Ltd. (Madrone) conducted field surveys to identify suitable breeding sites for Red-legged Frogs (*Rana aurora*), a Provincially Blue-listed and Federal species of *Special Concern* within the Stave River watershed. The goal was to locate and confirm critical breeding habitat for this species and to recommend suitable sites for protection under the *Forest and Range Practices Act* as Wildlife Habitat Areas (WHAs).

A total of 16 sites (wetlands and lakes) in the Stave River watershed were assessed by Madrone for evidence of Red-legged Frog breeding activity (egg masses) in 2010. The sites surveyed ranged from 48 metres to 543 m elevation, with an average of 270 m. The average pH of wetlands that contained egg masses was 6.2, ranging between 5.2, and 7.7. Water temperatures at confirmed Red-legged Frog breeding sites averaged 9.8 °C, and ranged from a low of 5.7 °C on March 30th 2010, to a high of 17 °C on April 17th 2010. Water depths ranged from 0.5 m in the small, shallow water wetlands to >20 m in the larger lakes.

Three survey sessions for Red-legged Frog egg masses were completed during the weeks of March 15th, March 29th, and April 19th, 2010. A total of 40 hours (divided between the team members) were spent surveying the 16 sites; however, not every site was assessed during all three survey sessions due to time constraints and priority of survey effort for the sites with the greatest likelihood of breeding by Red-legged Frogs (sites rated as having "High" habitat suitability).

Red-legged Frog breeding was documented at twelve of the 16 sites (75%), with highest (peak) counts ranging from one to 40 egg masses per site. A total of 324 Red-legged Frog egg masses were located during the 40 survey hours resulting in a success rate of 8.1 egg masses/hour. During the first round of surveys from March 16th to 18th, observed egg masses were either in Stage 1 or Stage 2 of development. Egg masses found during the second round of surveys on March 30th to April 1st were generally in late Stage 2 or Stage 3. The majority of the egg masses observed during the week of April 19th were either partially (Stage 4), or completely hatched out (Stage 5) with masses of egg mass 'jelly' found floating on the surface of the water.

Including Red-legged Frogs, a total of 963 amphibian egg masses were found during the three survey sessions for a detection rate of 24.3 amphibian egg masses found per hour. Breeding (all amphibian species) was confirmed at 14 of the 16 sites (87%) for three additional species of aquatic amphibians: Pacific Treefrog (*Hyla regilla*) (8 sites), Northwestern Salamander (*Ambystoma gracile*) (13 sites), and the Federally listed species of *Special Concern*, Western Toad (*Bufo boreas*) (1 site). No Oregon Spotted Frog (*R. pretiosa*) adults or evidence of breeding activity were found in the project area.

All of the wetlands and lakes where Red-legged Frog breeding was detected in 2010 had water depths ranging between 1 m – 4 m and had moderate to abundant (greater than 30%) egg mass attachment substrate (*i.e.*, emergent or submergent vegetation and small, submergent woody debris). Confirmed breeding sites also had CWD for cover and were in close proximity to suitable foraging (upland) habitat. The majority of the sites had very soft organic bottoms and lacked rocks or gravel. Some of the larger water bodies had gravel along the fringe, but like the wetlands, were dominated by soft organic substrate. As a result of the vegetation assessments for each site, two were classified as bogs, one as a fen, two as marshes, six as swamps, four as lakes, and one as a pond.

Five sites of particularly high quality breeding habitat (Doback, Hunter East, H100 Fork, Pikes Pond, and Worldwide) represent potential WHA candidates. We have mapped suggested WHA boundaries that consist of the breeding site as well as a 50 m buffer to provide foraging and overwinter habitat for adults. Prior to official proposal of these sites for WHA designation, the Ministry of Environment (MoE) recommends obtaining at least one more year of data to justify their protection. Ideally, as per MoE recommendations, at least three years of surveys would be completed at the sites proposed as WHAs.

IDENTIFICATION AND PROTECTION OF CRITICAL BREEDING HABITAT – RED-LEGGED FROGS

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1.0 INTRODUCTION

Hydroelectric power operations in the Stave River watershed date back to 1911 when the Western Canada Power Company constructed two dams on the Stave River. The development of the Stave Falls and Blind Slough Dams caused the Stave River to flood and resulted in the formation of Stave Lake. In 1930, the Ruskin Dam was built on the Stave River, downstream from the previously constructed dams. The reservoir formed behind Ruskin Dam is known as Hayward Lake. In addition to the three dams on the Stave River, B.C. Hydro has a 1 km tunnel flowing southeast from the north end of Alouette Lake to Stave Lake which supplements flows to the Stave Falls and Ruskin Dam powerhouses (B.C. Hydro 2000). The specifications for the facilities and reservoirs associated with the study area are presented in Table 1.

The flooding of Stave and Hayward Lakes is estimated to have resulted in the loss of approximately 2,923 ha of original lake habitat and 2,612 ha of terrestrial habitat, now covering 5,858 ha and 276 ha respectively (Table 1) (B.C. Hydro 2000). It is likely that flooding the area also resulted in a loss of complex wetland habitats used by numerous amphibian species. Although reservoir impoundment can create large expanses of aquatic habitat, they generally lack shallow shoreline areas where emergent vegetation can develop, and regulated water fluctuations further inhibit the growth of aquatic plants. Moreover, fluctuating water levels caused by seasonal water storage and releases can strand frog egg masses, thereby killing embryos through desiccation or freezing (Hawkes 2005). Mortality of embryos also increases with the increasing depth of egg masses in the water column as the water levels rise (Hayes *et al.* 2008).

Table 1. Specifications of Facilities and Reservoirs Associated with the Stave River Watershed (Adapted from B.C. Hydro 2000).

Dam	Stave Falls	Ruskin
Nameplate Capacity (MW)	52.5	106
Dependable Capacity (MW)	50	100
Dam Function	Storage	Storage, Diversion
Date Constructed	1911	- -
Date Operational	- -	1930
Date Reconstructed	1923 (raised)	- -
Height (m)	26	59.4
Length (m)	67	125
Fishway at Dam	No	No
Historic Anadromous Fish Presence	No	Yes
Reservoir	**Stave Lake**	**Hayward**
Cleared / Not Cleared	NC	NC
Present Area (ha)	5,858	276
Watershed Area (km^2)	1,170	953
Present Elevation a.s.l. (m)	81	45
Normal Drawdown Range (m)	9.1	0.5 – 1 (1.8)
Mean Depth (m)	35	16
Maximum Depth (m)	101	38
Storage (million m^3)	365	24
Mean Water Retention Time	5.0 months	Less than 3 days
Mean Annual Discharge (m^3/s)	132	132
Diversion	**To Powerhouse**	**To Powerhouse**
Structure Type	Penstock (43 m – 99 m)	Penstock (22 m – 77 m)
Licensed Flow (m^3/sec)	238	357
Fish Flow Release (m^3/sec)	28 – 84	28 – 84
Mainstem Length Diminished (km)	- -	- -
Mainstem Length Augmented (km)	(from Alouette)	2.8

Due to the loss of these important habitat types, the flooding of Stave Lake may have negatively impacted local populations of Red-legged Frogs (*Rana aurora*) and other amphibians. In addition, increased flows resulting from the Alouette diversion have changed channel hydraulics through the Stave and Hayward lakes portion of the watershed (Lewis *et al.* 1996, cited in B.C. Hydro 2000). Red-legged Frogs are known to be vulnerable to habitat loss and degradation, and the cumulative effects of these processes are of concern throughout their range, including the Lower Mainland (Wind 2003, Ovaska *et al*. 2004). In consequence, Red-legged Frogs have been placed on the Provincial Blue-list and are a COSEWIC (Federal) species of *Special Concern* (COSEWIC 2004, Maxcy 2004).

Established in 1999, the goal of the B.C. Hydro Bridge Coastal Restoration Program (BCRP) is to restore fish and wildlife resources that have been negatively impacted by the development of the hydroelectric facilities.

Impacts include historical effects on fish and wildlife that have occurred as a result of reservoir creation, diversion of watercourses and the construction of dams.

1.1 Red-legged Frog

The range of Red-legged Frogs extends from northern California to B.C. In B.C., Red-legged Frogs are found on the coast, on Vancouver Island and the Gulf Islands, the mainland adjacent to the Strait of Georgia, and through the Fraser Valley inland to Hope (COSEWIC 2004).

Red-legged Frogs use both aquatic and terrestrial habitats. Adults and juveniles forage primarily in terrestrial habitats, typically spending up to 90% of their time in moist forested areas with abundant leaf litter and woody debris (COSEWIC 2004). Juvenile and adult life stages are opportunistic foragers that feed on slugs, spiders, and numerous insect species (IWMS 2004). Tadpoles are herbivorous and feed on algae and decomposing vegetation.

Breeding habitats include a variety of aquatic and wetland sites with still or slow moving water, adequate water depth (> 50 cm) for larval rearing, and emergent vegetation suitable for egg mass attachment (IWMS 2004). Submergent vegetation and coarse woody debris (CWD) can also be important breeding habitat attributes, as they provide attachment substrates for egg masses and protective cover from predation, particularly for larvae and small juveniles. Aquatic sites may be either permanent or ephemeral in nature, but in the latter case the site must have a hydroperiod (when a wetland contains visible water) for at least five months to allow for successful rearing of tadpoles (COSEWIC 2004).

In southwestern B.C., breeding activities typically begin between late February and early March. Adult frogs become active from a state of torpor and migrate to breeding habitat during late winter and early spring. Migration to breeding sites begins when daylight temperatures exceed 4 – 5°C. Males begin calling to potential mates (not audible to humans without a hydrophone) when air and water temperatures have been at least 6°C for several days (Brown 1975). Breeding activities can last anywhere from 2 – 4 weeks, depending on the weather conditions. Females lay a single mass, consisting of hundreds of eggs. Clutch sizes can be large (up to 1300 eggs) and shows a positive correlation with body size of the female (Leonard *et al*. 1993). One study near Vancouver, B.C. recorded an average clutch size of 680 eggs (range: 243 – 935 eggs; Licht 1974).

Once laid, the eggs take up to 5 weeks to hatch. Red-legged Frog tadpoles then take from 3 – 4 months to metamorphose. Adults reach sexual maturity 2 – 3 years after metamorphosis (Licht 1974). As Red-legged Frog females lay only one clutch per season, complete counts of egg masses can be used to gauge the breeding population size (Crouch and Paton 2000, Sendak 2008).

1.1.1 Egg Masses

Red-legged frog egg mass development is typically classified into five stages. When Red-legged Frog egg masses are first laid, they are roughly the size of a grapefruit or cantaloupe and are considered to be in Stage 1 of development (Photo 1) (Corkran and Thoms 1996). Each egg is approximately 3 mm in size, black on top and white below, and is surrounded by a layer of thick jelly. As the eggs progress through development they take on a kidney shape (Stage 2) (Photo 2), at which time the entire egg mass commonly floats to the surface where it can begin "foaming" as air bubbles accumulate around the eggs (Photo 3) (Corkran and Thoms 1996). In Stage 3 of development (Photo 4 and Photo 5), the egg becomes a tadpole about 4 mm – 6 mm long. As the tadpole continues to grow it eventually hatches out of the jelly egg mass and is free swimming (Stages 4 and 5) (Photos 6 and 7). The time frame for eggs to metamorphose from Stage 1 through to Stage 5 is dependent on environmental conditions such as water temperature, and can take 3 – 5 weeks (Brown 1975, Lange 2010).

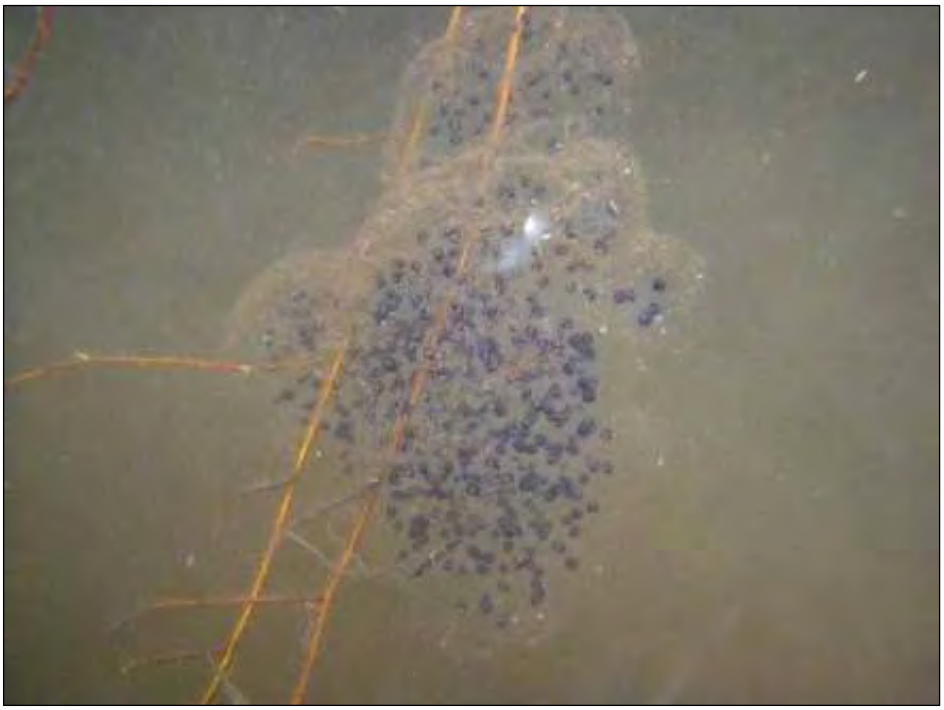

Photo 1. A Stage 1 egg mass found in Hunter West on March 30th, 2010.

Photo 2. A Stage 2 egg mass found in Salsbury Creek on April 20th, 2010.

Photo 3. A frothing egg mass found in H100 Fork on April 20th, 2010.

