Terrestrial Wildlife and Vegetation Effects Assessment

2012

Part 2: Amphibians and Reptiles

Front Page
Photograph: Western toad (*Anaxyrus boreas*)
Source: L. Andrusiak, June 20, 2011

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Preface

This Technical Data Report summarizes the results of the Terrestrial Vegetation and Wildlife baseline studies conducted for the Site C Clean Energy Project (Project) between 2005 and 2012. The purpose of the terrestrial vegetation and wildlife baseline studies was to identify and collect site specific data on the occurrence, abundance, and habitat of key vegetation and wildlife indicators. These data were used to analyse the potential effects of the project on vegetation and wildlife as described in the Section 13 Vegetation and Section 14 Wildlife of the EIS.

Scope

The Project design was advanced and the understanding of potential effects changed during the eight years of data collection. Adjustments to baseline surveys and target species were made in response to these changes. A brief summary of the baseline data collection program is provided below to aid understanding of this report. Surveys were conducted based on Resource Inventory Standard Committee methodologies where available.

Initial baseline data collection in 2005 encompassed a technical study area defined as a four kilometre corridor centered on the Peace River between Hudson's Hope and the Alberta border. An issues scoping identified the need for additional data on the occurrence and habitat use of: raptor and heron nests, amphibians, owls, breeding birds, butterflies, waterfowl and water associated birds, bats, ungulates, vascular plants, and rare ecosystems. Within these species groups, species at risk and species of management concern became the focus of data collection efforts. These species groups were also identified as potential key indicators for a future effects assessment.

In 2006, a transmission line right-of-way (TL) between the proposed dam site and the Peace Canyon dam substation was added to the Project and the technical study area. The boundary for data collection was selected to be 500 metres on either side of the TL. Terrestrial Ecosystem Mapping of habitats within the TL and technical study areas was also completed. Baseline studies continued to be focused on key indicators identified in 2005.

Surveys in 2008 focused on addressing identified data gaps and reconnaissance surveys for dragonflies were added to the study program. Technical Advisory Committee meetings were held with Regulators and First Nations to initiate conversation regarding the Project and potential impacts to vegetation and wildlife and to further guide collection of the baseline data. The committee recommended that additional species-specific surveys be conducted on rare plants and bird species of provincial and federal conservation concern. An additional recommendation was for surveys to be conducted in the broader region outside of the technical study area.

The survey programs of 2009 and 2010 initiated species-specific surveys on swallows, select raptors, Common Nighthawk, marsh birds, non-migratory game birds, and furbearers as recommended by the Technical Advisory Committee. The survey area was expanded to collect baseline data in the region outside the Peace River Valley to allow for comparisons between species occurrence and habitat use within and outside the Project activity zone.

A two-year study was launched in 2010 to gather detailed data on moose, elk and mule-deer populations, movement patterns, and habitat use in the Peace River Valley. Studies of the fisher population were initiated in 2011 and two years of data collection were completed within the Peace River Valley and adjacent areas. In 2011, additional baseline surveys were initiated at quarry sites that were added to the Project.

In the final year of baseline surveys (2012), habitat mapping at quarry sites and surveys of birds on migration were completed. Valued Components and key indicators that would be used to assess potential effects of the Project were also finalized in 2012. Two valued components were selected: Vegetation and Ecological Communities and Wildlife Resources; under each component key indicators were defined.

Approach

A considerable amount of information has been collected and analyzed in the past eight years. This Technical Data Report has been structured to present a standardized summary of the baseline data, methods, results, and effects assessment. Some methodologies and study areas for key indicators changed over the duration of the survey program in response to changes in the Project layout, data collection standards, and shifts in objectives. The full report is divided into seven different Parts with each Part focusing on one key indicator group. Baseline data on Vegetation and Ecological Communities including habitat mapping are presented in **Part 1** of the Technical Data Report. Data on Wildlife Resources have been divided over six parts representing five species groups as follows: **Part 2 Butterflies and Dragonflies**, **Part 3 Amphibians and Reptiles**, **Part 4 Migratory Birds**, **Part 5 Non-migratory Game Birds**, **Part 6 Raptors**, and **Part 7 Mammals**.

Within each Part, the reporting structure is as follows:

- Introduction of the key indicator species within the group

- A review of historical data prior to the onset of the Project baseline
- A description of the methods used to collect the data
- Summary of results
- Potential effects of the Project which includes a quantification of the potential habitat losses
- Recommended mitigation measures
- Residual effects characterization

Following the requirements of the Project EIS Guidelines, an assessment of the significance of residual effects, an assessment of cumulative effects, and recommendations for follow-up programs are presented in the Site C Clean Energy Environmental Impact Statement supported by data presented in this report.

Quantification of habitat loss for key indicators was achieved through the development and application of species models, which are presented in each relevant Part. Models were developed for individual key indicators or species groups. Species models summarise life history requirements and habitat uses and assign ratings for each unique habitat mapped in the Project area. Habitat loss was derived from comparisons of the amount of suitable habitat within and without the Project.

A number of preliminary reports regarding baseline findings have been submitted previously to BC Hydro. Some of the information provided in these reports has been updated within this report with additional information and analysis. Where any differences appear, the information presented in the Technical Data Report supersedes any previous submissions.

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Abbreviations and Acronyms

BC	British Columbia
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
LAA	Local Assessment Area
MFLNRO	Ministry of Forests, Lands, and Natural Resources Operations
NAD83	North American Datum of 1983
PAZ	Project Activity Zone
Project	Site C Clean Engery Project
RIC	Resources Inventory Committee (now RISC)
RISC	Resource Inventory Standards Committee (previously RIC)
SARA	Species at Risk Act
SVL	Snout to vent length
TEM	Terrestrial Ecosystem Mapping
TL	Transmission Line Right-of-Way
UTM	Universal Transverse Mercator

Acknowledgements

- Gartersnake fieldwork and habitat evaluation completed by Mike Sarell
- Gartersnake habitat suitability model refined by Mike Sarell
- Amphibian fieldwork completed with input from Denis Knopp, Sandra Kinsey, and Laird Law

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1 BASELINE CONDITIONS

1.1 Amphibians

1.1.1 Species

Amphibians have been documented in the Peace River Valley since the 1970s. The five species known to occur in the local assessment area (LAA) include boreal chorus frog (*Pseudacris maculata*), Columbia spotted frog (*Rana luteiventris*), long-toed salamander (*Ambystoma macrodactylum*), wood frog (*Lithobates sylvaticus*), and western toad (*Anaxyrus boreas*). Historical data have been reported by a number of authors while completing work for BC Hydro:

- Blood (1979) recorded incidental observations of western toads, wood frogs, and spotted frogs during wildlife surveys completed between 1974 and 1976 for earlier assessments of the Project. Western toads were common near rivers in the Peace River Valley and the author suggested breeding may occur in cut-off river channels.
- During the late summer and early fall of 1999, Fraker and Hawkes (2000) searched backchannels, ponds, and wetlands along the Peace River for earlier assessments of the Project. Western toads and wood frogs were detected during these surveys. The western toads were found throughout the Peace River Valley and surrounding wetlands.
- Amphibian occurrences were surveyed by Hengeveld (2000) between 1998 and 1999 throughout the Williston and Dinosaur Reservoir watersheds. Thirty-three breeding sites were identified for western toads, wood frogs, Columbia spotted frogs, and long-toed salamanders.
- LGL Ltd. (Hawkes et al. 2006) found western toads, wood frogs, and long-toed salamanders in the Peace River Valley. Western toads were documented at 21 unique locations and thousands of toadlets were observed at one location near Boudreau Lake, south of the Peace River.
- From May 6 to June 23, 2007 in the Dawson Creek Timber Supply Area, Phinney (2007) conducted standard auditory, road, and pond breeding surveys. Wood frogs, boreal chorus frogs, and western toads were detected during auditory surveys and boreal chorus and wood frogs were detected during road surveys. Adults and eggs were primarily found in ponds surveyed in May while hatchlings and tadpoles were found in ponds surveyed in June and July. Western toads were noted in ponds along Bear Mountain, Del Rio, and North Monias transects.

1.1.1.1 Western Toad

Of the five species known to occur in the LAA, only the western toad is listed; it is classified as Blue-listed provincially, of special concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and as Schedule 1—a species of special concern—under the *Species at Risk Act* (SARA) (BC Conservation Data Centre 2011).

1.1.2 Field Survey Methods

Surveys for western toad were based on *Inventory Methods for Pond-Breeding Amphibians and Painted Turtle* (Resources Inventory Committee 1998a). The survey methodology included a map-based evaluation for western toads—based on draft species habitat model (**Appendix A.1**)—followed by field surveys. Although field surveys primarily focused on western toad, surveys were completed to document occurrences of other amphibian species—frogs—within the LAA and included pond breeding, auditory, and road surveys.

Pond breeding surveys targeted western toads to determine whether or not breeding was occurring. Auditory surveys were used to document frog species in the area and road transects to determine dispersal routes for western toads and frogs. All transect locations are shown on **Map 1.3.1** and **Map 1.3.2**.

1.1.2.1 Pond Breeding Surveys

Accessible sites were surveyed from spring thaw through August to determine the presence of amphibians, their breeding status, and the suitability of the habitat. While the western toad was the target species, all species observed were recorded. All observations were noted on customized standard Resource Inventory Standards Committee (RISC) datasheets. Weather conditions were recorded at the beginning and end of each survey using standard definitions. Additional information recorded included: species, Universal Transverse Mercator (UTM) North American Datum of 1983 (NAD83) location, development stage, count, aggregate (egg mass) size, tadpole and adult snout-vent length[1], water depth of observation, distance from shore to observation, average water depth, water drop—slope from pond edge to deeper water—attachment substrate, bottom substrate, and macrohabitat (stream, log jam, shoreline).

[1] Snout-vent length (SVL): "Length of an animal measured from the tip of the snout to the anterior end of the cloacal vent" (Resources Inventory Committee 1998a).

Observations were recorded as absolute counts or estimates when large numbers—hundreds or thousands—were observed.

Habitat attributes were recorded at the end of the survey and were considered representative of the entire wetland. Larger wetland complexes were subdivided based on areas with continuous open water. The wetland classification used was adapted from the wetland classes described in *Wetlands of British Columbia* (MacKenzie and Moran 2004) and grouped similar wetland associations (**Table 1.1.1**).

Table 1.1.1 Wetland habitat classes

Code	Name	Description
DT	Ditch	A long narrow man-made excavation used for drainage.
GB	Gravel bar	An elongated landform generated by waves and currents and usually running parallel to the shore. It is composed of unconsolidated small rounded cobbles, pebbles, stones, and sand.
GP	Gravel pit	Site used for the purpose of rock or gravel extraction.
LA	Lake	A large inland body of standing water.
PD	Puddle	A small, temporary pool of usually muddy water.
RB	River backchannel	A channel that is connected to the main river, but does not necessarily flow through.
RI	River	A watercourse formed when water flows between continuous, definable banks. The flow may be intermittent or perennial. An area that has an ephemeral flow and no channel with definable banks is not considered a river.
SW	Shallow water	Aquatic wetlands dominated by rooted, submerged and floating aquatic plants. Associated with permanent still or slow-moving waterbodies.
Wb	Bog	Shrubby or treed, nutrient-poor peatlands with ericaceous shrubs and hummock-forming Sphagnum species. Develop in basins.
Wf	Fen	Peatlands characterized by non-ericaceous shrubs, sedges, grasses, reeds and brown mosses. Develop in basins, lake margins, river floodplains and seepage slopes.
Wm	Marsh	Shallowly flooded mineral wetland dominated by emergent grass-like vegetation.
Ws	Swamp	Forested, treed, or tall-shrub, mineral wetland dominated by trees or broadleaf shrubs.

Source: definitions developed from MacKenzie and Moran 2004

In 2006, potentially suitable sites identified using Terrestrial Ecosystem Mapping (TEM) were targeted for reconnaissance surveys. River backchannels visited during waterfowl surveys were also searched. Suitable amphibian breeding sites identified during field reconnaissance in 2006 were revisited in 2008 to confirm breeding activity for western toads. Additional sites identified on the TEM and encountered during other field surveys were included. In 2012, amphibian surveys were conducted at the dam site, West Pine Quarry, 85th Avenue Industrial Lands, and Del Rio Pit.

The species habitat model for western toad identified 13,864 hectares of habitat within the LAA as suitable for reproducing (**Map 1.3.5** and **Map 1.3.6**).

1.1.2.2 Auditory Surveys

Auditory surveys were conducted for the wood frog and boreal chorus frog along transects in proximity to wetlands and backchannels. If no frogs were heard, then auditory recordings of frogs were broadcast to elicit a response. Calls of both boreal chorus frog and wood frog were played, if required.

Each transect consisted of four to seven listening stations spaced 500 metres apart. At each station, observers waited one minute after leaving the vehicle or arriving at the wetland before listening for three minutes for frog calls. Observers listened for up to two additional minutes if ambient noise—e.g., traffic—interfered with the ability to hear calls. All species seen or heard were recorded with the direction and distance to the calling frog(s) estimated. If inclement weather conditions—e.g., rain, wind greater than Beaufort 3—were experienced during a survey, stations were not completed.

Stations were revisited during the breeding season unless the habitat was unsuitable—e.g., cultivated fields—or no frogs were heard on the initial visit. Transect starting points were varied between visits to sample listening stations at different times. Observations were recorded on a standard data sheet using the call index recommended by Gartshore et al.(1992) along with UTM (NAD83) location and start and end time (**Table 1.1.2**).

Table 1.1.2 Amphibian call index matrix

Rating	Definition
0	No calls detected
1	Individuals can be counted with no overlapping calls
2	Individual calls are distinguishable with overlapping of some calls
3	Full chorus or continuous calls where individuals cannot be distinguished.

1.1.2.3 Road Surveys

Road transects can be used to identify potential migration corridors for dispersing juvenile western toads when those corridors are intersected by roads. Following metamorphosis, juvenile western toads can be found dispersing away from breeding sites end masse (Matsuda et al. 2006b), making them easy to locate with road surveys.

In 2008, road surveys were conducted in proximity to suitable wetlands. Roads targeted were those expected to have higher use during construction or operation of the Project

Surveys began at dusk and continued for two to five hours. To detect amphibians moving across the road and roadkills, two surveyors travelled on foot using headlamps or in a vehicle at slow speeds—less than 10 kilometres per hour—using low beam headlights. The UTM (NAD83) location time, species, condition, development stage, size, and number observed were recorded for all amphibians detected along each transect. Weather conditions at the start and end of the survey and any occurrence of rainfall 12 to 24 hours prior to the survey were also recorded.

1.1.3 Field Survey Results

1.1.3.1 Pond Breeding Surveys

Sixty-three surveys were conducted between April 23 and June 21, 2006 for a total of 19 hours and ten minutes survey time. All five species of amphibians were detected during surveys. At least one species was detected at 25 (40%) of sites visited. Some sites where habitat appeared suitable did not result in amphibian detections when initially visited in April. These sites were revisited in June. Egg masses western toad, wood frog, boreal chorus frog and Columbia spotted frog were observed as well as western toad and wood frog tadpoles.

The onset of spring was delayed in 2008 with cold weather persisting into May. Surveys were completed from May 6 to August 16. In total, 82 pond breeding surveys were completed for a total of 74 hours and 32 minutes survey time. Fifty-nine of these sites (72%) supported amphibians. Sites where egg masses were observed in May and June were re-surveyed in July and August to determine development stage of tadpoles and their potential to disperse. During these surveys, western toads, boreal chorus frogs and wood frogs were observed. Boreal chorus frog and wood frog eggs were observed as well as western toad and wood frog tadpoles.

In 2012, twenty-eight pond breeding surveys were conducted between April 28 and May 15 for a total of 10 hours and 21 minutes survey time. Seventeen sites recorded amphibian detections (61%) and eleven sites recorded no activity. Seven sites had wood frog eggs; no other species' egg masses were detected. In 2012 western toad, boreal chorus frog, and wood frogs tadpoles were observed. Adults of all three species were observed.

Over the three years of surveys a large number of western toad and wood frog tadpoles were noted (**Table 1.1.3**). Smaller numbers of the other amphibian species were detected including one long-toed salamander. The majority of detections of boreal chorus frog were adults (n=170). Only eggs and adults of Columbia spotted frog were observed, both in 2006.

Table 1.1.3 Amphibian: detections by development stage – pond surveys

Year	Development stage	Boreal Chorus Frog	Columbia Spotted Frog	Long-toed Salamander	Western Toad	Wood Frog	Unknown Frog
2006	Eggs	8	30	ND	1	144	ND
	Tadpoles	ND	ND	ND	736	100	ND
	Juvenile	ND	ND	ND	1	7	ND
	Adult	13	12	1	77	22	1
2008	Eggs	1	ND	ND	ND	72	ND
	Tadpoles	ND	ND	ND	76,176	5,277	ND
	Juvenile	ND	ND	ND	1,515	163	ND
	Adult	102	ND	ND	16	80	9
	Unclassified	ND	ND	ND	ND	7	ND
2012	Eggs	ND	ND	ND	ND	274	ND
	Juvenile	ND	ND	ND	ND	1	ND
	Adult	55	ND	ND	4	104	ND
Total		**179**	**42**	**1**	**78,526**	**6,251**	**10**

ND – not detected

Pond breeding surveys were completed in three years. Eleven of the 12 wetland habitat classes identified (see **Table 1.1.1**) were surveyed in 2006, eight in 2008, and six in 2012 (**Table 1.1.4**). In 2008 high counts of wood frog tadpoles were observed in a backchannel. Western toad tadpoles were observed in high numbers along the TL as well as in backchannels. **Table 1.1.4** shows the number of sites of each type of habitat that was sampled and the number of sites where species were observed.

Table 1.1.4 Amphibian: detections by habitat type – pond surveys 2006, 2008, and 2012

Habitat Type	Total Sites Sampled	Boreal Chorus Frog	Columbia Spotted Frog	Long-toed Salamander	Western Toad	Wood Frog
Bog	7	1	ND	ND	1	1
Ditch	9	4	ND	ND	1	7
Fen	34	10	ND	1	3	7
Gravel Bar	1	ND	ND	ND	2	1
Gravel Pit	1	1	ND	ND	ND	1
Lake	6	3	ND	ND	2	4
Marsh	37	12	2	ND	5	22
Puddle	6	3	ND	ND	ND	3
River Backchannel	19	1	ND	ND	5	4
River	1	ND	ND	ND	1	1
Shallow Water	13	4	ND	ND	7	9
Swamp	1	ND	ND	ND	ND	ND
Unidentified	3	ND	ND	ND	ND	ND

Habitat Type	Total Sites Sampled	Boreal Chorus Frog	Columbia Spotted Frog	Long-toed Salamander	Western Toad	Wood Frog
Total	**137**	**39**	**2**	**1**	**27**	**60**

ND – not detected

Amphibian species were detected in all wetland habitat types with the exception of swamps and unidentified sites. Fens and marshes both supported four of the five species. Fens had all species with the exception of Columbia spotted frog and marshes had all with the exception of long-toed salamanders. Survey results indicate these two species—Columbia spotted frog and long-toed salamanders—are rare in the LAA. They were only detected during in surveys in 2006. Boreal chorus frogs were detected in nine of 12 wetland habitat classes and were found at 39 sites. Wood frogs were the most commonly detected species with detections in 11 of 12 wetland habitat classes at 60 sites.

Western toads were detected in nine of 12 wetland habitat classes and were detected at 26 sites (**Map 1.3.5** and **Map 1.3.6**). Western toad egg masses were found on May 28, 2006. In late April of 2006, approximately 75 western toads were found in amplexus in a backchannel. A female was observed laying eggs in the same backchannel. The backchannel is located on the south side of the Peace River just east of the confluence of the Beatton River and the Peace River. In 2008 approximately 10,000 western toad tadpoles were observed in a backchannel near the Clayhurst bridge and at a backchannel near Farrell Creek along the Peace River observers noted approximately 20,000 tadpoles. Two large groups of tadpoles were found in two wetlands near the existing TL. The first was located near the Del Rio pit and observers noted approximately 30,000 western toad tadpoles. The second wetland had approximately 20,000 tadpoles. Tadpoles were recorded between May 31 and June 21, 2006 and May 27 to July 27, 2008. No egg masses were observed in 2008 or 2012 and no tadpoles were observed during surveys in 2012.

1.1.3.2 Auditory Surveys

Fifty-one auditory surveys were completed between April 19 and May 31, 2006 for a total of 10 hours and 16 minutes survey time. In 2008, eight transects with up to seven stations were established and visited one to six times between May 5 and June 10. Twenty-five surveys were completed for a total of eight hours and 11 minutes survey time.

The 2006 and 2008 auditory surveys resulted in higher numbers of boreal chorus frog detections than the corresponding pond surveys. Surveys in 2006 saw high numbers of wood frog detections and some of the only Columbia spotted frog detections. There were 13 visual detections of western toads during both years of surveys (**Table 1.1.5**; **Map 1.3.5** and **Map 1.3.6**).

Table 1.1.5 Amphibian detections: auditory surveys

Year	Boreal Chorus Frog	Columbia Spotted Frog	Western Toad[a]	Wood Frog	Unknown Frog	Total
2006	119	6	3	184	1	**313**
2008	146	ND	10	14	ND	**170**
Total	**265**	**6**	**13**	**198**	**1**	**483**

[a] Visual detections
ND – not detected

1.1.3.3 Road Surveys

In 2008, three road transects with four to 17 listening stations were surveyed (**Table 1.1.6**). During road surveys, three amphibian species were detected including western toads, boreal chorus frog, and wood frogs.

Table 1.1.6 Amphibian effort: road surveys – 2008

Transect Label	Visit Date	Total Stations Surveyed	Total Survey Time (hrs:min)
Del Rio East	27-Jul-08	4	4:10
Del Rio East	12-Aug-08	11	7:27
Del Rio West	26-Jul-08	7	4:12
Del Rio West	11-Aug-08	17	7:46
Johnson Road	15-Aug-08	4	3:05
Total		**43**	**26:40**

Adult and juvenile toads were observed on roads during all surveys. Over the two nights of surveying in 2008, 200 western toads were detected along the Del Rio East transect and 238 were detected along the Del Rio West transect. Large concentrations of juvenile toads found on the Del Rio East transect indicates proximity to suitable toad breeding habitat. Sixteen of the toads found during road surveys were roadkill including 14 adults, one subadult, and one juvenile. Tadpoles occasionally were observed in roadside ditches. Detections are summarized in **Table 1.1.7**.

Table 1.1.7 Amphibian detections by development stage: road surveys – 2008

Transect Label	Western Toad			Boreal Chorus Frog			Wood Frog			Total
	Adult	Juvenile	Subadult	Tadpole	Adult	Subadult	Juvenile	Subadult	Tadpole	
Del Rio East	52	87	60	1	ND	1	ND	ND	ND	**201**
Del Rio West	154	29	55	ND	ND	2	1	5	7	**253**
Johnson Road	35	1	ND	ND	1	1	ND	ND	ND	**38**
Total	**241**	**117**	**115**	**1**	**1**	**4**	**1**	**5**	**7**	**492**

ND – not detected

Wood frogs and boreal chorus frogs were detected during surveys but with less frequency. Multiple occurrences of wood frogs were observed in a small area at the western end of the Del Rio West transect indicating proximity to suitable breeding habitat.

Clockwise: wood frog, long-toed salamander larvae, spotted frog, wood frog egg mass, western toads in amplexus

Source: L. Andrusiak, C. DiCorrado, L. Law

Photograph 1.1.1 Amphibians

1.1.3.4 Incidental Observations

Incidental observations of all five amphibian species have occurred since 2005 (**Table 1.1.8**). Long-toed salamanders were detected only as adults during amphibian surveys but were incidentally observed in the hatchling stage.

Table 1.1.8 Amphibian incidental observations – 2005 to 2012

Species	Developmental Stage	2005	2006	2008	2009	2010	2011	2012	Total
Boreal Chorus Frog	Adult	ND	4	40	2	ND	91	5	**142**
	Tadpole	ND	2	ND	ND	ND	ND	1	**3**
Columbia Spotted Frog	Unclassified	ND	1	ND	ND	ND	ND	ND	**1**
Long-toed Salamander	Adult	ND	ND	ND	ND	ND	2	ND	**2**
	Eggs	ND	ND	ND	ND	ND	ND	1	**1**
	Hatchling	5	ND	ND	ND	ND	ND	22	**27**
	Unclassified	1	ND	ND	ND	ND	1	ND	**1**
Western Toad	Adult	24	10	40	ND	32	17	6	**129**
	Eggs	ND	ND	ND	ND	ND	ND	6	**6**
	Tadpole	41	2802	1153	ND	1003	253	>100,000	**>100,000**
	Unclassified	2	410	2	ND	45	5	6	**470**
Wood Frog	Adult	2	16	78	ND	ND	12	18	**126**
	Eggs	ND	ND	ND	ND	ND	ND	26	**26**
	Tadpole	ND	15	28	ND	ND	ND	5	**48**
	Unclassified	ND	1	1	ND	ND	10	17	**29**
Unknown Frog	Adult	ND	1	ND	ND	ND	ND	ND	**1**

During invertebrate surveys in June 2012 surveyors noted a wetland with approximately 100,000 western toad tadpoles. This wetland is located within the LAA near the Del Rio Pit, and is the same location as an observation of approximately 30,000 tadpoles during surveys in June 2008.

1.2 Reptiles

1.2.1 Species

The Peace River Valley is home to two of the province's reptiles (BC Conservation Data Centre 2011)—the common gartersnake, red-sided subspecies (*Thamnophis sirtalis parietalis*) and the terrestrial gartersnake (*T. elegans*) (Matsuda et al. 2006a). Both snakes are provincially yellow-listed and neither is SARA-listed.

Both species have been observed during previous studies completed for the Project, which looked within likely habitats including the interface between grassy and shrubby or forested areas, gravel pits, gravel bars, rights-of-way, and roadsides (Hawkes et al. 2006). No other literature exists for these species in the Peace Region.