Photo 4. A Stage 3 egg mass found in Pikes Pond on March 30th, 2010.

Photo 5. A late Stage 3, early Stage 4 egg mass found in Hunter West on April 21st, 2010.

Photo 6. A Stage 4 egg mass, with algae incorporated into the eggs, found in Doback on April 20th, 2010.

Photo 7. An entirely hatched out Stage 5 egg mass found in H100 Fork on April 19th, 2010.

1.1.2 Status of Red-legged Frog

The Red-legged Frog is a Federal species of Special Concern (COSEWIC 2004) and Provincially Blue-listed. Frog populations in BC are susceptible to habitat degradation as well as to predation and competition from introduced species such as Bullfrogs (*Rana catesbeiana*), Green Frogs (*Rana clamitans*), and predatory fish including Rainbow Trout (*Oncorhynchus mykiss*). Extensive residential and agricultural development in the Fraser Valley threatens to further fragment historically rich Red-legged Frog habitat (COSEWIC 2004).

2.0 PROJECT OBJECTIVES

Madrone Environmental Services Ltd. (Madrone) was funded by the B.C. Hydro BCRP to identify and survey suitable breeding sites for Red-legged Frogs within the Stave River watershed. Egg mass surveys were carried out during the spring 2010 breeding season to identify specific sites and types of aquatic/wetland habitat being used by Red-legged Frogs in the area. The ultimate goal was to locate regionally important breeding habitat for this Blue-listed species of *Special Concern* and to recommend suitable sites for protection under the *Forest and Range Practices Act* as Wildlife Habitat Areas (WHAs).

Project objectives consisted of the following:

I. To survey and map occupied Red-legged Frog breeding habitat in the Stave River Watershed.

II. To determine the relative importance of each documented breeding site as judged from egg mass counts, which can provide a reliable measure of the minimum effective breeding population size for that season.

III. To describe key biotic (vegetation), physical and hydrological attributes of these sites.

IV. To recommend specific habitat areas for protection through the establishment of WHAs as warranted by the data.

3.0 STUDY AREA

The Stave River watershed encompasses an area over 1,100 km^2 (Figure 1) and is located within the Coastal Western Hemlock (CWH) and Mountain Hemlock (MH) biogeoclimatic zones (Green and Klinka 1994). The project study area is situated in both the CWHdm (dry, mild) and CWHvm1 (submontane, very wet maritime) subzones. Warm, dry summers and moist, mild winters with little snowfall characterize the CWHdm subzone. The CWHvm1 subzone (160 m – 650 m a.s.l.) occurs at elevations above the CWHdm (0 – 160 m a.s.l.) and features wet, cool summers and mild winters with little snow (Green and Klinka 1994).

Forests in the CWHdm are comprised predominantly of western hemlock (*Tsuga heterophylla*), Douglas-fir (*Pseudotsuga menziesii*) and western redcedar (*Thuja plicata*) while forests in the CWHvm1 are comprised of western hemlock, amabilis fir (*Abies amabilis*), and western redcedar. Habitats of concern with regard to this project included primarily aquatic and wetland ecosystems.

The area of focus for this study consisted of Provincial Crown land in the central / southern end of the Stave River Watershed (Figure 2).

Terrarosa Lake
Kinnear Lake
Widgeon Lake
Hector Ferguson Lake
Blinch Lake
Talus Lake
Gabbro Lake
Raven Lake
Kenyon Lake
Bennie Lake
Stave Lake
Salisbury Lake
Florence Lake
Rose Lake
Katherine Lake
Pine Lake
Morgan Lake
Twin Lakes
Munro Lake
Eunice Lake
Alouette Lake
Gwendoline Lake
Placid Lake
Peaceful Lake
Crane Ponds
Bird Lake
Lost Lake
Loon Lake
Jacobs Lake
Beautiful Lake
Sayres Lake
McKay Lake
Davis Lake
Blaney Lake
Goose Lake
Devils Lake
Cannell Lake
Hoover Lake
Rolley Lake
Allan Lake
Whonnock Lake
Hayward Lake
Silvermere Lake
Hatzic L

British Columbia
Vancouver Island
Study Area
Pacific Ocean

Stave River Watershed
Red-legged Frog Surveys (2010)

- Survey Locations
- Stave Watershed Boundary
- Stream
- Lake / River
- Paved Road
- Unpaved Road
- Contour (20m interval)

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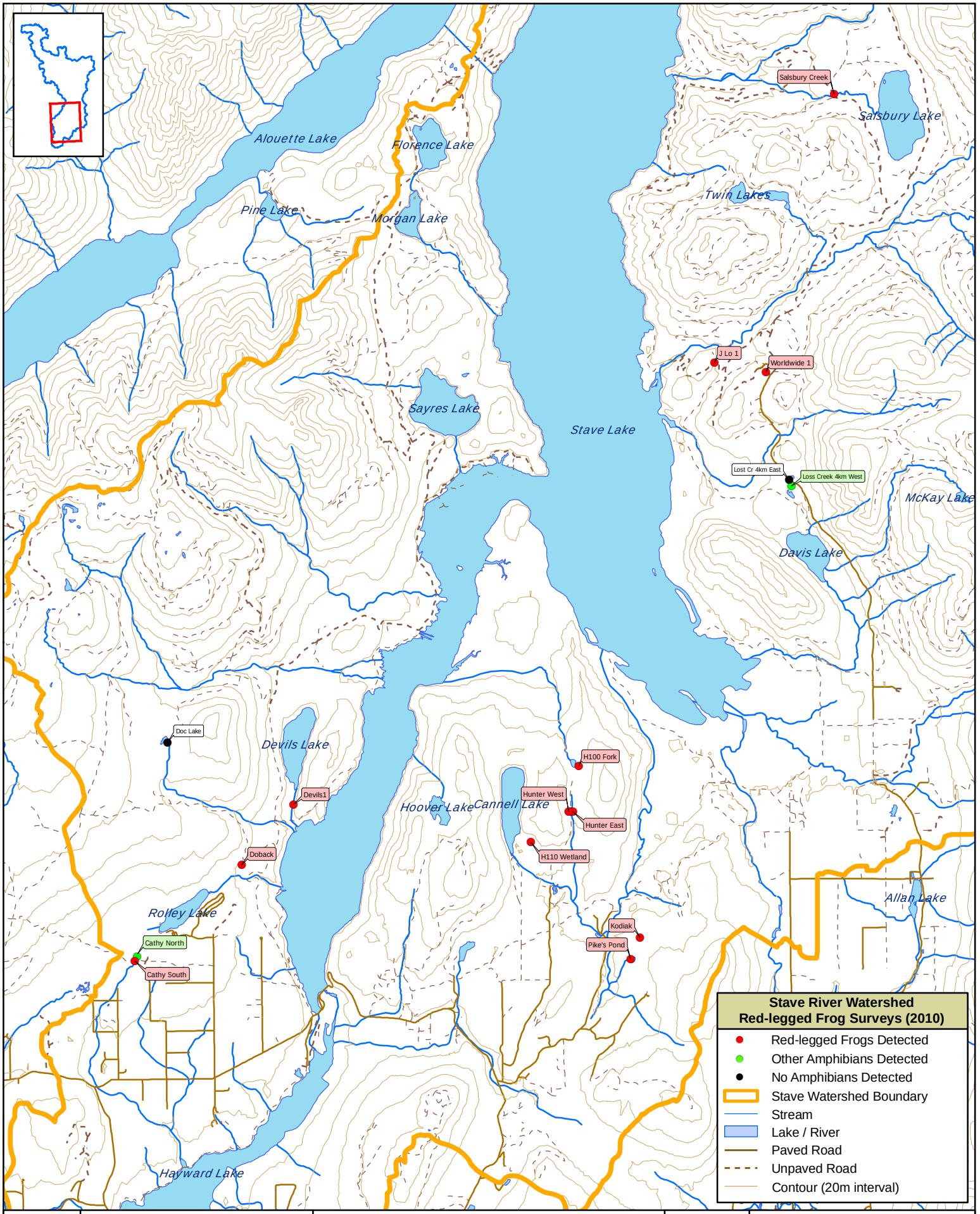
FIGURE 1:	PROJECT:	DOSSIER NO:
Study Area Location Map	Protection of Critical Breeding Habitat for Red-Legged Frogs	10.0033

GEOGRAPHIC AREA:	CLIENT:	FIELD DATES:	MAP SCALE:	MAPPING DATE:	DRAWN BY:
Stave Lake, BC	BC Hydro BCRP	March- April 2010	1:175,000	May 25, 2010	Anna Jeffries

N

Scale 1:175,000

0 2 4 6 km



MADRONE ENVIRONMENTAL SERVICES LTD	*FIGURE 2:* Focal Area within Stave River Watershed	*PROJECT:* Protection of Critical Breeding Habitat for Red-Legged Frogs				*DOSSIER NO:* 10.0033
	GEOGRAPHIC AREA: Stave Lake, BC	*CLIENT:* BC Hydro BCRP	*FIELD DATES:* March- April 2010	*MAP SCALE:* 1:80,000	*MAPPING DATE:* August 12, 2010	*DRAWN BY:* Anna Jeffries

4.0 METHODS

Prior to commencing fieldwork, GIS-based field maps of the study area were produced using Terrain Resource Inventory Management (TRIM) Data at a scale of 1:60,000 for overview reference and 1:5,000 to 1:15,000 for site surveys. Detailed maps of the Stave River watershed, as well as the B.C. Wetlands page on the Community Mapping Network (2008) website, were used initially to identify suitable wetlands for surveys. As WHAs can only be proposed on Provincial Crown land, we limited the survey sites to applicable lands.

Systematic, visual surveys of lakes and wetlands were carried out by boat and wading according to Resources Inventory Standards Committee (RISC 1998). A boat was only used to conduct surveys when water levels were too high to safely wade. Lake shorelines, for the most part, were surveyed along a single curvilinear transect, circling the fringe of the entire water body. In the more suitable and complex wetland habitats, multiple, irregular transects were used in order to obtain a census of the wetland. Our primary objective was to identify critical breeding sites for Red-legged Frogs, therefore our level of effort varied between sites based on quality and documentation of focal species presence.

Each lake/wetland was given a unique identification code, and data were recorded with respect to weather conditions, location, littoral area, water body description, water searchability, water temperature, water pH, elevation, fish presence, and amphibian egg mass presence. Water temperature and water pH data were collected at or near outlets of the subject wetlands using a Hanna Instruments™ model HI 98129 water tester. Location and elevation data were collected using a Garmin® GPSmap Cx 76 handheld GPS unit.

Information pertaining to substrate (*i.e.,* rocky or soft organic substrate), vegetation type (*i.e.,* within the water body and riparian area), and vegetation cover (percentage of emergent and submergent) was recorded. Each surveyed site was documented and marked in the field using GPS coordinates and digital photography. All surveyed wetlands were classified based on *Wetlands of British Columbia – A guide to identification* by MacKenzie and Moran (2004).

Sites were assessed for habitat suitability and rated as High, Moderate or Low for Red-legged Frog breeding potential. Ratings were determined by comparing each site against a set of criteria that included: quality of vegetation for egg mass attachment, CWD for protection from predators (*i.e.*, fish presence), and pond permanence.

Although Red-legged Frog breeding activity was the main focus of our surveys, any indication of breeding by other aquatic amphibian species was recorded, including information on the size and developmental stage of all observed egg masses. The field guide *Amphibians and Reptiles of British Columbia* (Matsuda *et al*. 2006) was used to assist with identification where needed.

4.1 Mapping and Data Entry

All of the project field data were recorded on the Ministry of Environment Ecosystems Section Amphibian Survey Data Forms (Appendix III). The data were then organized into a spreadsheet to be uploaded to the Provincial Species Inventory (SPI) Database.

Final map products were produced in ArcMap 9.3 using TRIM Data. An overview map of the Stave River Watershed, which displayed the location of each survey site, was produced at a scale of 1:175,000. More detailed maps were produced for those sites being proposed as WHAs. A combination of ortho-photography and TRIM Data were used to display the boundaries of each site at a scale of 1:5,000.

5.0 RESULTS

A total of 26 lake and wetland sites within the Stave River Watershed study area were selected as candidates for egg mass surveys on the basis of pre-field suitability mapping or discovery while traveling within the project area. Upon further evaluation in the field, we concluded that 16 of the 26 candidate sites had habitat characteristics to warrant at least one egg mass survey. The remaining 10 sites were inaccessible and/or unsuitable (lacking suitable habitat characteristics or not on Crown land) and therefore not assessed. The sites surveyed ranged in elevation from 48 m to 543 m (Table 2).

Ambient temperature data from Environment Canada for January through March 2010 appears to be higher than average historical averages (Figure 3). Surveys were initiated in early spring due to the mild winter of 2010 potentially accelerating ice-off for wetlands in the project area.