1.2.1.1 Hibernacula

The characteristics of gartersnake hibernacula (dens) are not well known and no records of confirmed hibernacula in or near the LAA could be located in the literature; general locations were suggested by regional BC Ministry of Forests, Lands, and Natural Resources Operations staff. Talus, fractured bedrock, road beds, clusters of tree roots, shale or rocky cliffs, road embankments, rock piles, pits, culverts, limestone sinkholes, caves, abandoned cisterns, anthills, animal burrows, and house foundations have been reported as hibernacula sites (Resources Inventory Committee 1998b; Takats 2002). Earthen dikes have been documented as hibernation sites along the Okanagan River (M. Sarell 2010, pers. Comm.).

Field surveys were completed to locate hibernacula and identify areas with potential to support hibernacula within the LAA.

1.2.2 Field Survey Methods

Previous observations of gartersnakes in the Peace River Valley were reviewed and plotted on field maps and a species model ranking hibernation habitat was created using TEM (**Appendix B.1**). Ratings for gartersnake hibernation habitat were used to produce a themed map identifying the location of polygons with characteristics suitable for snake den sites.

In 2011, time-constrained surveys were completed in the Peace River Valley following the Inventory Methods for Snakes (Resources Inventory Committee 1998b). Transects were completed within likely hibernacula habitat identified by the snake hibernacula suitability model

(**Map 1.3.3** and **Map 1.3.4**). Surveys in 2012 focused on the proposed quarry site at Portage Mountain.

Surveys were conducted by foot or vehicle in accessible areas beginning around 10:00 to ensure temperatures had risen to a point where gartersnakes would to be basking. No surveys were conducted during cool—below 12°C—or rainy weather. Information recorded on RISC standard data forms included: UTM coordinates (NAD 83), start and stop time, and weather conditions (Resources Inventory Committee 1998b).

1.2.3 Field Survey Results

Due to an unusually late snow-melt, 2011 field sampling began in May with spring surveys completed May 8 and 12 through 15; fall surveys were completed on September 8, 11 through 13, and 16. A total of 42 hours and 8 minutes of surveying time was completed, covering 58 kilometres (**Table 1.2.1**). Spring surveys were completed in 25 hours and 11 minutes and covered 24 kilometres. Fall surveys totalled 16 hours and 57 minutes and covered 33.9 kilometres.

Table 1.2.1 Reptile detections and effort by transect: 2011

Transect	Station Type	Visit Date	Visit No.	Transect Length (km)	No. Observed	Total Search Time (hh:mm)
Spring 2011 Surveys						
Bear Flat 1	Transect	May 13	1	7.2	3	08:16
Bear Flat 2	Transect	May 15	1	6.0	1	05:10
Cecil Lk Rd	Spot-check	May 12 (morning)	1	0.3	ND	00:36
Cecil Lk Rd	Spot-check	May 12 (afternoon)	2	0.3	ND	00:25
Cecil Lk Rd	Spot-check	May 14	3	0.3	ND	00:27
HH Pumphouse	Spot-check	May 5	1	0.2	ND	00:23
HH Pumphouse	Spot-check	May 15	2	0.2	ND	00:32
Tea Creek 1	Transect	May 12	1	3.4	ND	03:01
Tea Creek 2	Transect	May 14	1	4.8	1	05:44
Watson Slough1	Transect	May 15	1	1.3	ND	00:37
Fall 2011 Surveys						
Bear Flat 3a	Transect	September 13	2	10.8	ND	07:00
Cecil Lk Rd	Spot-check	September 8	4	0.3	ND	00:20
Clayhurst 1	Transect	September 11	1	2.5	ND	02:51
Clayhurst 2	Transect	September 11	1	11.3	1	01:15
Halfway R	Spot-check	September 12	1	0.1	ND	00:15
HH Pumphouse	Spot-check	September 16	3	0.3	ND	00:13
Peace R	Transect	September 12	1	1.4	ND	00:35

Transect	Station Type	Visit Date	Visit No.	Transect Length (km)	No. Observed	Total Search Time (hh:mm)
Site C	Transect	September 12	1	5.9	2	03:10
Watson Slough 2	Transect	September 12	1	1.3	ND	01:18
Total					**8**	**42:08**

[a] a portion of this transect retraced the route previously surveyed in the spring
ND – not detected

Spot-checks were made at two reported sites of snake aggregation: one at a highway embankment on Cecil Lake Road north of Fort St. John and one at the Hudson's Hope pumphouse. Each site was visited twice in the spring and once in the fall. No snakes were observed.

Limestone formations along the north bank of the river from Hudson’s Hope west to the Peace Canyon Dam were noted as providing good denning opportunities. No snakes were sighted and local landowners contacted had not observed snake concentrations.

Two surveys were completed on foot at Bear Flats in the spring and one in the fall. Two terrestrial gartersnakes were observed emerging at one site and one snake was observed at another site. Both sites were cracks at the bases of cliffs on steep, warm aspect slopes. A fourth snake was observed on a path on a gentle slope. No den was identified in the vicinity. Rodent burrows were observed in a nearby cutbank. As snakes may not remain in the vicinity of a hibernacula once emerged (Shine et al. 2006), surveyors checked wetlands in the Bear Flats area to see if snakes had emerged and moved to feeding habitat. No snakes were observed in the wetlands.

One foot-transect was completed along the highway embankment south of Watson Slough in the spring; the slough was visited again in September. No snakes were observed although the highway embankment was assessed as having moderately suitable hibernation habitat. The Watson Slough wetland provides high suitability foraging habitat for gartersnakes during the growing season and gartersnakes have been observed during other Project surveys.

Two transects were completed on foot at Tea Creek in the spring. One terrestrial gartersnake was observed emerging from a crack at the base of cliffs with a steep, warm aspect. A juvenile gartersnake was observed during bat surveys at the Tea Creek cliffs.

Foot surveys were completed in the fall in the areas of Clayhurst, the dam site, and at the Halfway River bridge abutment. On the Clayhurst transect, one snake track was photographed in a rock crevice suspected of being a den. Two gartersnakes, one live and one roadkill, were observed on the dam site transect. No denning features were located in the vicinity of the observations.

Field sampling in 2012 was completed May 9 and 10 at Portage Mountain. The southern rock outcropping was identified as good denning habitat. A total of nine hours and 19 minutes of surveying was completed covering 7 kilometres of transects (**Table 1.2.2**). No snakes were detected.

Table 1.2.2 Reptile detections and effort by transect: 2012

Transect	Station Type	Visit Date	Visit No.	Transect length (km)	No. observed	Total Search Time (hh:mm)
Portage 1	Transect	May 9	1	1.7	ND	02:38
Portage 2	Transect	May 10	1	5.0	ND	06:41
Total					**0**	**09:19**

ND – not detected

Incidental observations of 24 common gartersnakes, eight terrestrial gartersnakes, and five unknown gartersnakes have been recorded during other taxa surveys in the Peace River area from 2005 to 2012. These observations include both dead and live snake observations.

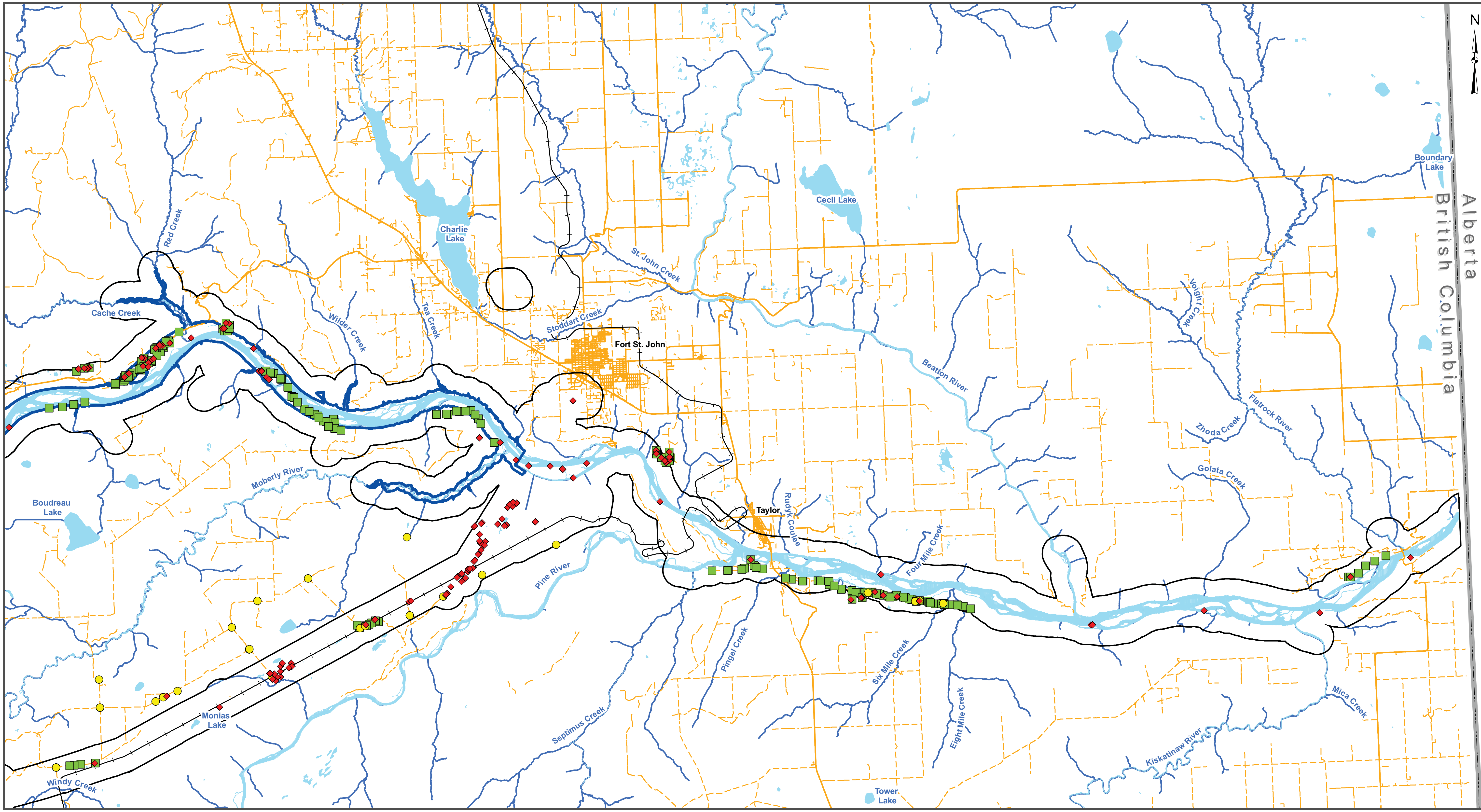
The soils in the vicinity of the LAA are generally fine-textured and not highly suitable for hibernacula but small areas of suitable soil do occur. No talus, sinkholes, or deep caves are known to be present within the LAA and rock outcrops are limited in size, number, and distribution. Within the LAA, data suggest snakes hibernate communally in very small numbers or individually which makes it difficult to verify exact hibernacula locations.

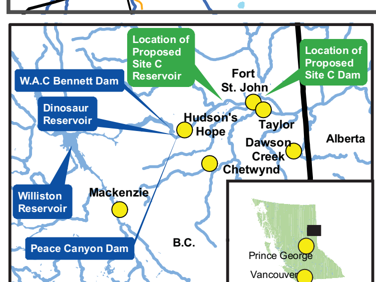
Four hibernacula were confirmed: two at Bear Flats, one at Tea Creek, and one west of the Clayhurst Bridge. All confirmed sites were crevices on steep, warm aspect cliffs or rock outcrops and outside the flood zone. Based on roadkill, additional dens are suspected along Cecil Lake Road, on the east side of the first bridge crossing of St. John Creek, and on Highway 29 west of Lynx Creek. A den is reputed to be in the rip-rap of the Highway 29 bridge footing on the east side of Halfway River. This site was visited twice with no gartersnakes observed although one roadkill was found within 700 metres of the site.

It is assumed north aspect slopes in the Peace region retain snow longer in the spring delaying snake emergence and are too cool in the fall for returning snakes. Some of the largest areas of warm-aspect rock on the north side of the river are located between Hudson’s Hope and the Peace Canyon Dam, on the Bear Flats cliffs, in the Tea Creek drainage, and in the Alces River drainage near Clayhurst. Access constraints prevented surveys of additional habitat along the Peace River east of Bear Flats where rock outcrops visible at a distance were assessed as having high suitability for hibernacula and assigned a high rating. A number of additional small vertical rock-outcrops, not detectable on air photographs, were noted and assigned a suitability rating during field surveys.

A total of 4,084 hectares of suitable habitat was identified within the LAA (**Map 1.3.7** and **Map 1.3.8**).

1.3 Maps





Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. Proposed Reservoir Area (461.8 m maximum normal elevation) from Digital Elevation Models (DEM) generated from LiDAR data acquired July/August 2006.
5. Wildlife Data acquired from Keystone Wildlife Research Ltd, 2012.

LEGEND
- Proposed Reservoir
- Gravel Road
- Paved Road
- Rail Line
- Provincial/Territorial Boundary

Wildlife Data
- Pond Breeding Station
- Road Transect
- Auditory Transect
- Wildlife Resources, Vegetation and Ecological Communities Local Assessment Area (LAA)

1:225,000

0 5 km

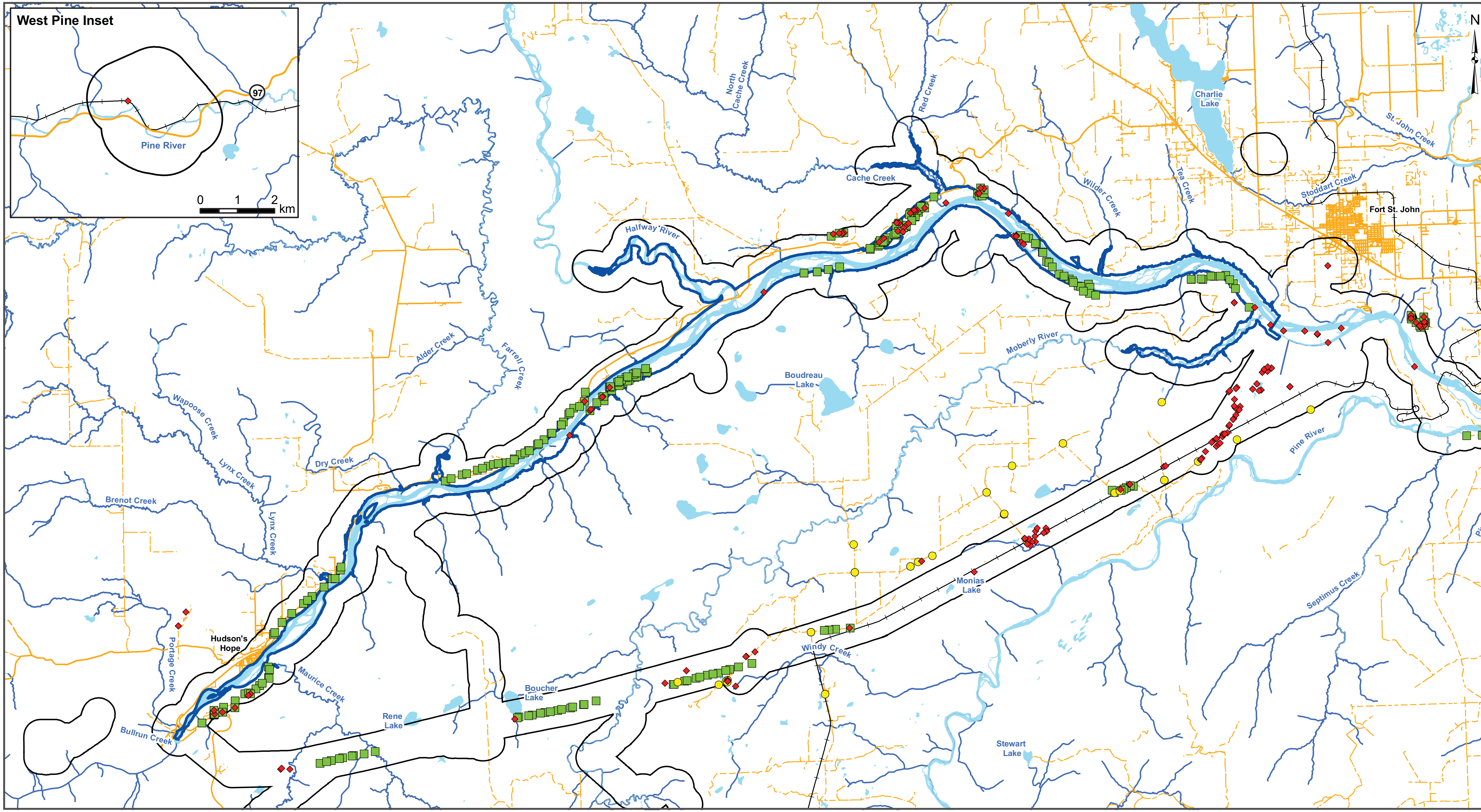
SITE C CLEAN ENERGY PROJECT

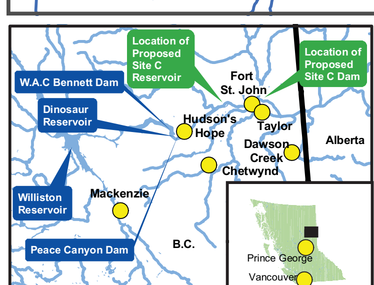
BC hydro

MAP 1.3.1. TRANSECT LOCATIONS: AMPHIBIANS - EAST

DATE	DECEMBER 13, 2012	DWG NO	1016-C14-B4541-1	R 0

Construction of the Site C Clean Energy Project is subject to required regulatory approvals including environmental certification





LEGEND

- Proposed Reservoir
- Gravel Road
- Paved Road
- Rail Line

Wildlife Data

- Pond Breeding Station
- Road Transect
- Auditory Transect
- Wildlife Resources, Vegetation and Ecological Communities Local Assessment Area (LAA)

1:225,000

0 5 km

Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. Proposed Reservoir Area (461.8 m maximum normal elevation) from Digital Elevation Models (DEM) generated from LiDAR data acquired July/August 2006.
5. Wildlife Data acquired from Keystone Wildlife Research Ltd, 2012.

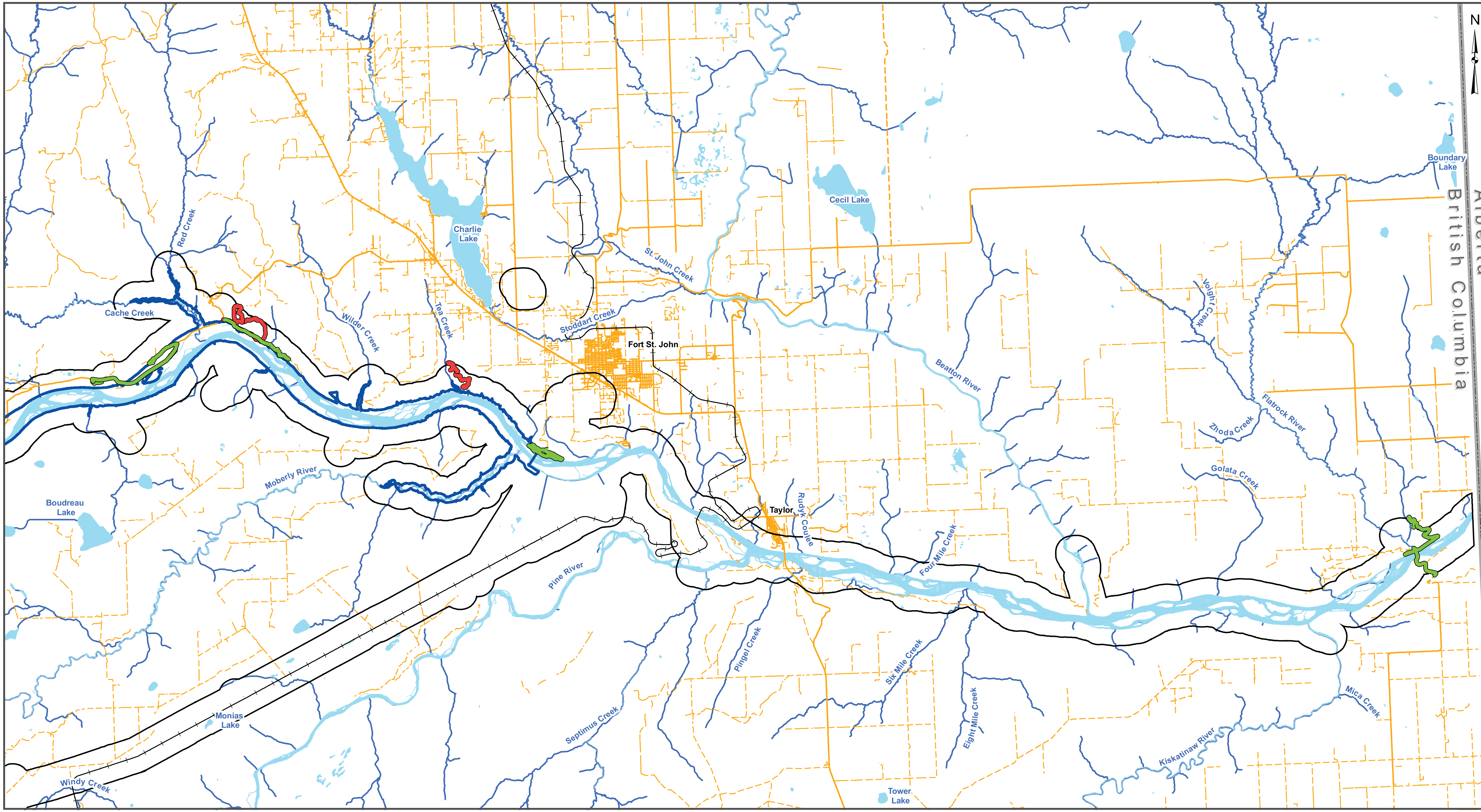
SITE C CLEAN ENERGY PROJECT

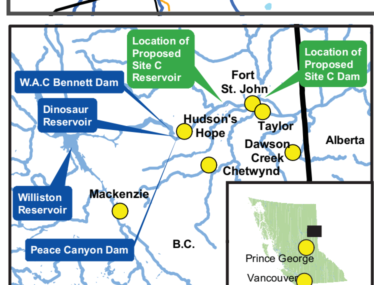
BC hydro

MAP 1.3.2. TRANSECT LOCATIONS: AMPHIBIANS - WEST

DATE	DECEMBER 13, 2012	DWG NO	1016-C14-B4541-1	R 0

Construction of the Site C Clean Energy Project is subject to required regulatory approvals including environmental certification





Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. Proposed Reservoir Area (461.8 m maximum normal elevation) from Digital Elevation Models (DEM) generated from LiDAR data acquired July/August 2006.
5. Wildlife Data acquired from Keystone Wildlife Research Ltd, 2012.

LEGEND
- Proposed Reservoir
- Gravel Road
- Paved Road
- Rail Line
- Provincial/Territorial Boundary

Wildlife Data
- Survey Transect - Spring
- Survey Transect - Fall
- Wildlife Resources, Vegetation and Ecological Communities Local Assessment Area (LAA)

1:225,000

0 5 km

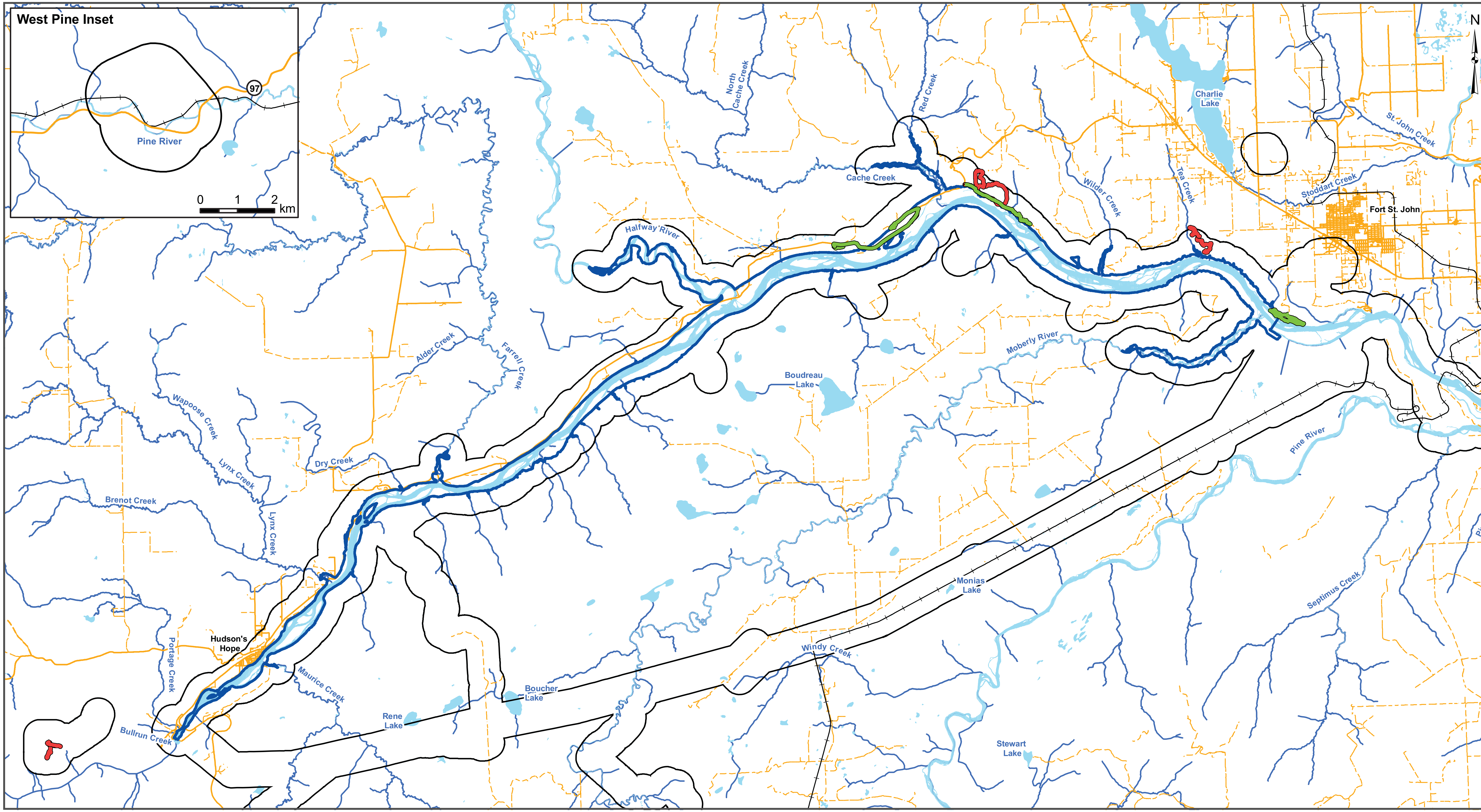
BC hydro

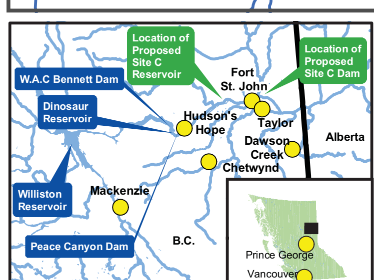
SITE C CLEAN ENERGY PROJECT

MAP 1.3.3. TRANSECT LOCATIONS: REPTILES - EAST

DATE	DECEMBER 3, 2012	DWG NO	1016-C14-B4541-2	R 0

Construction of the Site C Clean Energy Project is subject to required regulatory approvals including environmental certification





Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. Proposed Reservoir Area (461.8 m maximum normal elevation) from Digital Elevation Models (DEM) generated from LiDAR data acquired July/August 2006.
5. Wildlife Data acquired from Keystone Wildlife Research Ltd, 2012.