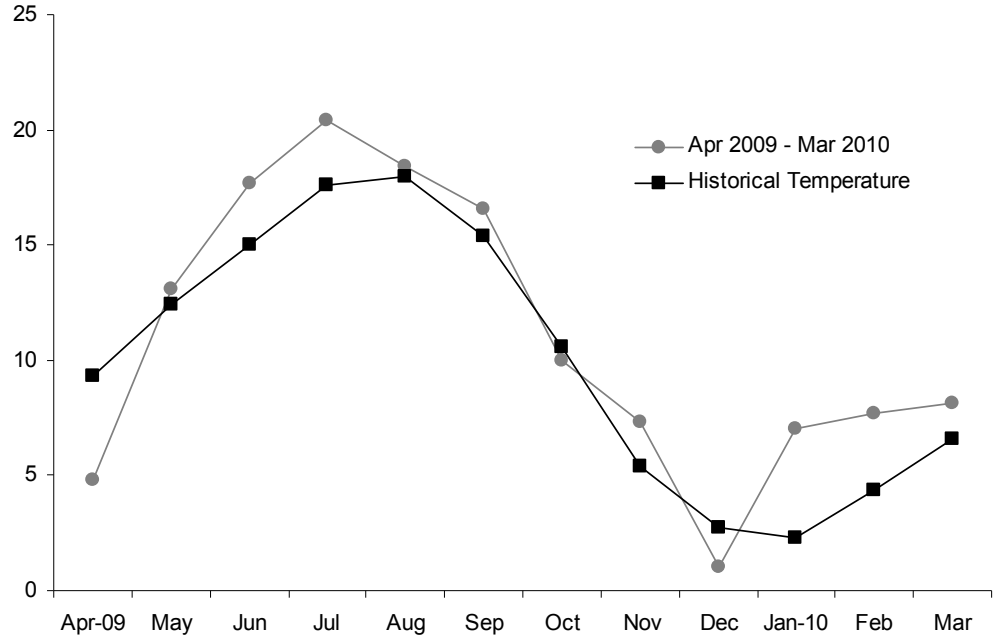


Figure 3. Comparison of the period from April 2009 to Mar 2010 and historical average temperatures for the Mission area (Environment Canada 2010).

Three survey sessions for Red-legged Frog egg masses were completed during the weeks of March 15th, March 29th, and April 19th 2010. A total of 40 hours were spent surveying the 16 sites. This survey time includes each surveyor's effort (e.g. if two people spent 1 hour surveying a wetland, total survey time would equal 2 hours). Not every site was assessed during all three survey sessions due to time constraints and priority of survey effort for the sites with the greatest likelihood of breeding by Red-legged Frogs (sites rated as having "High" habitat suitability). Red-legged Frog breeding was documented at twelve of the 16 sites (75%), with highest (peak) counts ranging from one (Devils 1, April 1st) to forty (Worldwide 1, March 31st) egg masses per site (Table 2). A total of 324 Red-legged Frog egg masses were located during the 40 survey hours (8.1 egg masses/hour) (Table 2).

Table 2. Number of Amphibian Egg Masses Counted During Surveys of Potential Red-legged Frog Breeding Sites in the Stave River Watershed Study Area in 2010.

Wetland ID (Elevation in m)	Elev. (m)	Survey Date	Water Temp (ºC)	pH	RAAU Egg Masses	HYRE Egg Masses	AMGR Egg Masses	BUBO Egg Masses	Total of All Species
Cathy North	226	March 18, 2010	6.5	6	0	0	1	0	1
		April 20, 2010	12	5.6	0	5	0	0	5
Cathy South	226	March 18, 2010	6.5	6	38	0	0	0	38
		April 20, 2010	12	5.9	5	1	19	0	25
Devils 1	132	April 1, 2010	8.4	7.6	1	0	1	0	2
Doback	206	March 18, 2010	8.3	6.3	31	1	19	0	51
		April 20, 2010	14	6.4	13	0	0	0	13
Doc Lake	543	March 18, 2010	6.5	5.2	0	0	0	0	0
		April 20, 2010	13	5.2	0	0	0	0	0
H110 Wetland	280	March 16, 2010	10	6.3	15	0	1	0	16
		April 21, 2010	10	6.9	5	0	20	0	25
H100 Fork	311	March 17, 2010	8	7	20	0	0	0	20
		April 19, 2010	15	7.5	20	80	0	0	100
Hunter East	347	March 17, 2011	-	-	6	0	0	0	6
		March 30, 2010	6.8	6.9	26	0	5	0	31
		April 21, 2010	8.8	6.8	18	0	11	0	29
Hunter West	370	March 30, 2010	7.3	7.1	9	0	0	0	9
		April 21, 2010	8.6	6.9	8	0	5	0	13
J Lo 1	190	April 20, 2010	12	5.7	6	0	5	0	11
Kodiak	215	March 16, 2010	7.7	6.5	9	3	4	0	16
		March 30, 2010	7	7.2	9	0	6	0	15
Lost Creek 4k West	200	March 31, 2010	7.7	7.3	0	0	6	0	6
Lost Creek 4k East	202	March 31, 2010	7.4	7.6	0	0	0	0	0
Pikes Pond	212	March 30, 2010	5.7	7.7	23	0	4	0	27
		April 19, 2010	17	7.7	14	150+	75+	0	239
Salsbury Creek	425	April 20, 2010	12	6.8	2	35	91	~75*	203
Worldwide 1	313	March 31, 2010	7.5	6.4	40	3	5	0	48
		April 20, 2010	14	6.1	6	0	8	0	14
TOTAL					324	278	286	75	963

A-RAAU (*Rana aurora*) = Red-legged Frog, HYRE (*Hyla regilla*) = Pacific treefrog, AMGR (*Ambystoma gracile*) = northwestern salamander, BUBO (*Bufo boreas*) = Western toad.
*BUBO egg masses seen at Salsbury Creek were tightly packed together in a shallow 2 m x 2 m area which did not allow for accurate counts without risk of damage to the masses.

During the first round of surveys from March 16th to 18th, observed egg masses were either in Stage 1 or Stage 2 of development. Egg masses found during the second round of surveys between March 30th and April 1st were generally in late Stage 2 or Stage 3.

Salsbury Creek, the second highest site surveyed in the project area at 425 m elevation, had two Stage 3 egg masses when surveyed on April 20th (third round of surveys). However, the majority of the egg masses in the other sites during the week of April 19th were either partially (Stage 4), or completely hatched out (Stage 5) with masses of egg mass 'jelly' found floating on the surface of the water.

All of the wetlands and lakes where Red-legged Frog breeding was detected in 2010 had water depths ranging between 1 m – 4 m and had moderate to abundant (greater than 30%) egg mass attachment substrate (*i.e.*, emergent or submergent vegetation and small, submergent woody debris). Confirmed breeding sites also had CWD for cover and were in close proximity to suitable foraging (upland) habitat.

The majority of egg masses found in the subject wetlands were attached to herbaceous vegetation. Beaver activity was noted throughout the project area and in many wetlands Red-legged Frogs used the vegetation within the deep pools created by beaver dams for egg mass deposition sites. There were only two survey sites (Worldwide 1 and Cathy South) where egg masses attached to submergent woody material was greater than or equal to the number of egg masses attached to herbaceous vegetation. These two sites were also the wetlands with the greatest number of egg masses observed during 2010 surveys.

Breeding was also confirmed at 14 of the 16 sites for three additional species of aquatic amphibians: Pacific Treefrog, Northwestern Salamander and the Federally listed species of *Special Concern*, Western Toad (Table 2). Northwestern Salamander egg masses were recorded at 13 sites, Pacific Treefrog at 8 sites, and Western Toad at 1 site. No Oregon Spotted Frog adults or evidence of their breeding activity were found in the project area. Including Red-legged Frogs, a total of 963 amphibian egg masses were found during the three survey sessions for a rate of 24.3 egg masses found per hour.

All surveyed wetlands in the watershed had similar pHs, and ranged between 5.2 and 7.7 (Table 2). The average pH of wetlands that contained egg masses was 6.2. Water temperatures at confirmed Red-legged Frog breeding sites averaged 9.8 °C, and ranged from a low of 5.7 °C on March 30th to a high of 17 °C on April 17th (Table 2). Water levels dropped considerably throughout the wetlands in the project area over a one month period (March 18th to April 20th). For example, Cathy North showed a 0.5 m decrease over that period, stranding some Northwestern Salamander egg masses above the water line.

5.1 Habitat Suitability

The majority of the sites that were assessed for Red-legged Frog breeding habitat suitability had very soft organic bottoms and lacked rocks or gravel. Some of the larger water bodies had gravel along the fringe, but like the wetlands, were dominated by soft organic substrate.

Of the 16 sites surveyed, five were rated as High, six Moderate, and five as Low breeding habitat suitability. Vegetation assessments at each site resulted in two being classified as bogs, one as a Fen, two as Marshes, six as Swamps, four as lakes, and one as a pond (Table 3). A summary of the different types of wetlands and waterbodies found in the project area is found in Table 3. Detailed descriptions on each site are provided in the following Section 5.1.1, and Appendix IV.

5.1.1 High Habitat Suitability Sites

The following waterbodies were rated as having High habitat suitability based on the presence of characteristics as described in COSEWIC (2004). These sites appear to have the most potential for designation as WHAs for protection of Red-legged Frog critical breeding habitat. Under the *Forest and Range Practices Act*, in conjunction with the document *Accounts and Measures for Managing Identified Wildlife*, buffers for WHA's are set at 50 m from the edge of the wetland to protect the breeding site as well as the foraging and overwinter habitat for both juveniles and adults.

The WHA buffer encompasses a core area (30 m from the high water mark) and management zone (20 m beyond the core area) (IWMS 2004). Figure 4 to Figure 8 illustrate the proposed WHA boundaries for each of the five sites with High habitat suitability. Moderate and Low habitat suitability waterbodies are described in Appendix IV.

Table 3. Wetland Classification and Habitat Suitability Results for Surveyed Waterbodies in the Stave River Watershed.

	UTM (10U)	Elevation (m)	Submergent & Emergent Vegetation (%) [1]	Large Woody Debris [2]	Fish Presence (Predation Risk)	Beaver Activity	Suitability Rating	Red-legged frog Breeding
Bog								
Wb50 – Labrador tea - Bog laurel – Peat-moss								
Kodiak	5454519N, 552235E	190	S: 70, E: 25	T	No	Yes	Moderate	Y
H110 Wetland	5456049N, 550430E	280	S: 70, E: 20	M	No	No	Moderate	Y
Fen								
Wf52 – Sweet gale – Sitka sedge								
Cathy South	5454065N, 543808E	226	S: 20, E: 10	M	No	Yes	Moderate	Y
Marsh								
Wm50 – Sitka Sedge – Hemlock-parsley								
Lost Creek 4k East	5462107N, 554751E	202	S: 5, E: 2	M	No	No	Low	N
Lost Creek 4k West	5462006N, 554787E	200	S: 45, E: 35	M	No	Yes	Low	N
Swamp								
Ws50 – Pink spirea – Sitka sedge								
Cathy North	5454130N, 543850E	226	S: 75, E: 15	M	No	No	Low	N
J Lo 1	5464061N, 553504E	190	S: 10, E: 20	A	No	No	Moderate	Y
Ws54 – Western redcedar – Western hemlock – Skunk cabbage								
Doback	5455670N, 545593E	206	S: 60, E: 15	A	No	Yes	High	Y
Hunter East	5456554N, 551139E	363	S: 20, E: 15	A	No	Yes	High	Y
Hunter West	5456565N, 551062E	370	S: 15, E: 10	M	No	Yes	Moderate	Y
Salsbury Creek	5468572N, 555578E	425	S: 50, E: 30	M	Yes	Yes	Moderate	Y

Table 3. Wetland Classification and Habitat Suitability Results for Surveyed Waterbodies in the Stave River Watershed (con't)

	UTM (10U)	Elevation (m)	Submergent & Emergent Vegetation (%) [1]	Large Woody Debris [2]	Fish Presence (Predation Risk)	Beaver Activity	Suitability Rating	Red-legged frog Breeding
Lake								
H100 Fork	5457320N, 551229E	311	S: 40, E: 15	M	Yes	Yes	High	Y
Devils 1	5456681N, 546460E	132	S: 30, E: 20	M	Yes	Yes	Low	Y
Doc Lake	5457718N, 544358E	543	S: 5, E: 10	T	No	No	Low	N
Worldwide 1	5463905N, 554363E	313	S: 5, E: 1	M	No	No	High	Y
Pond								
Pikes Pond	5454093N, 552169E	185	S: 70, E: 15	T	No	Yes	High	Y

[1] The percentage of the substrate of the wetland that is covered by either submergent or emergent vegetation. For example, Pikes Pond has 70% submergent vegetation (S) cover and 15% emergent vegetation (E) cover for a total of 85% of the substrate of the pond being covered by vegetation. Non-vegetated portions of the wetlands in the study area were generally organic soil or wood covered.

[2] N = None ; T = Trace (3 to 5% of substrate is covered by CWD); M = Moderate (5 to 20% cover); A = Abundant (greater than 20% cover).

5.1.1.1 Doback

Habitat Type: Ws54 – Western redcedar – Western hemlock – Skunk cabbage Swamp / Proposed WHA size: 2.8 ha

This 0.5 ha swamp is situated on the northwest side of Rockwell Road prior to Doc Lake (Photo 8). Habitat in this wetland was very complex with abundant CWD, stumps, and submergent vegetation located throughout. Emergent vegetation such as rushes (*Juncus* sp.) and sedges (*Carex* sp.) were not prevalent, but the amount of submergent vegetation present was suitable for Red-legged frog egg mass attachment, based on the number found (30) during the initial survey on March 18th. The majority of the egg masses found in Doback were located on the west bank of the wetland.