LEGEND

- Proposed Reservoir
- Gravel Road
- Paved Road
- Rail Line

Wildlife Data

- Survey Transect - Spring
- Survey Transect - Fall
- Wildlife Resources, Vegetation and Ecological Communities Local Assessment Area (LAA)

1:225,000

0 5 km

SITE C CLEAN ENERGY PROJECT

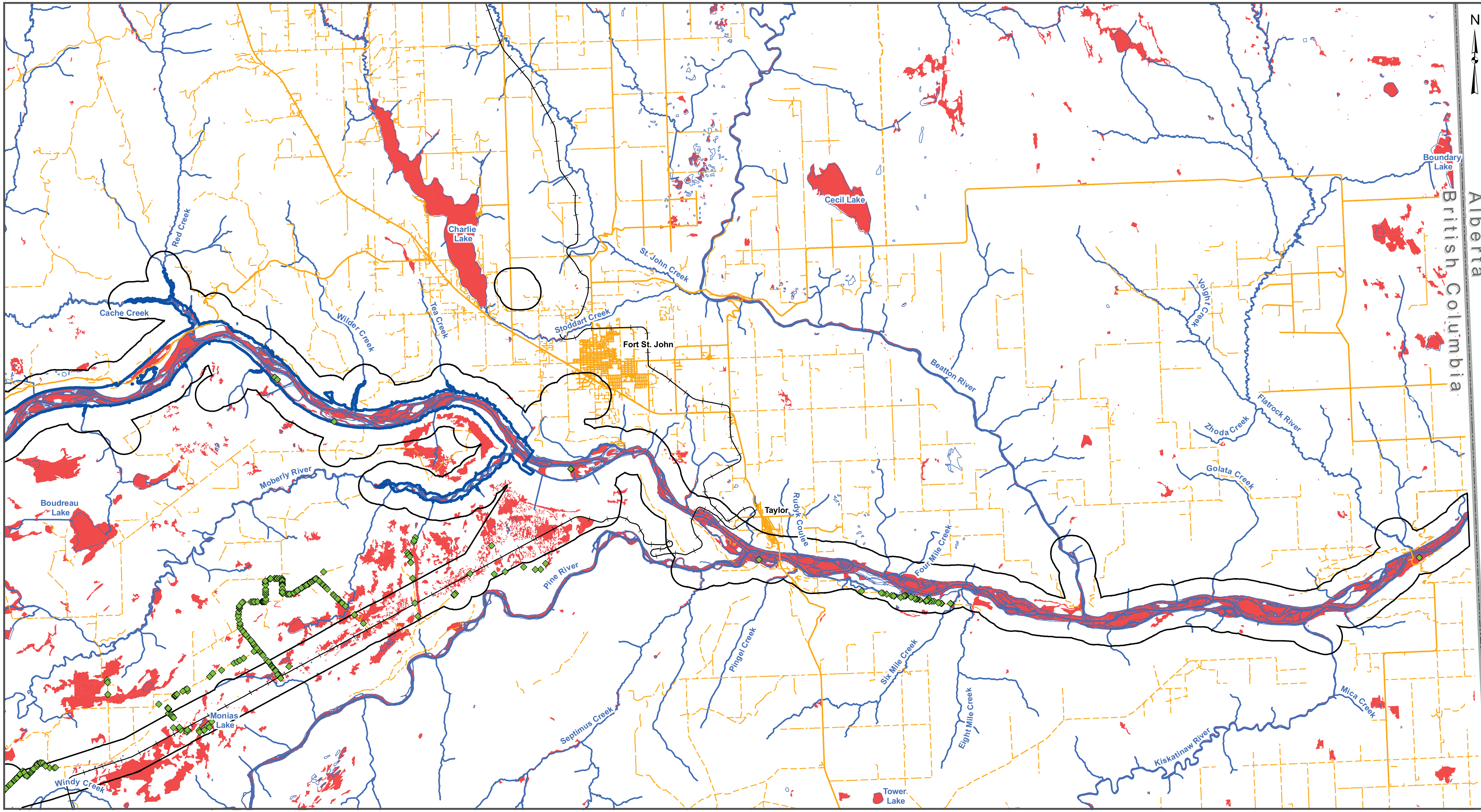
BC hydro

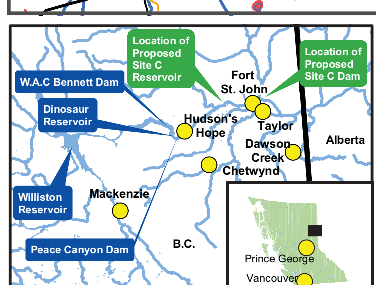
Keystone

MAP 1.3.4. TRANSECT LOCATIONS: REPTILES - WEST

DATE	DECEMBER 3, 2012	DWG NO	1016-C14-B4541-2	R 0

Construction of the Site C Clean Energy Project is subject to required regulatory approvals including environmental certification





Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. Proposed Reservoir Area (461.8 m maximum normal elevation) from Digital Elevation Models (DEM) generated from LiDAR data acquired July/August 2006.
5. Wildlife Data acquired from Keystone Wildlife Research Ltd, 2012.

LEGEND

- Proposed Reservoir
- Gravel Road
- Paved Road
- Rail Line
- Provincial/Territorial Boundary

Wildlife Data

- Western Toad
- Suitable Habitat
- Wildlife Resources, Vegetation and Ecological Communities Local Assessment Area (LAA)

1:225,000

0 5 km

SITE C CLEAN ENERGY PROJECT

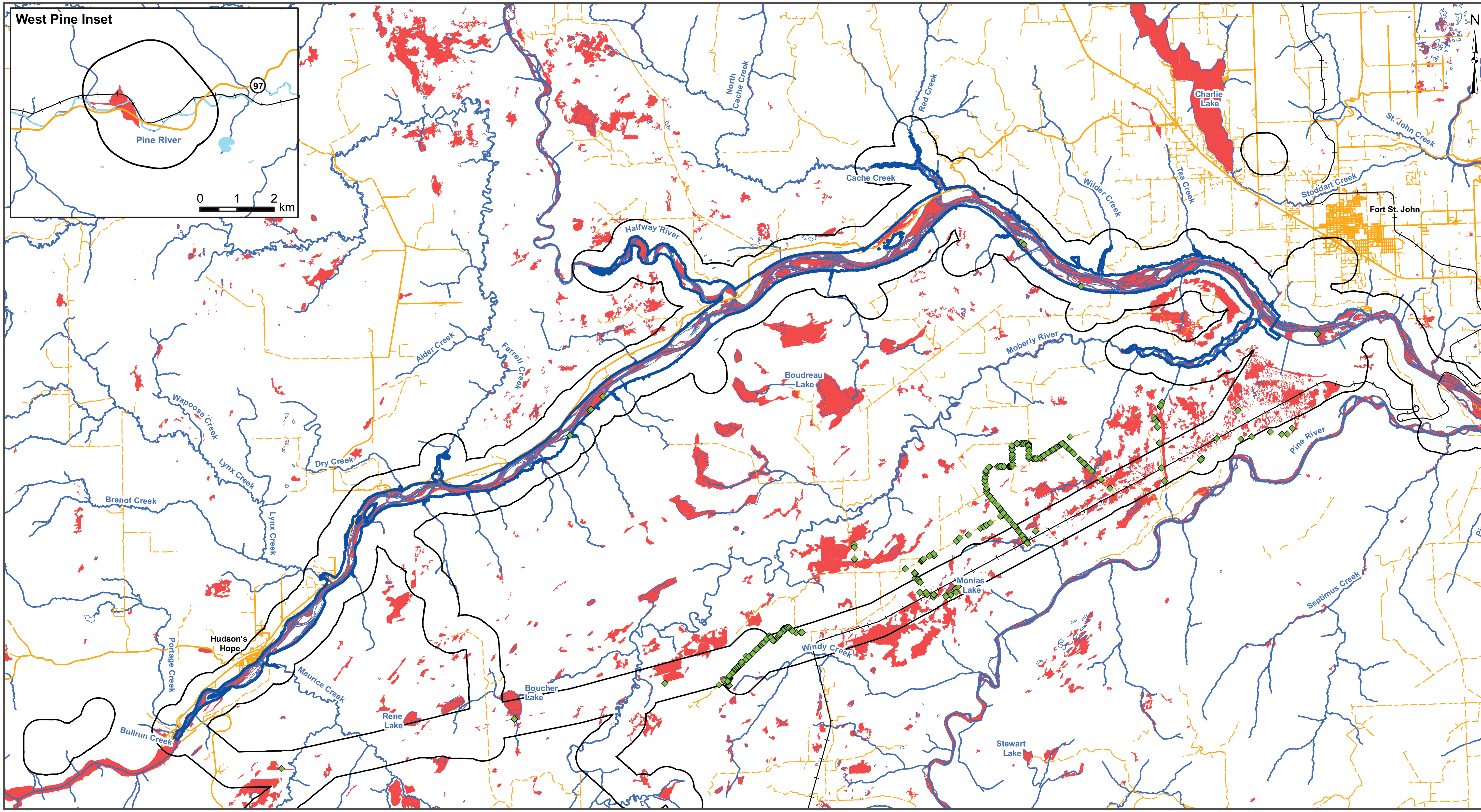
BC hydro

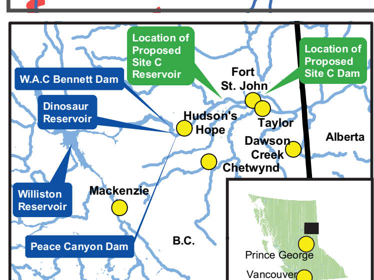
Keystone

MAP 1.3.5. HABITAT SUITABILITY: WESTERN TOAD - EAST

DATE	DECEMBER 13, 2012	DWG NO	1016-C14-B4541-3	R 0

Construction of the Site C Clean Energy Project is subject to required regulatory approvals including environmental certification





Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. Proposed Reservoir Area (461.8 m maximum normal elevation) from Digital Elevation Models (DEM) generated from LiDAR data acquired July/August 2006.
5. Wildlife Data acquired from Keystone Wildlife Research Ltd, 2012.