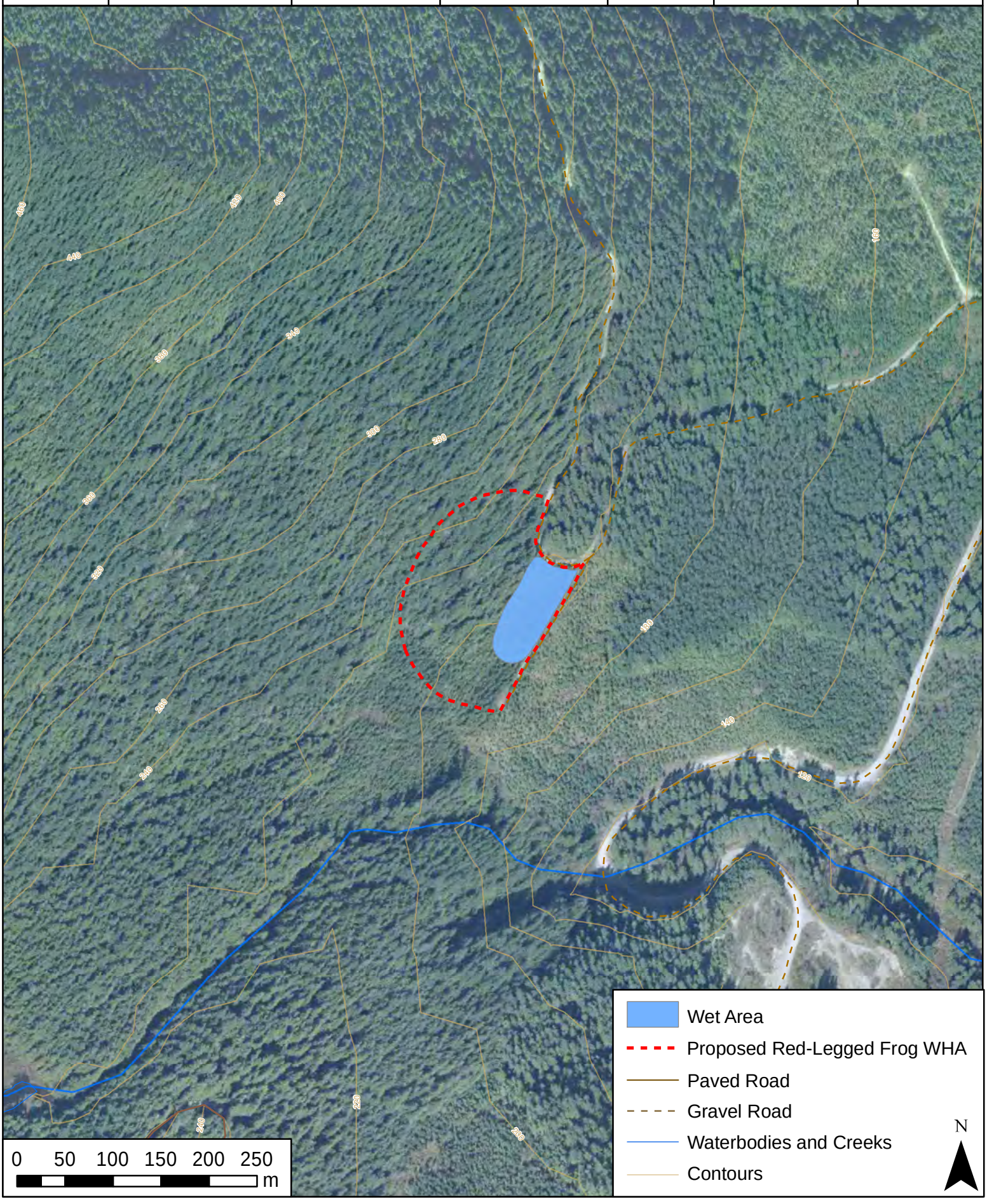
The surrounding western redcedar and western hemlock forest was younger on the east side of the wetland (Structural Stage 4), than on the west side (Structural Stage 5), possibly due to a partially overgrown road bordering the eastern side of the pond. The shrub layer consisted primarily of salal (*Gaultheria shallon*) and regenerating western redcedar. Herbaceous vegetation in the forested fringe was dominated by deer fern (*Blechnum spicant*) and trailing blackberry (*Rubus ursinus*).

Beaver activity on the south end of Doback was obvious, with numerous small stumps and two dams forming a small, relatively deep pool (greater than 2 m deep) (Photo 9). The outflow of Doback was strongly affected by the outer dam, as the dam was over 1 m in height, allowing for a slow flow out of the wetland. Deep water (greater than 1 m deep) was still present throughout the southwestern portion of the swamp during a site visit on July 19th, 2010.

Photo 8. Facing north toward the top end of Doback on March 18th2010. This area is highly complex, with ample submergent vegetation and large wood. Red-legged Frog masses were scattered throughout this portion of the wetland, but most abundant on the west side.

Photo 9. Facing west at a beaver dam at the southern end of Doback on March 18th2010. The pool formed as a result of beaver activity was approximately 1.5 m deep and red-legged frog egg masses were found in the area marked by the orange circle.

MADRONE environmental services ltd	FIGURE 4: Doback Potential WHA	PROJECT: Protection of Critical Breeding Habitat for Red-Legged Frogs				DOSSIER NO: 10.0033
	GEOGRAPHIC AREA: Stave Lake, BC	CLIENT: BC Hydro BCRP	FIELD DATES: March - April 2010	MAP SCALE: 1:5,000	REVISION DATE: Oct 26, 2010	DRAWN BY: Anna Jeffries



5.1.1.2 Hunter East

Habitat Type: Ws54 – Western redcedar – Western hemlock – Skunk cabbage Swamp / Proposed WHA size: 5.0 ha

Hunter East is a swamp located approximately 1.5 km up Hunter Road from the gate at the end of Roach Road in Mission. Hunter East comprises of a series of pools totaling 1 ha in size, with relatively abundant CWD located at the northern inflow area and ample vegetation throughout (Photo 10).

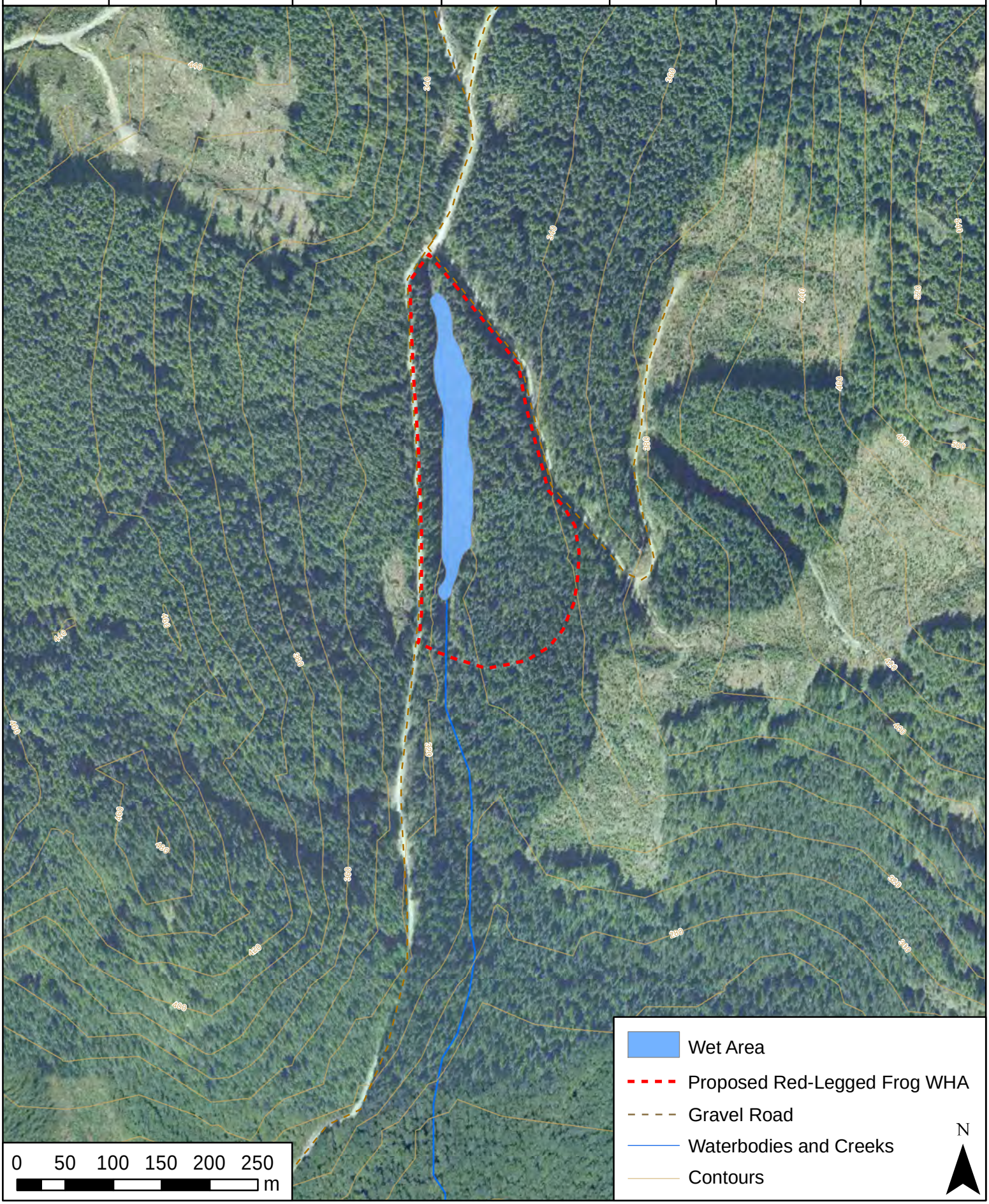
The series of pools making up Hunter East drain down into each other over multiple beaver dams. Flow over the dams is limited, except for the southernmost dam where flows increase, with alluvial deposits present downstream. Alluvial deposits are also present at the northern boundary of Hunter East.

Salal, salmonberry (*Rubus spectabilis*), and skunk cabbage (*Lysichiton americanum*) dominate the fringe of the wetland, with rushes and sedges making up the majority of herbaceous vegetation within the waterbody. A young forest of western hemlock, western redcedar, and Douglas-fir surrounds the wetland.

The southwestern end of the northern most pool was where the majority of the egg masses were located. This area of the wetland had the most suitable vegetation and appeared to be the area collecting the greatest amount of sun during the day, based on aspect and shade from surrounding trees.

Photo 10. Looking south at Hunter East on March 30th2010. This wetland was given a high ranking for Red-legged Frog habitat due to the presence of ample vegetation, deep water, and large wood.

MADRONE environmental services ltd	FIGURE 5: Hunter East Potential WHA	PROJECT: Protection of Critical Breeding Habitat for Red-Legged Frogs				DOSSIER NO: 10.0033
	GEOGRAPHIC AREA: Stave Lake, BC	CLIENT: BC Hydro BCRP	FIELD DATES: March - April 2010	MAP SCALE: 1:5,000	REVISION DATE: Oct 26, 2010	DRAWN BY: Anna Jeffries



5.1.1.3 H100 Fork

Habitat Type: Lake / Proposed WHA size: 5.8 ha

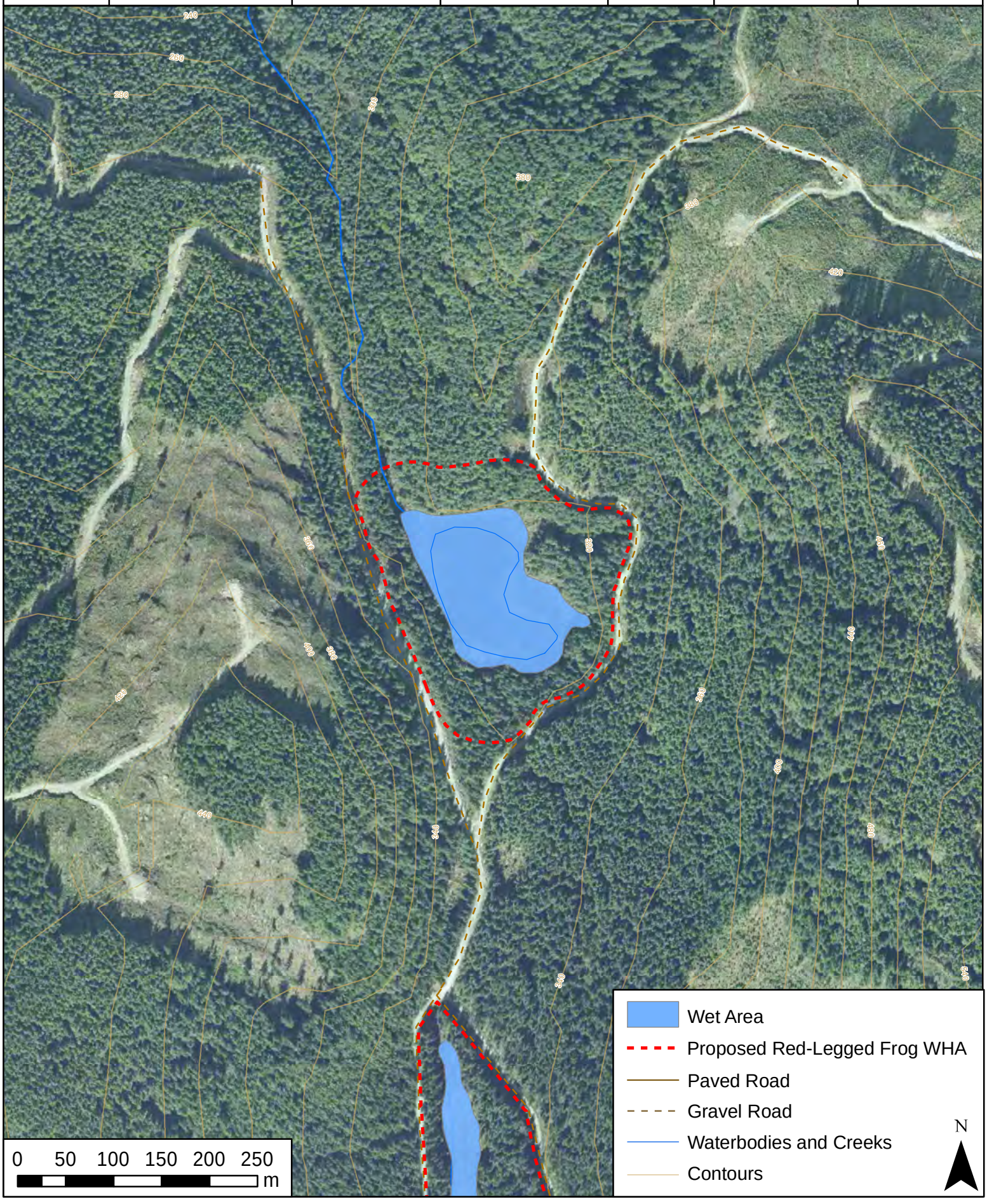
H100 Fork was one of the larger wetlands surveyed in the watershed with a littoral area size of approximately 1.5 ha (Photo 11). It is located slightly north of the fork of Spur Roads HW100 and H100 and represents the headwaters for Isle Slough, which is an arm of Stave Lake. Boat surveys were primarily used to search for egg masses due to the size and depth (greater than 4 m at steep drop offs) of this peatland lake; however, in shallow areas, wading surveys also occurred.

The forested area surrounding the complex was dominated by western redcedar with scattered western hemlock. Hardhack (*Spirea douglasii*) and salal dominated the shrub layer in the forested area, with Labrador Tea (*Ledum groenlandicum*) found primarily on the vegetated islands in the wetland. Submergent vegetation was prevalent throughout the shallow area of H100 Fork. Large woody debris was particularly abundant at the northeast corner of the wetland near the outflow. A beaver dam occurred at the outflow and a lodge was located in close proximity to the dam on the north shore near an inflow.

Egg masses (20) found in H100 Fork on March 17th were concentrated on the north shore of the wetland in water between 0.5 m and 1 m in depth. All of the masses were attached to herbaceous vegetation.

Photo 11. Looking northwest at H100 Fork on March 17th 2010. This peatland lake consisted of a shallow, well vegetated area on the east side, and a much deeper, less vegetated area on the west side.

MADRONE environmental services ltd	FIGURE 6: H100 Fork Potential WHA	PROJECT: Protection of Critical Breeding Habitat for Red-Legged Frogs				DOSSIER NO: 10.0033
	GEOGRAPHIC AREA: Stave Lake, BC	CLIENT: BC Hydro BCRP	FIELD DATES: March - April 2010	MAP SCALE: 1:5,000	REVISION DATE: Oct 26, 2010	DRAWN BY: Anna Jeffries



5.1.1.4 Pikes Pond

Habitat Type: Pond / Proposed WHA size: 4.8 ha

The area surrounding this small pond (0.5 ha) is a popular site for hikers, with heavily used trails around the entire pond and nearby vicinity. The edge of the wetland has dense salal growth mixed with young regenerating western redcedar and western hemlock. The presence of the herbaceous vegetation in the pond was suitable for Red-legged Frog egg mass attachment. Vegetation cover was consistent throughout Pikes Pond, with the shallow north end containing more emergent vegetation than the south end. The deeper south end, however, had plentiful potential egg mass attachment media just under the surface (Photo 12).

Beaver activity was present in the form of a dam at the outlet at the south end of the pond. The depth of the pond at the south end made wading difficult; however, the water was clear enough to see to the bottom and any egg masses in the vegetation. Twenty three Red-legged Frog egg masses were found during the initial site visit on March 30th. The second visit on April 20th revealed that all Red-legged egg masses had hatched out.

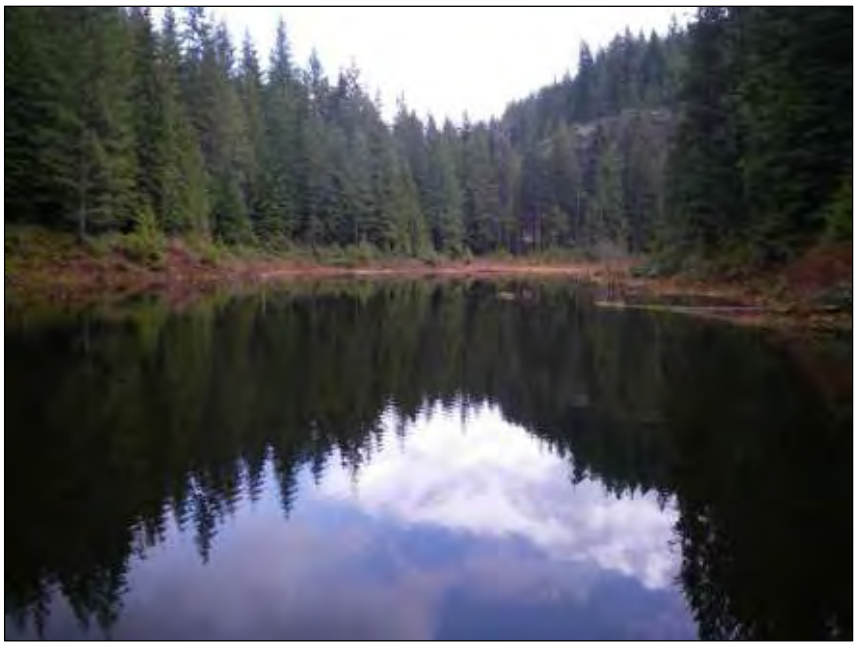
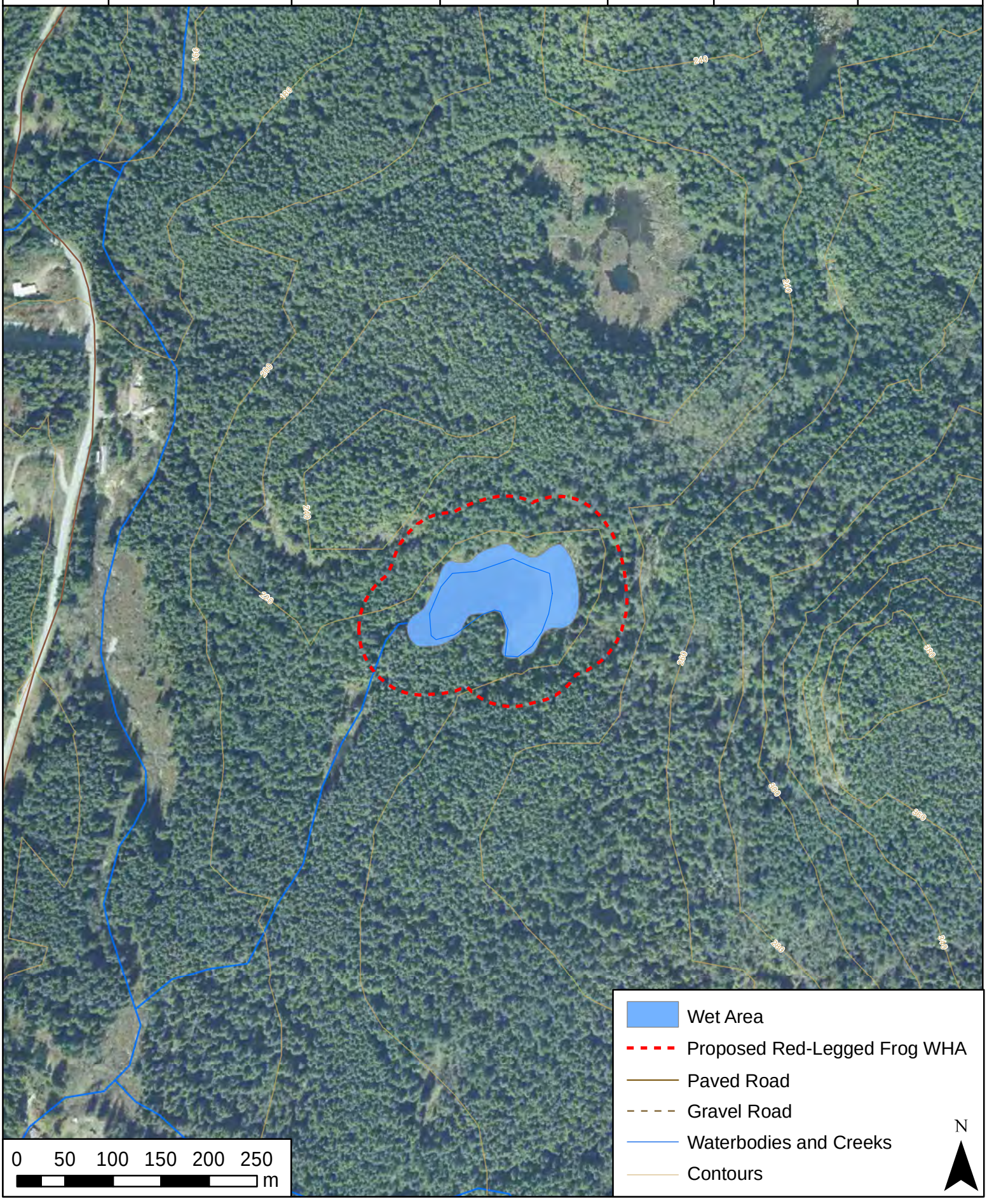


Photo 12. Looking northeast at Pikes Pond on March 30th2010. This wetland had an excellent mix of emergent and submergent vegetation throughout.

MADRONE environmental services ltd	FIGURE 7: Pikes Pond Potential WHA	PROJECT: Protection of Critical Breeding Habitat for Red-Legged Frogs				DOSSIER NO: 10.0033
	GEOGRAPHIC AREA: Stave Lake, BC	CLIENT: BC Hydro BCRP	FIELD DATES: March - April 2010	MAP SCALE: 1:5,000	REVISION DATE: Oct 26, 2010	DRAWN BY: Anna Jeffries



5.1.1.5 Worldwide 1

Habitat Type: Lake / Proposed WHA size: 2.5.ha

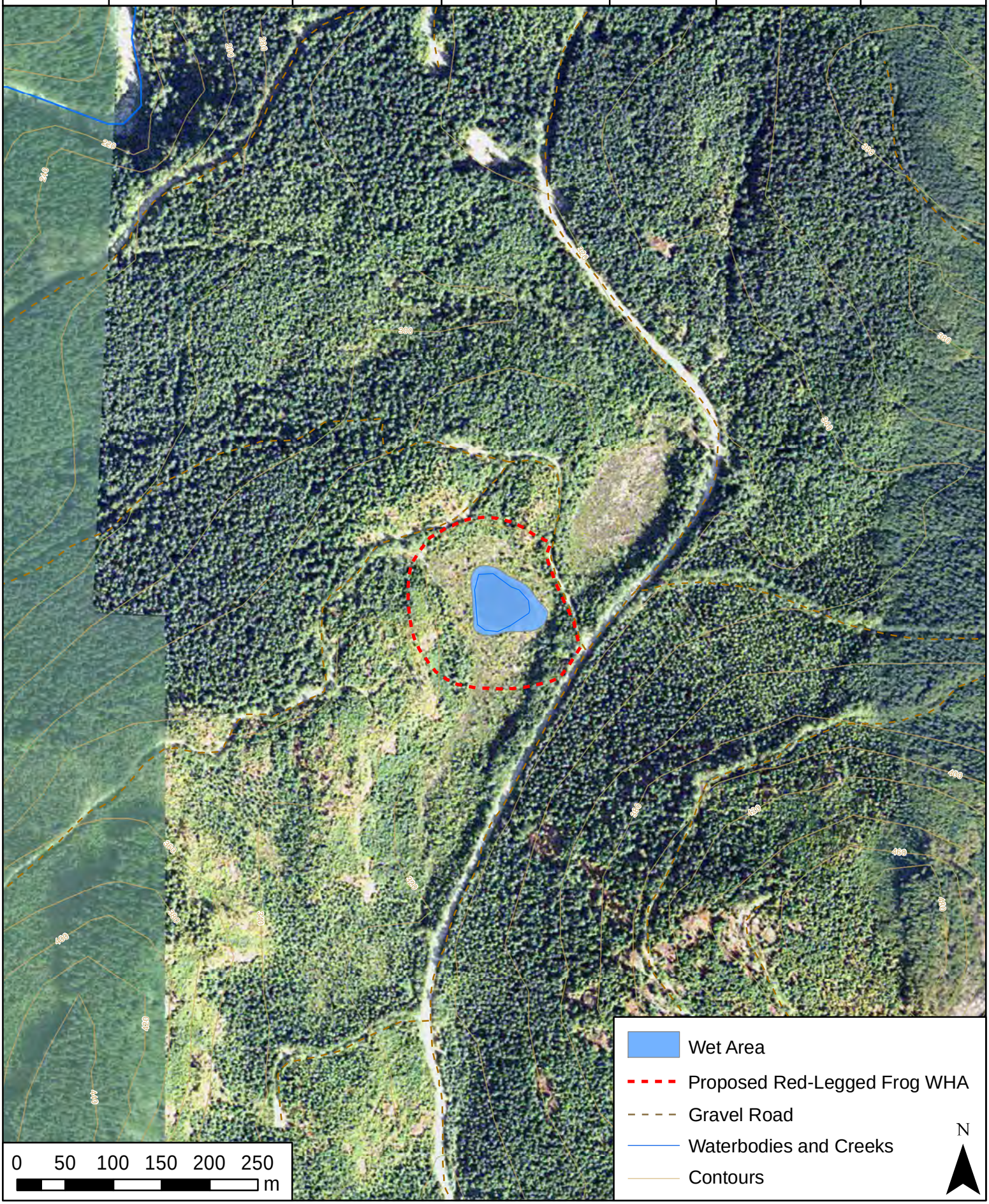
This was a deep lake with an unstable peat moss (*Sphagnum* sp.) fringe (Photo 13). Trees surrounding the immediate area showed irregular growth (misshapen) with western redcedar, western hemlock, and lodgepole pine (*Pinus contorta*) being the dominant species. Labrador tea was the dominant shrub species located throughout the peat moss / bog fringe of the lake.

Large woody debris was present in moderate abundance around the fringe. Vegetation was very limited within the bog, and over 50% of the egg masses were attached to small woody debris. There was no obvious sign of beaver activity in or around the wetland.

Forty Red-legged Frog egg masses were found throughout the wetland, with some masses located in small, deep pockets of water.

Photo 13. Looking southwest at Worldwide 1 on March 31st2010.