LEGEND
- Proposed Reservoir
- Gravel Road
- Paved Road
- Rail Line

Wildlife Data
- Western Toad
- Suitable Habitat
- Wildlife Resources, Vegetation and Ecological Communities Local Assessment Area (LAA)

1:225,000

0 5 km

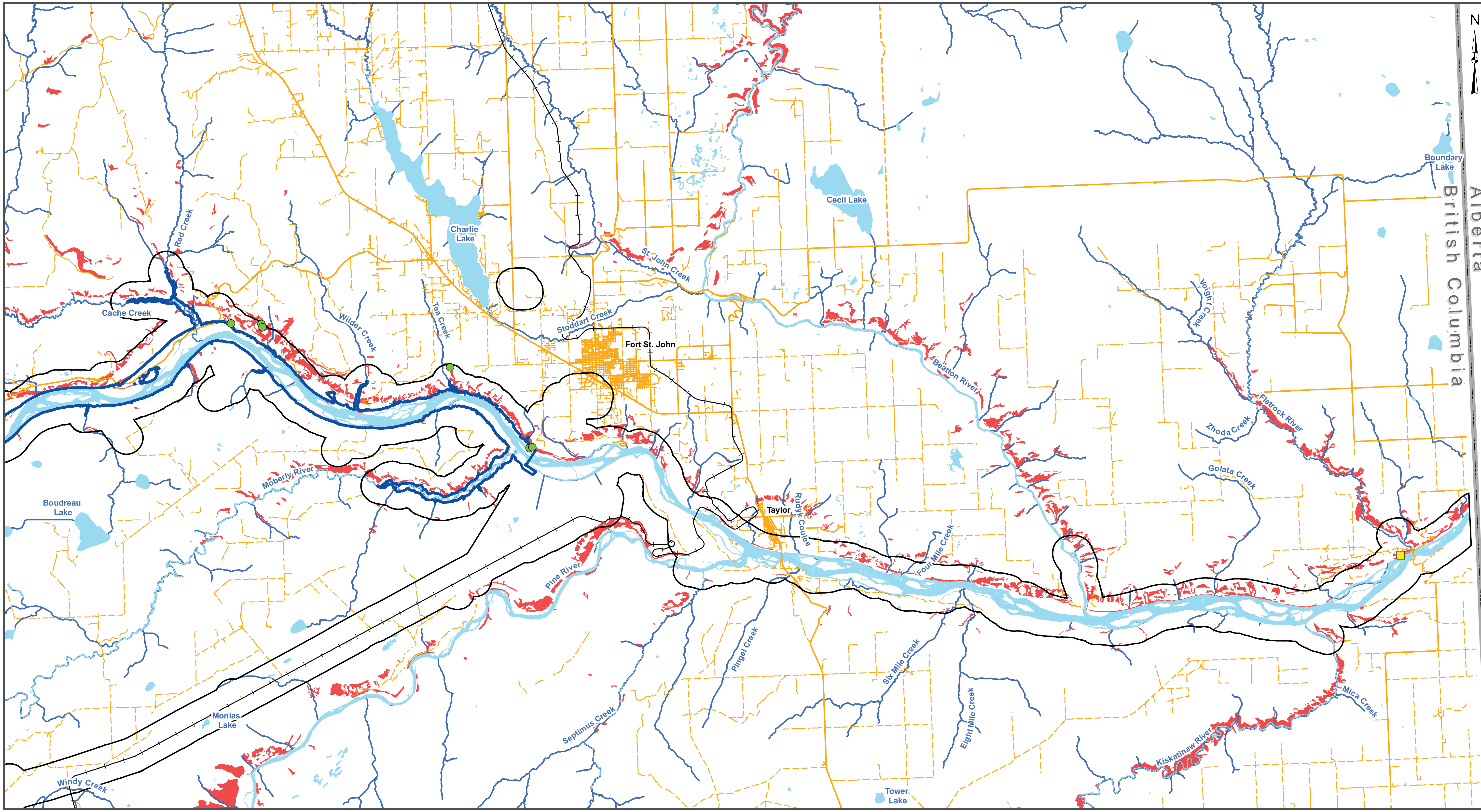
BC hydro

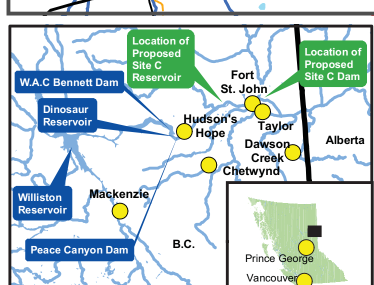
SITE C CLEAN ENERGY PROJECT

MAP 1.3.6. HABITAT SUITABILITY: WESTERN TOAD - WEST

DATE	DECEMBER 13, 2012	DWG NO	1016-C14-B4541-3	R 0

Construction of the Site C Clean Energy Project is subject to required regulatory approvals including environmental certification





Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. Proposed Reservoir Area (461.8 m maximum normal elevation) from Digital Elevation Models (DEM) generated from LiDAR data acquired July/August 2006.
5. Wildlife Data acquired from Keystone Wildlife Research Ltd, 2012.

LEGEND

- Proposed Reservoir
- Gravel Road
- Paved Road
- Rail Line
- Provincial/Territorial Boundary

Wildlife Data

- Snake (including roadkill)
- Snake Track
- Suitable Habitat
- Wildlife Resources, Vegetation and Ecological Communities Local Assessment Area (LAA)

1:225,000

0 5 km

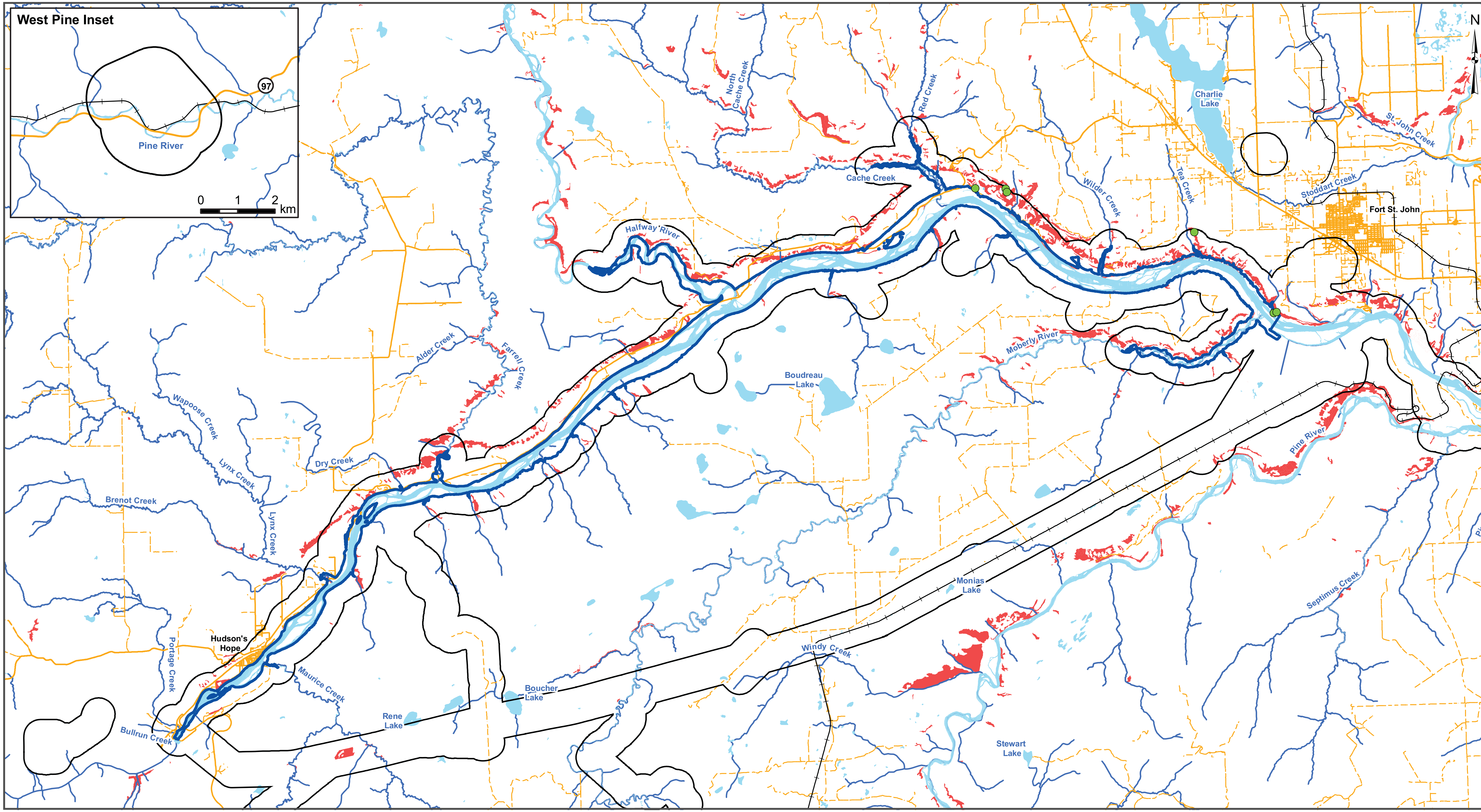
BC hydro

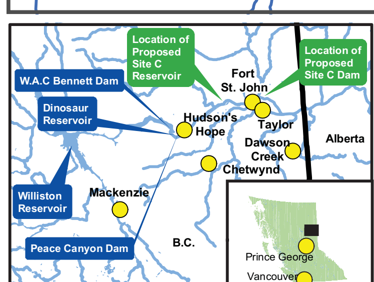
SITE C CLEAN ENERGY PROJECT

MAP 1.3.7. HABITAT SUITABILITY: GARTERSNAKE - EAST

DATE	DECEMBER 3, 2012	DWG NO	1016-C14-B4541-4	R 0

Construction of the Site C Clean Energy Project is subject to required regulatory approvals including environmental certification





Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. Proposed Reservoir Area (461.8 m maximum normal elevation) from Digital Elevation Models (DEM) generated from LiDAR data acquired July/August 2006.
5. Wildlife Data acquired from Keystone Wildlife Research Ltd, 2012.

LEGEND

- Proposed Reservoir
- Gravel Road
- Paved Road
- Rail Line

Wildlife Data

- Snake (including roadkill)
- Snake Track
- Suitable Habitat
- Wildlife Resources, Vegetation and Ecological Communities Local Assessment Area (LAA)

1:225,000

0 5 km

BC hydro

SITE C CLEAN ENERGY PROJECT

MAP 1.3.8. HABITAT SUITABILITY: GARTERSNAKE - WEST

DATE	DECEMBER 3, 2012	DWG NO	1016-C14-B4541-4	R 0

Construction of the Site C Clean Energy Project is subject to required regulatory approvals including environmental certification

2 POTENTIAL EFFECTS

2.1 Habitat Alteration and Fragmentation

Habitat alteration and fragmentation is defined as the permanent removal or loss of habitat or a reduction in habitat suitability for one or more life stages. Project components and related Project activities during construction and operation expected to cause habitat alteration and fragmentation to amphibians and snakes include:

- **Dam, Generating Station and Spillways**: site clearing and preparation, temporary and permanent access roads, relocating surplus excess, sand and gravel source pits, existing infrastructure relocation, Stage 1 and Stage 2 channelization and diversion works
- **Reservoir**: vegetation removal, flooding, Hudson's Hope shoreline protection, debris management, and bank erosion
- **Transmission Line**: vegetation removal, access construction and vegetation maintenance during operations
- **Highway 29 Realignment**: vegetation removal, temporary and permanent road construction, relocating and removing infrastructure and surplus materials, bridge construction and shoreline protection
- **Construction Access Roads**: Site preparation, earthworks, drainage, and railway construction
- **Quarried and Excavated Materials**: Site preparation, earthworks, operations

Amphibians and reptiles are vulnerable to a variety of environmental changes due to reduced ability to move and migrate freely, increased vulnerability to mortality when moving across roads or through inhospitable environments, and relatively narrow habitat needs. The direct loss of habitat is the primary effect of the Project on amphibians and reptiles. This includes the physical removal of vegetation, seasonal flooding due to confinement of the river channel during construction, temporary construction footprints including roads, reservoir filling, and continued erosion during reservoir operations.

Approximately 38% of the 13,864 hectares of suitable toad habitat available within the LAA will be lost due to construction and operations (**Table 2.1.1**). The majority of this habitat loss will be the result of construction of the reservoir. This is considered to be a slight over-estimation as loss of wetlands along the TL is not anticipated. Effects during operations are dependent on activities planned[2]. The Highway 29 realignment does not overlap any potential amphibian breeding habitats.

Table 2.1.1 Habitat loss: amphibians and reptiles

Species	Total suitable habitat (ha)	Project Phase	Loss of suitable habitat by Project Component (ha)						
			Dam Site	Reservoir[a]	TL	Hwy Realign	Roads	Quarries	Total
Western Toad	13,864	Construction	208	4763	102	0	37	2	5112
		Operation	0	34	137	0	0	0	171
Gartersnake	4,084	Construction	90	228	14	39	4	0	375
		Operation	0	222	13	0	0	0	235

[a] Reservoir for construction is the full supply level and for operation it is the added loss between the full supply level and the erosion impact line.

A total of 15% of suitable hibernation habitat for gartersnakes will be lost due to the Project, the majority of which is a result of construction of the reservoir (**Table 2.1.1**). Additional effects associated with habitat alteration can also include a reduction of habitat suitability due to the release of deleterious substances and the introduction of invasive species.

Changes in hydraulic patterns—including water quality and quantity—as a result of the Project are expected to alter amphibian breeding habitat and some snake foraging sites. Suitable habitats can shift from an herbaceous wetland or pond community to a drier shrub community because of a reduction in water (MacKenzie and Moran 2004; Cox and Cullington 2009). Conversely, increases in water may also contribute to habitat loss as the inundation of smaller wetlands—leading to greater areas of ponded water—may change the vegetation composition, distribution, and abundance to something less favourable including the introduction of predatory fish.

The proximity of construction sites along the edges of wet areas or immediately upstream can increase water temperature in streams, change flows, and increase silt levels. Sediments can fill in portions of wetlands, altering water depth and smothering aquatic vegetation rendering it unsuitable for breeding or foraging. Increased turbidity affects amphibian eggs, larvae, and adults by interfering with respiration, forage, and shelter (Matsuda et al. 2006b). The release of deleterious substances—including concrete, fuel, oil and other hydrocarbons—can also be

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[2] Habitat loss along the TL during construction includes the amount of forest that would be cleared to make room for the additional right-of-way. Wetlands and other non-forested areas would not be cleared unless road construction or tower placement was required. Habitat loss during operations is the total right-of-way that would be managed during operations and includes the existing TL.

detrimental to terrestrial and aquatic species. The permeable skin of amphibians makes them particularly susceptible to harmful chemicals in the environment (Blaustein et al. 1995; Stuart et al. 2004). In addition, impacts to western toad can occur throughout all life-history phases from pesticide applications (Zevit and Wind 2010).