MADRONE environmental services ltd	FIGURE 8: Worldwide 1 Potential WHA	PROJECT: Protection of Critical Breeding Habitat for Red-Legged Frogs				DOSSIER NO: 10.0033
	GEOGRAPHIC AREA: Stave Lake, BC	CLIENT: BC Hydro BCRP	FIELD DATES: March - April 2010	MAP SCALE: 1:5,000	REVISION DATE: Oct 26, 2010	DRAWN BY: Anna Jeffries



6.0 DISCUSSION

This study successfully documented the presence of Red-legged Frog critical breeding habitat at multiple locations within the Stave River watershed. Based on our findings in 2010, it will be possible to more effectively identify additional breeding sites for protection in this watershed.

All of the wetlands and lakes where Red-legged Frog breeding was detected in 2010 had moderate to abundant egg mass attachment substrate (*i.e.*, emergent or submergent vegetation and small, submergent woody debris). These areas also had CWD for cover and they were in close proximity to suitable foraging (upland) habitat. These wetland attributes can be characterized as providing suitable security, foraging and thermal habitat (Hawkes 2005). It is likely that less predation on eggs and juveniles occurs in these small well-vegetated wetlands compared to larger lakes because the vegetation and woody debris provide cover from predators such as fish, dragonfly nymphs, garter snakes and leeches (Licht 1974, Cary 2010).

6.1 Comparison to other Egg Mass Surveys in BC

Suitable amphibian habitat occurs throughout the study area, and peak egg mass counts (218) in the Stave River Watershed were relatively high compared to some other recent egg mass surveys completed throughout the range of the Red-legged Frog in B.C. Lange (2009) had a total peak count of 98 egg masses in 17 wetlands in the Campbell River Watershed in 2009, but a much higher count (843) from the same area in 2010 (Lange and Tripp 2010). Baird (2010) surveyed 16 man-made ponds in the Little Campbell River Watershed (Township of Langley and City of Surrey) in 2010 and located 163 egg masses, and one year earlier 7 ponds in the same watershed had 104 egg masses.

The timing of peak counts in the Stave River Watershed was focused entirely in the last two weeks of March, which is consistent with breeding activity in the Little Campbell River Watershed (Baird 2010). Peak counts in the Campbell River Watershed in 2010 were generally in the second week of April. This could be a result of environmental factors or simply the timing of survey sessions; however, in 2009 in Campbell River, peak counts were observed later in the season, ranging between late April and early May (Lange 2009).

Based on the principle that Red-legged Frog females deposit one egg mass per year, the above egg mass counts give an approximate population total for the surveyed wetlands within the subject watersheds.

In the 16 wetlands that were surveyed within the Stave River Watershed in 2010, there are at least 218 breeding females based on the peak counts, which avoid double-counting of the same egg masses between surveys (*i.e.,* total egg masses counted over all surveys was 324). There is a very strong probability that the local breeding populations at these sites is much higher than 218 given a variety of sightability and access issues within the subject wetlands. A summary of recent Red-legged Frog surveys conducted in B.C. can be found in Appendix VI.

6.2 Influence of Herbaceous Vegetation and Woody Debris

Red-legged Frogs in the Stave River watershed appeared to select for herbaceous vegetation as ovideposition sites within wetlands when available. The majority (11 of 12) of sites where egg masses were located had the masses deposited primarily (> 80%) on sedges, rushes or other aquatic vegetation. This ovideposition site selection trait is consistent with studies completed in Northern California (Cary 2010), and Campbell River Watershed (Lange 2010). The COSEWIC Status Report for the Red-legged Frog (2004) indicates that waterbodies with ample emergent vegetation are very suitable for the species in regard to breeding activity. Red-legged Frogs may also select to deposit eggs on herbaceous vegetation given the propensity of sedges and rushes to bend if water levels drop, allowing the heavy egg masses to remain under water.

Only Worldwide 1 had more egg masses attached to small woody debris than herbaceous plants, which may be due to the overall lack of herbaceous vegetation occurring in that wetland. Baird (2010) observed that the majority (59%) of ovideposition sites of Red-legged Frogs in ponds within the Little Campbell River Watershed was on small, submerged sticks (fine, woody debris), even though the percent cover of herbaceous vegetation was greater. This may be due to the vegetation that is present being inappropriate for attachment, or, as in the case of Worldwide 1, the sites could also be relatively isolated and therefore represent the only suitable location for Red-legged Frogs to breed in that particular area. Burianyk (2010) found that Red-legged Frogs in the Little Campbell River Watershed appeared to use any sufficient attachment site, whether herbaceous or woody.

Percent cover of emergent / submergent vegetation may also influence where egg masses are deposited. The majority of the egg masses throughout the watershed were found in areas of the wetlands where vegetation cover was less than approximately 60%. Overall, it appeared that if vegetation was very dense (greater than 80%), the frogs would not use that area for egg mass attachment.

Furthermore, in some wetlands, if thick clumps of submergent or emergent vegetation were present, the frogs would use the less dense edge as a deposition site. It is important to exercise caution in eliminating sites with dense vegetation from future surveys, as there may be a bias towards surveying sites that are easier to access. Also, surveys can be more thorough at sites with low to moderate shrubby vegetation.

6.3 Environmental Factors

Due to the relatively mild winter of 2009 (Figure 3), water temperatures were warm enough (at least 6°C) for Red-legged Frog breeding activity to commence near the beginning of March 2010. Generally, Red-legged Frogs begin breeding in late February and early March (IWMS 2004), therefore this year could be considered a normal breeding year in the Stave River watershed. Because Red-legged Frogs are affected by water temperature, the slightly warmer temperatures of 2010 were likely more conducive to successful reproduction (Baird 2010).

Another factor that may affect where egg masses are deposited is aspect within the wetland. Licht (in COSEWIC 2004) stated that females preferred to deposit their eggs in sunny locations within a wetland. Typically, the majority of egg masses we observed were located on or near the area of the wetland that appeared to receive the most sunlight throughout the day. One would expect that the most sunlight would occur on the southern portion of the wetland and would, therefore, represent the portion of the wetland with the most egg masses, but this was not always the case. Some wetlands, such as Hunter East, had the majority of egg masses located on the sunnier southern end. Others, such as Kodiak, however, had the most egg masses near the northwestern corner of the wetland.

The seral stage and structure of forest stands bordering the subject wetlands may play a role as to where frogs may deposit egg masses, through the effects of shading. Cary (2010) found that vegetative cover on ponds negatively affected the presence of Red-legged Frog egg masses where Ostegaard and Richter (2001) found a positive correlation between proximate mature forest cover and Red-legged Frog presence.

We did not measure flow rates due to project scope; however, it appears that the Red-legged Frogs in the Stave River watershed select for areas of very low to no flow (less than 5 m/sec), which is consistent with observations in Maxcy (2004).

Devils 1 (1 egg mass) and Salsbury Creek (2 egg masses) were the two wetlands where there was an observable water flow (estimated > 5 m/sec) in the study area. Egg masses in both locations were found in slow flowing areas off the main channel.

6.4 Influence of Beaver Activity

There appears to be a correlation between the presence of Red-legged Frogs and beaver activity. With few exceptions, if a beaver dam was present on a surveyed wetland, there would be Red-legged Frog egg masses present. The damming of areas by beavers helps to provide permanent waterbodies and consistent depths by limiting (slowing) water flow, which effectively improves breeding habitat potential (egg laying through successful development of tadpoles) (Hayes *et al*. 2008). Salsbury Creek had no egg masses within the dammed portion of the wetland, but suitable vegetation and very recent beaver activity led to the wetland being given a moderate habitat ranking based on potential.

Without beaver activity, many of the surveyed wetlands would have lower water levels, or would dry up too early in the year, resulting in insufficient time for larval metamorphosis. We observed that the majority of egg masses in dammed wetlands occurred in slow flowing water near the shoreline of the pool formed by the dam.

Some wetlands showed marked decreases in water levels over a one month period, to a point where between March and April, Northwestern Salamander egg masses were found completely suspended above the water on small woody debris. On a field visit during the week of July 18th, all 5 high-rated habitat wetlands still had at least some portion of the wetland with deep water (greater than 1 m deep) for tadpoles to habituate. Barring the removal of the respective beaver dams, it would be reasonable to assume that the 5 high-rated wetlands are perennially inundated with standing water.

6.5 Threats to Red-legged Frogs in the Stave River Watershed

According to the COSEWIC status report on Red-legged Frogs (2004), the main threat to this species in B.C. is human development and the associated loss of suitable habitat. Pressure from urban, rural, and agricultural development in the Fraser Valley is significant.

If a decline in a local Red-legged Frog population took place, it would be a result of their vulnerability to environmental alterations, especially the loss of vegetative cover (COSEWIC 2004). Frog embryos and tadpoles will not survive in water with a pH less than 3.5 or greater than 9 and water temperatures greater than 21°C (Hayes *et al*. 2008).

An additional potential threat to the Red-legged Frog in the study area is the introduction of non-native predators such as the Bullfrog. Bullfrogs are voracious predators and have been known to displace B.C.'s native frogs from aquatic habitats where they were once present (Govindarajulu 2003). Bullfrogs are generally associated with human settlements, and the larvae require permanent water bodies in which to metamorphose (e.g. golf course ponds). Bullfrogs are known to be present in the Chilliwack Forest District (Govindarajulu 2003) but no evidence of adults or breeding activity was found during this project.

6.6 Oregon Spotted Frog

No evidence of the Red-listed Oregon Spotted Frog was seen during surveys within the project area in 2010. In B.C., Oregon Spotted Frogs are associated with permanent, warm waterbodies within the Fraser River Lowlands (Haycock 2000). The three sites where Oregon Spotted Frog presence has been confirmed in B.C. are all below 100 m and outside the boundaries of this project (pers. comm. Denis Knopp). Although areas of the Stave River watershed fall within the boundary of potential Oregon Spotted Frog habitat, all land below 100 m was generally privately owned and therefore no surveys were carried out in these areas.

6.7 Project Limitations

The main project limitations were related to accessibility of survey sites due to weather and / or site conditions. In early spring (early March) surveys were limited by lack of access due to snow and ice cover on the higher elevation wetlands. Other candidate wetlands that were deemed suitable from the pre-field mapping exercise were not surveyed as there was limited access from the mainline roads.

In addition, some of the wetlands had very soft organic bottoms making wading difficult at times. When wading was unsafe, crew members had to scan the immediate area for egg masses from a single location. Other sites were too small for boat surveys, but too soft to enable full coverage by wading. Therefore, it is likely that some egg masses were missed within wetlands, resulting in underestimated total counts.

For the most effective coverage, Doc Lake and Worldwide 1 should have been surveyed with a boat. However, they possessed very unstable peat moss mats on the shoreline which made launching a boat difficult and unsafe.

These two wetlands were surveyed using a curvilinear transect, and deep sections near the middle may have contained masses which would have been missed if present, again leading to an underestimation of total counts.

7.0 RECOMMENDATIONS

Degradation of habitat is a threat to survival for the Red-legged Frog. The range of the Red-legged Frog in B.C. overlaps with some of the highest populated areas of the province (Lower Mainland, Fraser Valley, and southern Vancouver Island). The pressure to develop these areas is very high so where possible, intact habitat should be protected.

Significant off-road vehicle activity was observed throughout the project area. The right-of-way under the B.C. Hydro towers appeared to be a popular location for 4x4's. Off-road vehicles were observed going through pools of water where amphibians had laid their eggs. Cathy South, located at the end of Cathy Road on the west side of Stave Lake, is located directly under hydro lines and has been negatively impacted by off-road vehicles. This wetland had one of the highest egg mass counts in the project area, even though there were tire tracks and garbage throughout the site. If it was not impacted, this site has the potential to provide excellent habitat for frogs in the area; Cathay South also has the potential for habitat rehabilitation.

Best Management Practices (BMPs) for Red-Legged Frog habitat protection in the Lower Mainland is made up of five broad steps (Ovaska *et al*. 2004): protecting critical habitat (breeding ponds and upland foraging areas); protecting suitable quantities of necessary components (protecting enough critical habitat for population to exist); maintain habitat quality through buffer zones; allow natural processes to continue (essentially maintain the natural hydrology of the wetlands); and maintain connectivity of habitats (unfragmented corridors between wetlands). In order to protect the integrity of the wetlands in the Stave River watershed which contained Red-legged Frog egg masses, as well as other non-focal species, it is recommended that buffers be established around all sites where breeding was confirmed.

We recommend WHA designation for sites located on Provincial Crown land that have high suitability as breeding habitat and confirmed breeding activity (*i.e.*, Doback, Worldwide 1, H100 Fork, Hunter East, and Pikes Pond) (Figures 4 – 8).

The recommended size of a WHA is less than 10 ha and generally will vary based on wetland size and access to foraging habitat for the frogs (IWMS 2004). There are no WHA's established for Red-legged Frogs on the Lower Mainland at this time; however, there are 17 on Vancouver Island. Typically, a Red-Legged Frog WHA has a buffer of 50 m surrounding the wetland, and if there is a creek connecting two or more wetlands, then a 20 m buffer is placed on either side of the creek (pers. comm. Erica McClaren, Ministry of Environment, Black Creek, Vancouver Island).

Protection of the highlighted sites through WHA establishment will prevent encroachment from development and logging activities, which could degrade water quality and negatively impact migration corridors that connect sensitive breeding habitat. Furthermore, protection of these sensitive habitats also helps to ensure that all amphibian life history phases will be completed (Wind 2003), especially when connectivity between two or more wetlands is established (IWMS 2004). The implementation of WHA's will benefit not only amphibians, but a variety of other wildlife including waterfowl, songbirds, ungulates and fish.

Wetlands deemed unsuitable for WHA designation are still highly valuable for wildlife, and should have at a minimum, a 1:3 ratio of wetland to upland habitat buffer surrounding the high water mark of the wetland (Ovaska *et al.* 2004). For example, if the surface area of a wetland is 0.5 ha, the buffer should be 1.5 ha in size.