Habitat fragmentation reduces the size and continuity of habitats. Fragmentation has been shown to exacerbate the impact of habitat loss when it leads to obstruction of natural migration pathways. Specific to the Project, roads are considered a leading influence on fragmentation although other footprints may isolate smaller patches of suitable habitat or create barriers to movement.

Where roads cause a loss of connectivity between breeding areas and upland habitat, the result can negatively impact populations (Zevit and Wind 2010). In altered landscapes a spatial separation often occurs between terrestrial habitat and breeding sites (Becker et al. 2007). In species with an aquatic larvae life stage, adults leave terrestrial environments to reach bodies of water for reproduction. In fragmented landscapes adults may have to travel through areas with multiple hazards such as, predation, exposure to chemicals and pollutants, and road traffic. Dehydration has been documented when amphibians are crossing large tracts of land to find a suitable wetland. For snakes, a reduction in the ability of males to locate females due to road induced fragmentation can lead to reproductive females not being inseminated (Shine et al. 2004). This could be the result of obstructions to the effectiveness of trail following by males, resulting in longer distances traveled and longer time to locate a potential mate, which may also increase exposure and mortality risk (Shine et al. 2004).

Physical barriers that prevent dispersal define the natural range and distribution of a species. Invasive species have circumvented these physical barriers and have been able to establish communities in areas unaccustomed to their presence. Continued changes in land use—together with the spread of the human population—have made it possible for invasive species to increase their range, sometimes to the extent that they crowd out native species. The introduction and potential proliferation of the more aggressive invasive species ultimately alters the habitat and leads to habitat loss. Fragmenting the natural areas provides more opportunities for the delivery and establishment of non-native species, which in turn continues to alter and fragment natural areas.

2.2 Disturbance and Displacement

Disturbance and displacement refers to activities that cause individuals to alter their behaviour or avoid habitats that are otherwise suitable. Disturbance to amphibians and reptiles due to noise or human presence is difficult to quantify and a species' persistence in an area is considered to be more strongly related to habitat quality than proximity to activities. Displacement is a more likely occurrence when changes force individuals to flee or relocate. This could result in increased energy expenditures, utilization of sub-optimal habitats and increased predation risk.

Timing of flow releases and temporary flooding resulting from seasonal and daily fluctuations in water level—upstream of the dam during construction and downstream of the dam during operation—will cause displacement of individuals. During Stage 1 and Stage 2 of dam construction the confinement of the flow past the work site will cause the Peace River to flood upstream of the dam site. The extent of flooding will be determined by the amount of water within the system which is dependent on flow releases from the Peace Canyon Dam and natural inputs from tributaries. The spring freshet is expected to increase flooding at a time when species may be breeding.

The dam site and other Project components will require artificial lighting. There are few actual data on the effects of artificial lighting on free-living amphibians. Inferences from laboratory studies suggest artificial lighting may have effects on amphibian migration and metamorphosis and light pollution may pose a serious threat to reptiles and amphibians in urban environments (Perry et al. 2008). Artificial light may interfere with movements to breeding areas or inhibit frog breeding choruses (Longcore and Rich 2004; Baker and Richardson 2006). Some frog species may be attracted to artificially lit areas. It is unclear whether this is actual phototaxis[3] or if the frogs are attracted to the prey that congregate under the lights (Perry et al. 2008). If this occurs during construction mortality within the Project area is expected to increase.

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[3] Phototaxis refers to an animal or plant moving towards light

2.3 Mortality

Mortality is anticipated for all life stages of amphibians and snakes. The larger mortality risk is associated with the alteration of habitats during construction activities, flooding including temporary inundation, and the release of deleterious substances into aquatic habitats. Adults have a limited flight response and may not be able to escape these events.

In late summer, juvenile western toads (toadlets) congregate in large numbers along the sides of breeding pools before dispersing (COSEWIC 2002). Roadways that cut through core habitat areas or dispersal corridors and lack appropriately sighted exclusion fencing and amphibian or wildlife passage structures lead to increased levels of vehicle induced mortality and population fragmentation (deMaynadier and Hunter, Jr 1995; Waye 1999; Marsh et al. 2005; Eigenbrod et al. 2008). Road mortality is also a factor for snakes as they are attracted to the sun-warmed road surface for thermal regulation in evenings (Shine et al. 2004).

Clearing of riparian vegetation and the movement of large construction machinery within or adjacent to riparian areas during construction may cause direct mortalities to amphibians and reptiles. Blasting through rock cliffs, rock outcrops, and talus slopes may result in direct mortality to snakes by potentially removing hibernacula and thermal habitats.

Deleterious substances—including herbicide—are harmful to amphibians and snakes. Amphibians are considered more susceptible to environmental contamination than many other species (Geer and Krest 2000). Herbicides are known to cause mortality in amphibians if they are exposed at sufficient concentrations of the herbicide (Edginton et al. 2004; Chen et al. 2004; Relyea 2004; Relyea 2005a; Relyea 2005c; Relyea 2005b; Relyea 2006). Uncertainty and debate surround the potential direct impacts of herbicides to amphibians, particularly what exact concentration of herbicide starts significant increases in mortality and whether this concentration can be found following industrial herbicide applications (see (Thompson et al. 2006) and (Relyea 2006). Toxicity of herbicides is often dependent on the herbicide's main ingredient, the surfactant used, and the amphibian species exposed (Howe et al. 2004).

3 MITIGATION MEASURES

This assessment proposes technical mitigation measures to address potential Project effects to amphibians and reptiles during construction and operations. Avoiding potential Project-related adverse effects is one of the first priorities during the environmental assessment process. Avoidance measures can include refining Project boundaries and selecting the most appropriate construction methods, equipment, material, and timing of activities. Additional mitigation measures include environmental protection measures, Best Management Practices (BMPs) for Amphibians and Reptiles (Ovaska et al. 2004). Where feasible, mitigation measures will be refined based on consultation with federal and provincial regulatory agencies and First Nations.

3.1 Habitat Alteration and Fragmentation

3.1.1 Mitigation for Habitat Loss

The potential adverse effects of permanent habitat loss cannot be avoided within the reservoir and much of the dam site although they can be measurably reduced for other Project components—e.g., TL and roads—during final design. This includes placing transmission towers and access roads away from wetlands unless it is proven that no other option is feasible.

All known wetland locations or snake hibernacula will be provided as inputs during the final design phase so further reductions and avoidances are considered. If new Project footprints are added or the area where disturbance is to occur is poorly understood or changed, the new areas will be checked to document breeding areas and assess hibernacula potential. Ways to minimize disturbance will be explored.

If work is required immediately adjacent to any sensitive habitats for amphibians or snakes, a no access Environmental Protection Zone will be established to protect these sites. Habitat will be cleared in the approved footprint areas only and construction will be monitored to prevent any unnecessary clearing. Construction and maintenance activities in and around watercourses and wetlands will conform to BC Hydro's regulator-accepted practices including *Approved Work Practices for Managing Riparian Vegetation* (BC Hydro et al. 2003). An Agreement between BC Hydro, BC Ministry of Environment, and Fisheries and Oceans Canada (BC Hydro et al. 2009) identifies other accepted work practices that are to be developed and available for use in the near future.

New wetland habitat areas will be created as partial compensation for wetland loss due to the reservoir (as discussed in **Part 1**). Consideration for creating areas that are fish-free will be included to minimize the effects of fish predation on amphibians. As a mitigation measure for the loss of snake hibernacula, artificial dens will be considered on BC Hydro owned lands outside the reservoir and below the new highway alignment prior to the construction of the dam. In BC, artificial dens have been created as mitigation measures for hydro-electric substations, natural gas pipelines, and residential subdivisions (M. Sarell pers. comm.).

3.1.2 Maintaining Hydraulic Patterns

Maintaining surface flow patterns is important in the retention of functioning wetlands. Measures will be implemented to maintain existing hydraulic patterns as much as possible if roads cannot avoid wetlands. Ditches, culverts, and other structures will be placed to maintain the natural drainage patterns and allow the movement of flows.

3.1.3 Measures to Prevent Introduction of Deleterious Substances

Construction and maintenance activities in and around watercourses and aquatic habitats will conform to BC Hydro's accepted work practices with additional input from *Standards and Best Practices for Instream Works* (BC Ministry of Water, Land and Air Protection 2004) and the *Land Development Guidelines for the Protection of Aquatic Habitat* (Chilibeck et al. 1992), which are designed to reduce sedimentation and avoid introduction of deleterious substances to aquatic environments.

3.1.3.1 Erosion and Sedimentation

BC Hydro will have an Erosion Prevention and Sediment Control Plan as part of their Construction Management Framework. Stripping vegetation and soils will be minimized as much as possible taking into consideration proximity to sensitive habitats—e.g., wetlands—and slope stability.

Within the reservoir a hierarchal decision matrix has been developed for reservoir clearing to reduce erosion potential along steep, unstable slopes and along riparian zones for all defined watercourses. Specifically the decision matrix includes:

- Retention of all trees in areas with steep, unstable slopes that would be highly susceptible to landslides if the vegetation was removed.
- Retention of non-merchantable trees and vegetation within riparian areas around existing water bodies within a 15-metre buffer from the high water mark. Merchantable trees may still be removed using machine free clearing practices to remove vegetation within a 15-metre machine-free buffer zone.

These standards will be employed in other work areas and will follow BC Hydro's approved work practices.

Stormwater management will aim to control run-off and direct it away from work areas where excavation, spoil placement, and staging activities occur. Consideration for maintaining recharge levels to wetlands will be given when diverting water around work sites, providing there is not expected to be a measureable increase in sediment transport to these sensitive areas. A Surface Water Quality Monitoring and Protection Plan will be developed as part of BC Hydro's Construction Environmental Management Framework.

Cleared areas that will not have permanent features will be replanted with appropriate vegetation to promote soil stability. Regionally appropriate vegetation will be included in the reclamation activities for larger footprints. BC Hydro will develop a Soil Management Site Restoration and Re-vegetation Plan to guide reclamation and revegetation activities.

3.1.3.2 Hydrocarbon and Hazardous Materials Management

All activities that involve potentially harmful or toxic substances such as oil, fuel, antifreeze, and concrete will follow approved work practices and consider the provincial BMP guidebook *Develop with Care* (BC Ministry of Environment 2012). All construction machinery and vehicles will be properly maintained to ensure harmful fluids do not leak into aquatic environments or other sensitive areas. Prior to initiating construction activities in proximity to any water body, the hydraulic, fuel, and lubrication systems of all equipment will be checked to ensure systems are in good condition and free of leaks. All machines will have a spill kit and operators will be trained its use. Maintenance and refuelling will be conducted at a designated area at an approved distance from watercourses as outlined in BC Hydro's Fuel Handling and Storage Management Plan. BC Hydro's Construction Environmental Management Framework will include an Emergency Response Plan and a Hazardous Waste Management Plan which will be used in the event of a spill.

3.1.4 Invasive Species Management

Disturbed sites will be replanted quickly with ground cover, shrubs, or trees that are regionally appropriate once erosion concerns have been addressed. This will be part of BC Hydro's Soil Management and Site Restoration and Re-vegetation Plan. A Wildlife and Vegetation Monitoring and Management Plan will be included that defines objectives for limiting invasive species by monitoring the presence and possible spread of invasive plants in temporarily disturbed areas and the success of revegetation programs.

Mitigation measures to reduce the spread of invasive species include:

- Prior to work commencing surveys will be conducted to identify invasive species populations. Treatment will be initiated as required.
- All vehicles entering and leaving work sites will be washed thoroughly with special attention to wheel wells, tire treads, and tracks where mud and seeds of noxious weeds may be lodged.
- Locating wash areas away from any waterbody and riparian areas
- Treating used wash water to prevent seed dispersal.

The *Pest Management Plan for Management of Vegetation at BC Hydro Facilities* (BC Hydro 2012) and the *Integrated Vegetation Management Plan for Transmission Rights-of-way* (BC Hydro 2010) will be followed in order to reduce or avoid the spread of invasive species during the operations phase of the Project.

3.1.5 Mitigation for Habitat Fragmentation

Areas within the LAA have already experienced varying levels of habitat fragmentation with forestry, agriculture, oil and gas, and urban development. Efforts have been made to utilize existing corridors, deactivate temporary access roads, and minimize disturbance where possible to help minimize fragmentation. Project components where this has occurred include:

- **Substation and Transmission Lines to Peace Canyon Dam**: building the TL within and adjacent to the existing power line, maximizing the use of the existing corridor and maintenance access roads.
- **Highway 29 Realignment**: use portions of existing roads and selection of borrow sites that already exist or would be eventually covered by the reservoir.
- **Quarried and Excavated Construction Materials**: further develop existing quarry sites (e.g., Wuthrich, Del Rio, and West Pine) and use a site that has already seen development (e.g., 85th Avenue Industrial Lands).
- **Construction Access Roads**: use existing infrastructure for moving material, upgrade existing access roads and deactivate temporary roads used for reservoir clearing, and place the Project access road along the existing TL.

3.2 Disturbance and Displacement

The avoidance and reduction of displacement due to temporary flooding is not possible with mitigation as the timing of events is dependent on natural events—such as rainfall and the spring freshet—and power generation—e.g., downstream flow levels. This may be alleviated with the creation of potentially suitable habitats within the reservoir and the creation of additional habitats through compensation. The placement of any wetlands created through compensation will consider proximity to roads. Basking sites for snakes will be included in their design.