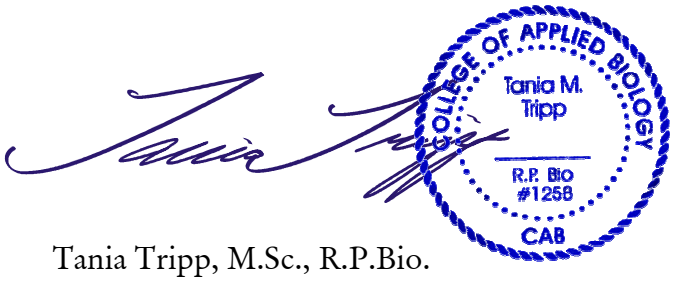
Many of the surveyed wetlands that contained Red-legged Frog egg masses were within Tree Farm License #26 (TFL 26) where the District of Mission is the licensee. Most of the wetlands within TFL 26 currently have a buffer around them due to a reserve system developed through the Mission Forest Stewardship Plan. These buffers are long term (set aside in perpetuity) or rotational (can change when timber matures) but are flexible to change in order to protect habitat (pers. comm. Bob O'Neal, District of Mission, Forestry). If wetland buffers are to be established in TFL 26, the District of Mission must be involved in the decision making process.

In order to be as biologically significant as possible, all buffers should be established as to encompass as much usable habitat as possible (biologically meaningful). Simply having a uniformly shaped buffer around a wetland may not be as effective as one that is shaped to avoid roads or other types of non-usable habitat.

Four of the five highest rated wetlands are near roads that would be included in the buffer if the buffer was applied uniformly. Using a biologically significant approach, H100 Fork would have a buffer up to the surrounding roads to the east and west, and a larger proportion of protected area to the north (Figure 5).

Due to annual fluctuations in weather conditions, water levels and local amphibian populations, establishment of WHAs based on one year of data is not scientifically defensible. Ideally, at least two to three survey seasons would be completed at the sites for proposed WHAs (pers. comm. Erica McClaren, MoE). Therefore, as directed by MoE, we recommend completing at least one more year of surveys at the High and Moderate suitability sites prior to submission of the sites as WHA candidates.

Prepared by:



Kyle Rezansoff, B.Sc., B.I.T. Tania Tripp, M.Sc., R.P.Bio.

8.0 ACKNOWLEDGEMENTS

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APPENDIX I. – Financial Statement

Dossier 10.0033

BC HYDRO FISH & WILDLIFE
BRIDGE COASTAL RESTORATION PROGRAM

I. Financial Statement Form

	BUDGET		ACTUAL	
	BCRP	**Other**	**BCRP**	**Other**
INCOME				
Total Income by Source	$32450.00	$4140.00	$32450.00	$4140.00
Grand Total Income (BCRP + other)	$36590.00		$36590.00	
EXPENSES	**Note: Expenses must be entered as negative numbers (e.g. – 1000, etc.) in order for the formulas to calculate correctly.**			
Project Personnel				
Wages	22500.00		27071.87	
Consultant Fees	4500.00		1125.00	
(List others as required)				
**GST# 86741 0953 RT001				
Materials & Equipment				
Equipment Rental	3050.00	1500.00	1765.20	1500.00
Materials Purchased				
Travel Expenses	2400.00		2504.83	
Permits				
(List others as required)				
Administration				
Office Supplies		2640.00		2640.00
Photocopies & printing				
Postage				
(List others as required)				
Total Expenses	-$32450.00	-$4140.00	-$32466.90	-4140.00
Grand Total Expenses (BCRP + other)	-$36590.00		-$36606.90	
BALANCE (Grand Total Income – Grand Total Expenses) inclusive of GST obligations	*The budget balance should equal $0* $0.0		*The actual balance might not equal $0** -$16.90	

* Any unspent BCRP financial contribution to be returned to: BC Hydro, BCRP
6911 Southpoint Drive (E16)
Burnaby, BC V3N 4X8
ATTENTION: PROGRAM MANAGER

**GST will it be paid unless a GST registration number is provided on all invoices.

APPENDIX II. – Performance Measures – Actual Outcomes

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II. Performance Measures

Using the performance measures applicable to your project, please indicate the amount of habitat actually restored/enhanced for each of the specified areas (e.g. riparian, tributary, mainstream).

Performance Measures – Target Outcomes												
Project Type	**Primary Habitat Benefit Targeted of Project (m^2)**	**Primary Target Species**	**Habitat (m^2)**									
			Estuarine	In-Stream Habitat – Mainstream	In-stream Habitat – Tributary	Riparian	Reservoir Shoreline Complexes	Riverine	Lowland Deciduous	Lowland Coniferous	Upland	Wetland
Impact Mitigation												
Fish passage technologies	Area of habitat made available to target species											
Drawdown zone revegetation/stabilization	Area turned into productive habitat											
Wildlife migration improvement	Area of habitat made available to target species											
Prevention of drowning of nests, nestlings	Area of wetland habitat created outside expected flood level (1:10 year)											
Habitat Conservation												
Habitat conserved – general	Functional habitat conserved/replaced through acquisition and mgmt	Approx.15 ha of habitat could be conserved via WHAs. Dist. of Mission also has buffers around				x						x
	Functional habitat conserved by other measures (e.g. riprapping)	non-WHA suitable habitat.										
Designated rare/special habitat	Rare/special habitat protected	Red-legged Frogs				x						x
Maintain or Restore Habitat forming process												
Artificial gravel recruitment	Area of stream habitat improved by gravel placement											
Artificial wood debris recruitment	Area of stream habitat improved by LWD plcmt											
Small-scale complexing in existing habitats	Area increase in functional habitat through complexing											
Prescribed burns or other upland habitat enhancement for wildlife	Functional area of habitat improved											
Habitat Development												
New Habitat created	Functional area created											

Performance Measures – Target Outcomes													
Project Type	**Primary Habitat Benefit Targeted of Project (m^2)**	**Primary Target Species**	**Habitat (m^2)**										
			Estuarine	In-stream Habitat – Mainstream	In-stream Habitat – Tributary	Riparian	Reservoir Shoreline Complexes	Riverine	Lowland Deciduous	Lowland Coniferous	Upland	Wetland
Impact Mitigation													
Fish passage technologies	Area of habitat made available to target species												
Drawdown zone revegetation/stabilization	Area turned into productive habitat												
Wildlife migration improvement	Area of habitat made available to target species												
Prevention of drowning of nests, nestlings	Area of wetland habitat created outside expected flood level (1:10 year)												
Habitat Conservation													
Habitat conserved – general	Functional habitat conserved/replaced through acquisition and management	Red-legged Frog				16*					5*	4*
	Functional habitat conserved by other measures (e.g. riprapping)												
Designated rare/special habitat (subset)	Rare/special habitat protected	Red-legged Frog				21*						4*
Maintain or Restore Habitat forming process													
Artificial gravel recruitment	Area of stream habitat improved by gravel placement												
Artificial wood debris recruitment	Area of stream habitat improved by LWD placement												
Small-scale complexing in existing habitats	Area increase in functional habitat through complexing												
Prescribed burns or other upland habitat enhancement for wildlife	Functional area of habitat improved												
Habitat Development													
New habitat created	Functional area created												

*Habitat Conservation based on potential WHA designation

APPENDIX III. – Field Form

Ecosystems Section Amphibian Survey Data Form- 2009

General Information:

Date: _____ Location: UTM Zone _____

Surveyor(s): _____ Easting _____

Northing _____

Location Description (include landscape context surrounding wetland): _____

Wetland ID: _____ Littoral Area (ha): ____ Bottom Substrate: _____

Seral Stage/Age Class: _____ Elevation (m): ____ Fish Species Present?: _____

Time: Start _____ Water Temperature: ____ Water body Searchability: / 5

End _____ Number of Trap Nights: ____ (1= very difficult; 5 = very good)

Search Conditions: / 5

Survey Type: (select) ☐ visual survey

☐ trapping funnel trap ( ), other trap ( ) Trap Night ____ / ____ Survey Timing: **early / ok / late** (circle one)

Weather	Ceiling	CC		Wind	Precip	Temp	Water Condition
Start							
End							

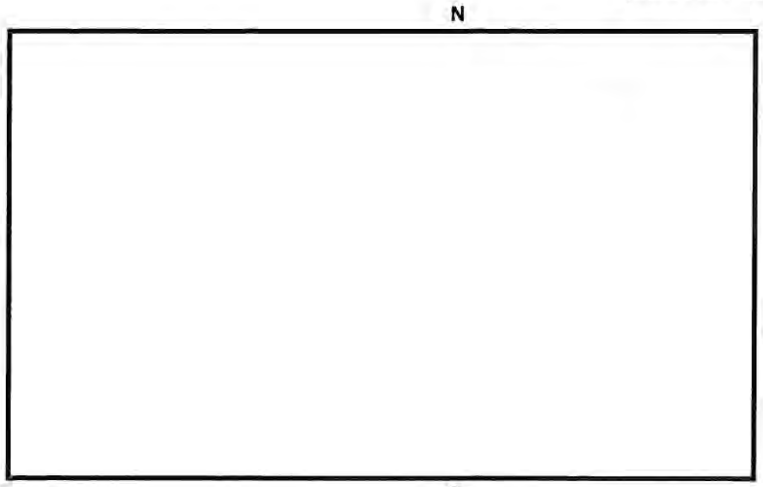
Ceiling: a/b tt = above/below tree tops; a/b r = above/below ridges; h/v h = high/very high CC: 1 = clear; 2 = scattered clouds (<50%); 3 = scattered clouds (>50%); 4 = unbroken

Wind: 0 = <2 km/h (calm); 1 = 2-5 km/h (light air); 2 = 6-12 km/h (leaves rustle); 3 = 13-19 km/h (leaves and twigs in constant motion); 4 = 20-29 km/h (small branches move, dust rises) 5 = 30-39 km/h (small trees sway); 6 = 40-50 km/h (large branches moving, wind whistling)

Precip: N = none; F = fog; M = misty drizzle; LR = light rain; HR = hard rain; S = snow

Temp (in degrees C); **Water Condition:** maximum vertical depth of visibility in cm. (should be meaasured with a Secchi disk)

Site Diagram:
(e.g., inflow, outflow, oviposition sites, open water areas, emergent vegetation, access, etc.)



Scale: 1 square = _____m

Amphibian Observations:

		Egg Mass Aggregates				Larval Stage				Adults			
Trap No.	**Photo (s)**	#	Species	Diameter (cm)	Dev. Stage	#	Species	Gos.Stage	SNVL	#	Species	SNVL	**Comments**

Comments: add information such as cardinal direction of pond that observations occurred (i.e. if egg masses were all on one side), malformations, etc.

Species: *salamanders* = AMMA (long-toed); TAGR (rough-skinned newt); AMGR (northwestern); PLVE (western red-backed); ENES (ensatina); ANVA (wandering); *anurans* = BUBO (western toad), HYRE (pacific treefrog); RAAU (red-legged); RACA (bullfrog); RACL (green); UNSP(unknown sp.)

Dev. Stage: 1 = round eggs, 2 = kidney (crescent) eggs, 3 = tadpoles, 4 = hatching, 5= hatched-out (each egg mass or round to 10s of % for large #s)

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APPENDIX IV. – Moderate and Low Habitat Suitability Site Descriptions

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Moderate Habitat Suitability

Note: Photos for the following sites are located in Appendix V

Cathy South

Cathy South was located across the access road from Cathy North and directly under the power lines. The culvert under the access road empties into a narrow, deep channel which then widens out to a deep open area (Photo A – Appendix V).

The northeastern portion of Cathy South consisted of vegetated islands, and small CWD was present throughout the northern/inflow regions (Photo B). Vegetation in the waterbody was primarily submergent, with limited emergent species. A beaver lodge was located on the western shore of the wetland and evidence of beaver activity was noted on shrubs in the area.

The area around Cathy South was significantly impacted by four wheel drive vehicle (4wd) activity, with the west side of the wetland bordered by a muddy, pitted 4wd path. The outflow of Cathy South on the southwestern boundary drains into this path and down to a low area immediately south of the wetland (Photo A and Photo C). The low area is part of a shallow, seasonally flooded access road that also appears to be used for 4wd activity.

Hunter West

Hunter West is a small (< 0.5 ha), shallow (~0.5 m) wetland on the west side of Hunter Road, located 250 m south of wetland 'H100 Fork' (Photo D). Large woody debris was present throughout the wetland; however, suitable ovideposition vegetation was not particularly abundant. The majority of the egg masses found in this wetland were located near the outflow, attached to floating woody or herbaceous vegetation.

Hunter East is across the road from Hunter West; however, these two wetlands do not connect directly to each other. The outlet of Hunter West flows under Hunter Road and into the fluvial area below Hunter East.

H110 Wetland

This small (~ 0.5 ha), shallow (average < 0.5 m deep) bog was accessed by walking north from the terminus of Spur Road H110 for approximately 150 m.

H110 is approximately 200 m east of Cannell Lake and drains into Cannell Creek. Large woody debris in H110 was abundant and allowed for increased survey efficiency of the wetland due to the wood functioning as natural foot bridges (Photo E).

Emergent and submergent vegetation such as sedges, rushes, Yellow pond-lily (*Nuphar polysepalum*), and pondweed (*Potamogeton* sp.) were plentiful and spread throughout the wetland. Labrador tea and peat moss dominated the areas within the waterbody that were not submerged with salal and hardhack located at forested fringes of the wetlands. The forested area surrounding the wetland was dominated by western redcedar with scattered western hemlock.

J Lo 1

J Lo 1 is located half way down Lost Lease Road, a spur road off Lost Creek Forest Service Road at approximately the 6k marker (Photo F). This wetland is one of the smallest wetlands surveyed in the project area. The most notable aspect of J Lo 1 is the abundance of CWD (approximately 80%) covering the wetland, which made locating egg masses difficult.

Lost Lease Road borders the southern end of the wetland, and a young forest consisting of western redcedar, Douglas-fir, and western hemlock surrounds the remainder of the wetland. Sedges and patches of aquatic grasses were the primary herbaceous species.

Kodiak

Kodiak was located near the terminus of Spur Road JR200 which is accessed through a gate at the end of Johnson Street in the Steelhead Community region of Mission. This site was a wetland complex of open bodies of water connected by narrow channels and is at an elevation of 215 m (Photo G). Some areas, primarily the connecting channels, were over 2 m deep with an average depth of approximately 0.75 m.

Emergent and submergent vegetation such as sedges, rushes, Yellow pond-lily, and pondweed were plentiful and spread throughout the wetland. Labrador tea and peat moss dominated the areas within the complex that were not submerged with salal and hardhack located at forested wetland edges. The forested fringe was dominated by western redcedar with scattered western hemlock. A beaver dam was located at the northwest corner of the wetland which aided retention of water within the wetland.

Low Habitat Suitability

Cathy North

Cathy North was located on the north side of an access road running parallel to the power lines near the end of Cathy Crescent (Photo H). This small (0.25 ha), mostly shallow (average 0.5 m deep) wetland had abundant CWD, an organic substrate, and was densely vegetated with rushes, sedges, and reed canary-grass (*Phalaris arundinacea*). The surrounding forest consisted mainly of western hemlock, western redcedar, and had sporadic Douglas-fir.

Devil 1

This wetland is essentially the outlet area of Devils Lake (Photo I). Although suitable vegetation was present throughout this area, and CWD was plentiful to protect frogs from predatory fish, the high flow rate of water in the outlet would likely restrict the presence of Red-legged Frog egg masses. One mass was found at the slow flowing southern portion of the lake, which could indicate that Devils Lake itself may represent more suitable habitat for egg mass surveys.

Doc Lake

Doc Lake was located 110 m west of the terminus of Spur Road R240 which is accessed from Rockwell Road. The lake, at an elevation of 543 m, was similar to Worldwide 1, with primarily open water and a lack of any substantial vegetation for frogs to deposit egg masses (Photo J). Floating peat moss mats lined the shore and formed islands in the lake. The area at the inflow of the lake contained suitable vegetation and water depth (~ 0.75 m) for egg mass attachment.

Lost Creek 4k East

This wetland, located near the 4k marker on Lost Creek Forest Service Road, is small, shallow, and heavily influenced by anthropogenic activity (Photo K). The north side is bordered by a cutblock, while the west and south side are bordered by resource roads. A large pile of wood chips and grass clippings was present on the west fringe, and scrap metal was noted throughout the wetland.

Herbaceous vegetation was sparse throughout the wetland and consisted primarily of horsetails (*Equisetum* sp.), which differed from all of the other wetlands surveyed in the area, which contained mostly rushes and sedges. Large woody debris was abundant at the culvert draining west into Lost Creek 4k West.

Lost Creek 4k West

Lost Creek 4k West is located across Lost Creek FSR, and receives water from Lost Creek 4k East. A fluvial section exists from the outlet of the culvert at Lost Creek FSR and flows for approximately 150 m before slowing and developing into a marshy, wet area, suitable for Red-legged Frogs to deposit egg masses (Photo L).

Dense, herbaceous vegetation was abundant throughout the majority of the wetland, mostly consisting of sedges and rushes. Historical beaver activity was present, including a lodge on the south side and dam at the western end of the wetland where the outlet was located.

Salsbury Creek

This large (~6 ha) wetland is located approximately 500 m west of Salsbury Lake. The Salsbury Creek site is essentially a complex of three ecosystem types with a fluvial portion taking up the vast majority of the southwest corner (Photo M), a shallow, seasonally flooded open water area in the northern portion, and a deep, slow flowing dammed area in the eastern portion (Photo N).

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APPENDIX V. – Photos of Survey Sites

Photo A. Facing east, an overview photo of Cathy South. The red arrow is pointing at the natural part of the wetland while the turquoise arrow is pointing at the low-lying, seasonally flooded road section. This area is heavily impacted by 4 wheel drive vehicle activity, as evidenced by the network of roads throughout the picture.

Photo B. Looking south from the north end of Cathy South on March 18th 2010.

Photo C. Facing southeast at the flooded road section of Cathy South on March 18th 2010.

Photo D. Looking south at Hunter West on March 30th 2010.

Photo E. Looking northeast at H110 Wetland on March 17th 2010. This wetland was very shallow and contained relatively sparse vegetation throughout.

Photo F. Looking north at J Lo1 on April 20th2010. This very small wetland had dense vegetation in areas not shaded by the extensive CWD cover. Egg masses found in this wetland were in very shallow water (less than 30 cm deep).

Photo G. Looking south at Kodiak from the outlet of the wetland on March 17th2010.

Photo H. Looking south from the centre of Cathy North on the March 18th 2010 field day. Note: This southern portion of the wetland was much deeper than the northern portion (greater than 1.5 m) and ice on the surface was less than 5 mm thick.

Photo I. Looking north at Devils 1 on April 1st2010. Vegetation and CWD was plentiful in this area; however, the water was flowing too fast for Red-legged Frogs to deposit eggs and predatory fish could easily move down from Devils Lake to prey on tadpoles.

Photo J. Facing west toward Doc Lake on March 18th 2010.

Photo K. Looking west at Lost Creek Road 4K East on March 31st 2010.

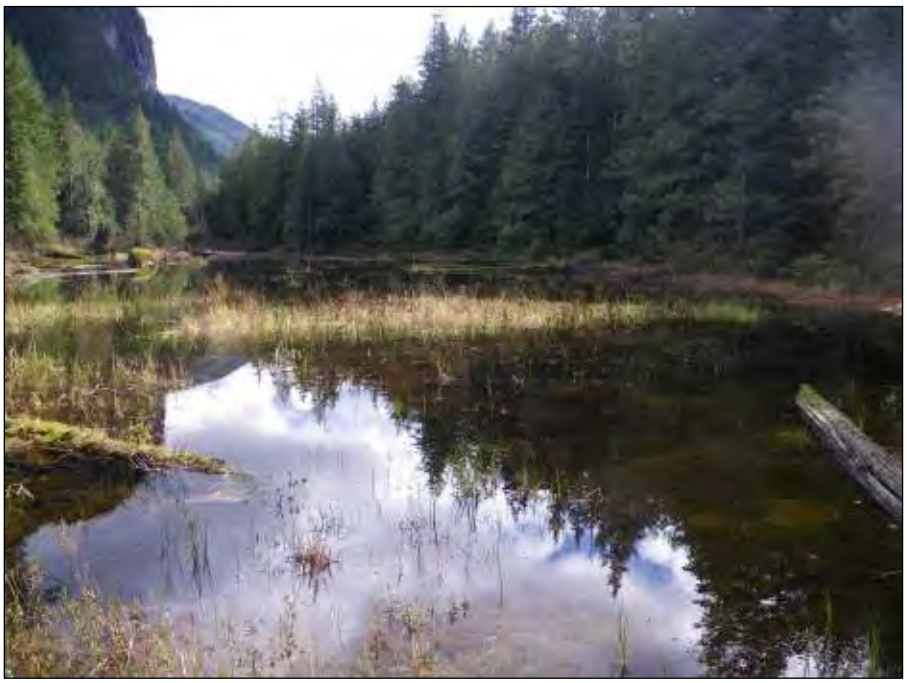

Photo L. Looking southeast at Lost Creek Road 4K West on March 31st2010.

Photo M. Looking south at the channelized area of Salsbury Creek on April 20th 2010. This photo was taken from the boundary of the slow moving dammed portion of Salsbury Creek.

Photo N. Looking northeast at the slow moving, dammed portion of Salsbury Creek on April 20th 2010.

Photo O. A Red-legged Frog tadpole found in H100 Fork on April 19th 2010.

Photo P. A Tree Frog found in H100 Fork on April 19th2010.

Photo Q. A Northwestern Salamander egg mass found in H100 Fork on April 19th2010.

Photo R. A Northwestern Salamander egg mass stranded above the surface of the water in Cathy North on April 20th 2010.

Photo S. Western Toad eggs found in Salsbury Creek on April 20th 2010.

Photo T. Beaver dam located in Salsbury Creek. This dam had a substantially deep pool behind it.

Photo U. Beaver sign in the dammed portion of Salsbury Creek. Sign was generally very recent.

Photo V. A beaver lodge located in Hunter West with evidence of recent construction activity.

Photo W. This picture was taken from a video of a Rough-skinned Newt feeding on a Northwestern Salamander egg-mass in Worldwide 1 on April 20th 2010.

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APPENDIX VI. – Red-legged Frog Study Summary

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Table B. Summary Table of Vancouver Island and Lower Mainland Red-legged Frog Egg Mass Surveys.

Study Area	Elevation Range of Sites (m)	Number of Sites Sampled	Number of Sites with Egg Masses	Range of Egg Masses Counted	Total of Egg Masses Counted	Level of Effort (min.)	Egg Masses Counted per unit of effort
Campbell River Watershed (MoE)							
2006	250 – 300	1	1	5	5	120	0.042
Total					**5**	**120**	**0.042**
2007	250 – 300	1	1	3	3	60	0.050
Total		**2**	**2**		**3**	**60**	**0.050**
Campbell River Watershed							
Lange 2009	0 – 50	0	0	0	0	0	0
	51 – 100	0	0	0	0	0	0
	101 – 150	0	0	0	0	0	0
	151 – 200	3	2	0 – 50	96	1782	0.054
	201 – 250	5	1	0 – 32	34	995	0.034
	251 – 300	7	3	0 – 8	20	2,650	0.008
	301 – 350	1	0	0	0	178	0
Total		**16**	**6**		**150**	**5,605**	**0.027**
Lange & Tripp 2010	0 – 50	0	0	0	0	0	0
	51 – 100	2	2	9 – 93	102	80	1.275
	101 – 150	1	1	95	95	126	0.753
	151 – 200	4	3	17 – 304	404	1601	0.252
	201 – 250	3	2	5 – 195	209	1110	0.188
	251 – 300	7	3	1 – 17	33	2219	0.017
Total		**17**	**11**		**1,508**	**5,230**	**0.290**
Stave River Watershed							
Rezansoff and Tripp 2010	0 – 50	1	0	0	0	50	0
	51 – 100	0	0	0	0	0	0
	101 – 150	1	1	1	1	75	0.013
	151 – 200	1	1	6	6	25	0.240

Table B. Summary Table of Vancouver Island and Lower Mainland Red-legged Frog Egg Mass Surveys (continued).

Study Area	Elevation Range of Sites (m)	Number of Sites Sampled	Number of Sites with Egg Masses	Range of Egg Masses Counted	Total of Egg Masses Counted	Level of Effort (min.)	Egg Masses Counted per Unit of Effort
Stave River Watershed							
	201 – 250	6	4	0 – 38	142	441	0.229
	251 – 300	1	1	5 – 15	20	52	0.288
	301 – 350	3	3	6 – 40	136	244	0.352
	351 – 400	1	1	8 – 9	17	42	0.214
	401 – 450	1	1	2	2	147	0.014
	451 – 500	0	0	0	0	0	0
	501 – 550	1	0	0	0	89	0
Total		**16**	**12**		**324**	**2,400**	**0.135**
North Island Central Coast Forest District (MoE) (Species Inventory Database)							
2006 – 2008	0 – 50	4	4	2 – 35	45	272	0.165
	51 – 100	3	3	1 – 2	16	385	0.042
	101 – 150	1	1	1	1	105	0.010
	151 – 200	1	1	2	2	115	0.017
	201 – 250	1	1	4	4	75	0.053
Total		**10**	**10**		**68**	**952**	**0.071**
South Island Forest District (MoE) (McConkey 2006-2008). Species Inventory Database.							
2006 – 2008	0 – 50	3	3	42 – 96	224	290	0.772
	51 – 100	4	4	71 – 445	1182	365	3.238
	101 – 150	0	0	0	0	0	0
	151 – 200	2	2	13 – 28	41	135	0.304
	201 – 250	2	2	14 – 151	165	85	1.941
	251 – 300	1	1	33	33	30	1.100
	301 – 350	5	5	2 – 20	55	260	0.212
	351 – 400	4	4	1 – 141	168	165	1.018
	401 – 450	2	2	5 – 10	15	120	0.125

Table B. Summary Table of Vancouver Island and Lower Mainland Re-legged Frog Egg Mass Surveys (continued).

Study Area	Elevation Range of Sites (m)	Number of Sites Sampled	Number of Sites with Egg Masses	Range of Egg Masses Counted	Total of Egg Masses Counted	Level of Effort (min.)	Egg Masses Counted per Unit of Effort
South Island Forest District (MoE)							
	451 – 500	1	1	7	7	45	0.156
	501 – 550	0	0	0	0	0	0
	551 – 600	1	1	4	4	60	0.067
	601 – 650	0	0	0	0	0	0
	651 – 700	6	6	5 – 38	126	443	0.284
	701 – 750	0	0	0	0	0	0
	751 – 800	1	1	3	3	60	0.050
Total		**32**	**32**		**2023**	**2058**	**0.983**
City of Surrey							
Englund 2007	0 – 50	1	1	135	135	-	-
	51 – 100	5	5	3 – 182	215	-	-
	101 – 150	0	0	0	0	-	-
Total		**6**	**6**		**350**	**-**	**-**
Little Campbell River							
Burianyk 2010	0 – 50	4	4	17 – 40	89	-	-
	51 – 100	2	2	8 – 13	21	-	-
Total		**6**	**6**		**110**	**-**	**-**

Little Campbell River							
Baird 2010	0 – 50	8	8	2 – 66	131	-	-
	51 – 100	3	3	1 – 18	32	-	-
Total		**11**	**11**		**163**	**-**	**-**