3.3 Mortality

Mortality related to habitat loss cannot be fully avoided for the Project but can be reduced with wetland avoidance along the TL when building access roads and by maintaining hydraulic patterns should a road bisect a wetland (**Section 3.1**).

Road mortality for both amphibians and snakes was documented during baseline studies and is expected to occur during Project construction as many roads have multiple users. During road design, efforts will be made to minimize or avoid additional losses. Where roads are adjacent to wetlands or migrations across roads are anticipated fencing will be placed along the length of the road to guide amphibians through structures designed for wildlife passage under the road. The size and number of the structures needed and the length of fencing will be determined in consultation with regulators.

The Project will avoid the release of deleterious hydrocarbons and other hazardous materials by following approved work practices and implementing Environmental Management Plans (**Section 3.1)**. Mortality due to sedimentation will be reduced or avoided following similar plans. Surface water quality will be monitored to ensure it does not exceed established guidelines for aquatic life (see **Volume 2 Appendix E Water Quality Baseline Conditions in the Peace River**). BC Hydro will follow their *Pest Management Plan for Management of Vegetation at BC Hydro Facilities* (BC Hydro 2012) and *Integrated Vegetation Management Plan for Transmission Rights-of-way* (BC Hydro 2010) for the use of herbicides. This includes consideration for use around wetlands and species at risk.

A portion of the wetlands created to compensate for habitat loss will be designed to remain fish-free to eliminate predation risk.

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4 RESIDUAL EFFECTS

Baseline information on amphibians was collected for all species but emphasis for assessing residual adverse effects is on western toad because it is Blue-listed, listed as Special Concern under COSEWIC and is also listed as Schedule 1- Special Concern by SARA. Habitats that are considered suitable for western toads are also suitable for the other amphibians in the study area; therefore, residual effects for toads would be the same as for other species.

Assessment of the residual effect of habitat alteration and displacement for reptiles focuses on suitable hibernation habitat as it is considered limiting habitat for gartersnakes.

4.1 Characterization of Residual Effects

Criteria used to characterize residual adverse effects are provided in **Table 4.1.1**. The rationale for characterizing the effects is provided below.

Table 4.1.1 Characterization of residual effects: criteria – wildlife resources

<table>
<tr><th>Criterion</th><th>Description</th><th>Quantitative Measure or Definition of Qualitative Categories</th></tr>
<tr><td rowspan="2">Direction</td><td rowspan="2">The ultimate long-term trend of the effect relative to baseline case.</td><td>Negative: condition of the VC is worsening in comparison to baseline conditions</td></tr>
<tr><td>Positive: condition of the VC is improving in comparison to baseline conditions</td></tr>
<tr><td rowspan="3">Magnitude</td><td rowspan="3">The amount of change in a key indicator or variable relative to baseline case.</td><td>Low: Less than 10% change</td></tr>
<tr><td>Moderate: Between 10-20% change</td></tr>
<tr><td>High: Greater than 20% change</td></tr>
<tr><td rowspan="3">Geographical Extent</td><td rowspan="3">The geographic area in which an environmental effect of a defined magnitude occurs.</td><td>Site-specific: the extent of the effect will have sub-local implications to key indicators</td></tr>
<tr><td>Local: the extent of the effect will have sub-population implications to key indicators within the LAA</td></tr>
<tr><td>Regional: the extent of the effect will have broader population implications to key indicators</td></tr>
<tr><td rowspan="4">Duration</td><td rowspan="4">The period of time required until the VC returns to its baseline condition, or the effect can no longer be measured or otherwise perceived.</td><td>Short-term: effect is limited to <1 year</td></tr>
<tr><td>Medium-term: effect occurs >1 year but only during construction</td></tr>
<tr><td>Long-term: effect lasts into Project operation but dissipates during the life of the Project</td></tr>
<tr><td>Permanent: effect lasts during the life of the Project and possibly beyond</td></tr>
<tr><td rowspan="4">Frequency</td><td rowspan="4">The number of times during a project or a specific project phase that an environmental effect may occur.</td><td>Once: occurs once</td></tr>
<tr><td>Continuous: occurs on a regular basis and at regular intervals</td></tr>
<tr><td>Weekly: occurs on a regular basis within one month but is sporadic throughout a year</td></tr>
<tr><td>Monthly: occurs on a regular basis for more than a month but is sporadic throughout a year</td></tr>
<tr><td rowspan="2">Reversibility</td><td rowspan="2">The degree or likelihood to which existing baseline conditions can be regained after factors causing the effect are removed.</td><td>Reversible: with reclamation and/or over time</td></tr>
<tr><td>Irreversible: over time even with reclamation</td></tr>
<tr><td rowspan="2">Context</td><td rowspan="2">The extent to which the area effected has already been adversely affected by human activities, and is ecologically fragile with little resilience and resistance to imposed stresses.</td><td>High resilience: Area or key indicator persists when it is subjected to frequent natural or anthropogenic disturbances</td></tr>
<tr><td>Low resilience: Area is relatively pristine with little or no recent disturbance, or the key indicator requires long-term ecosystem stability in order to thrive</td></tr>
</table>

Criterion	Description	Quantitative Measure or Definition of Qualitative Categories
Level of Confidence	An evaluation of the scientific certainty in the review of Project specific data, relevant literature, and professional opinion.	**Low:** The effectiveness of mitigation or scale of the effect is poorly understood; follow-up monitoring is recommended
		Moderate: Greater certainty in understanding an effects outcome but reflective of modeling confidence and an understanding of effect pathways
		High: Detailed modeling and an understanding of effect pathways are well understood
Probability	The likelihood that an adverse effect will occur	**Low:** An effect may occur but would not be measureable
		High: A measureable effect is understood to occur
		Unknown: It is difficult to determine how a key indicator will respond to a particular activity or to mitigation

4.2 Habitat Alteration and Fragmentation

The effects of Habitat Alteration and Fragmentation will differ between species. A total of 38% of identified suitable habitat for western toad within the LAA would be lost due to the Project (**Table 2.1.1; Section 2.1**). This includes delineated wetlands, riverine backchannels, and wet forests. For snakes, 15% of the potentially suitable hibernation habitat within the LAA would be lost due to the Project.

Mitigation measures can reduce or avoid habitat loss—especially along the TL and access roads—but loss cannot be avoided within the dam and reservoir footprint. As such, a residual adverse effect is anticipated for western toad and gartersnakes during construction and gartersnakes during operation. Very little potential toad breeding habitat would be affected during operations of the reservoir—0.2% within the LAA. Therefore, residual adverse effect is not considered during this phase. **Table 4.2.1** summarizes the characterization of the residual adverse effect for both the western toad and gartersnake.

Table 4.2.1 Characterization of residual effects: habitat alteration and fragmentation

Species Group	Characterization Criteria	Characterization	Rationale for Characterization
Construction			
Western toad	Direction	Negative	The overall loss of suitable habitat cannot be fully mitigated. The post-project amount of habitat would be less relative to baseline conditions.
	Magnitude	High	Mitigation will reduce the potential effects of roads and the TL. Habitat compensation will further reduce the effect. The loss of suitable breeding habitats due to the creation of the reservoir is an over-estimate, as much of the riparian forests included as suitable would not have standing water. Regardless the amount lost is still considered over 20% within the LAA.
	Geographic Extent	Local	The effect would occur within the LAA and the species is common within the Region.
	Duration	Permanent	Many of the habitats would be lost permanently within the reservoir. Habitat compensation will address loss to some habitats but cannot readily replace all.
	Frequency	Once	The largest loss of habitat would occur with the filling of the reservoir, considered a one-time occurrence.

Species Group	Characterization Criteria	Characterization	Rationale for Characterization
	Reversibility	Irreversible	Habitat compensation will replace some of the habitats removed within the reservoir, but cannot replace all habitat types (riparian forests) to the extent that they would be removed.
	Context	Low resilience	Wetlands are ecologically fragile with little resistance to imposed stresses.
	Confidence	Moderate	Habitat mapping and species modeling provides a quantitative assessment of habitat loss when overlaid with Project components. The amount of loss in the analysis is an overestimate, with riparian forest included as suitable habitat. Toads breed in a number of habitats and may be somewhat resilient to compensation and reservoir creation.
	Probability	High	Expected based on the size and location of the PAZ.
Gartersnakes	Direction	Negative	The overall loss of suitable habitat cannot be fully mitigated. The post-project amount of suitable habitat would be less relative to baseline conditions.
	Magnitude	Low	Approximately 9% of the available habitat would be lost during construction.
	Geographic Extent	Local	Hibernacula are expected to occur within the proposed reservoir. Confirmed sites are removed from development.
	Duration	Permanent	Many of the habitats would be lost permanently within the reservoir. Habitat compensation will address loss to some habitats but cannot readily replace all.
	Frequency	Once	The largest loss of habitat would occur with the filling of the reservoir, considered a one-time occurrence.
	Reversibility	Irreversible	Habitat compensation will replace some of the habitats removed within the reservoir, but cannot replace all habitat types (dry grasslands, rock outcrops) to the extent that they would be removed.
	Context	Moderate resilience	The existing topography characterized by a flat river channel and steep side slopes currently provide for occasional ground slumping along the Peace River.
	Confidence	Moderate	The habitat model is an assumption of the potential for hibernacula. Snakes within the region are considered to hibernate individually or in very small groups and hibernacula locations may not be fully understood.
	Probability	High	Expected based on the size and location of the PAZ.

Species Group	Characterization Criteria	Characterization	Rationale for Characterization
Operation			
Gartersnakes	Direction	Negative	The continued loss of habitat due to bank erosion along the reservoir could not be fully mitigated. The amount of habitat available during operations would be slightly less relative to baseline conditions.
	Magnitude	Low	Mitigation will reduce the potential effects of vegetation maintenance along the TL. 5% of the available suitable habitat within the LAA could be lost due to erosion along reservoir during operations.
	Geographic Extent	Local	The effects will be on specific slopes along the reservoir.
	Duration	Long-term	Bank erosion would occur during the life of the Project, but should be less frequent as slopes stabilize to current baseline conditions.
	Frequency	Continuous	Erosion would be more frequent in the first few years after the reservoir is established, and should continue sporadically on different slopes for the life of the Project.
	Reversibility	Reversible	When slopes stabilize to the extent of the Erosion Impact Line, the frequency should be similar to baseline.
	Context	Moderate resilience	The existing topography characterized by a flat river channel and steep side slopes currently provide for occasional ground slumping along the Peace River.
	Confidence	Moderate	Slope stability studies provide a quantitative assessment of the expected limit of erosion with the creation of the reservoir. This is relative to the confidence in the habitat model.
	Probability	High	Expected based on the extent of the Erosion Impact Line.

4.3 Disturbance and Displacement

The avoidance and reduction of displacement of amphibians and reptiles due to temporary flooding is not fully possible with mitigation as the timing of events is dependent on natural events and power generation. The Peace River experiences high flows during any year, notably during the spring freshet. Upstream releases from the Peace Canyon Dam also influence daily water levels. The frequency of larger flood events during construction and operations is anticipated to be greater than baseline. The extent this would displace local populations is unknown. The creation of potentially suitable habitats along the edge of the reservoir and the creation of additional habitats through compensation may offset any effect. **Table 4.3.1** summarizes the characterization of the residual adverse effect for western toad and gartersnakes.

Table 4.3.1 Characterization of residual effects: disturbance and displacement

Species Group	Characterization Criteria	Characterization	Rationale for Characterization
Construction			
Western toad and Gartersnake	Direction	Negative	The higher flood waters during construction, upstream of the dam site, would inundate habitats used for foraging and breeding.
	Magnitude	Low	The amount of suitable habitat affected would be variable, depending on the amount of water entering the Peace River. Greater flooding is expected during Stage 2 construction compared with Stage 1. The total area affected would be considerably less than what is lost during the filling of the reservoir.
	Geographic Extent	Local	Restricted to habitats immediately adjacent to the Peace River and more pronounced near the dam site.
	Duration	Moderate-term	Flooding upstream would be greatest during Stage 2 construction of the dam.
	Frequency	Monthly	Monthly instead of Continuous as flooding should be more pronounced during specific months when water volumes are high.
	Reversibility	Reversible	Many of the habitat sites already experience some level of seasonal inundation, although not to the extent or frequency expected due to the Project.
	Context	High resilience	Much of the area is within the existing floodplain and experiences flooding annually or every few years.

Species Group	Characterization Criteria	Characterization	Rationale for Characterization
	Confidence	Moderate	Hydrology modeling provides an understanding of the extent of flooding, but the reaction by the affected species is difficult to determine.
	Probability	Unknown	The season, extent and speed that flooding would occur will determine the effect. Species may be able to adapt.
Operation			
Western toad and gartersnake	Direction	Negative	The higher flood waters during operation, downstream of the dam site, may inundate habitats used for foraging and breeding
	Magnitude	Low	The amount of suitable habitat affected would be variable, depending on the amount of water leaving the dam. This would be attenuated further downstream due to the inflows of other rivers entering the Peace River.
	Geographic Extent	Local	Restricted to habitats immediately adjacent to the Peace River and more pronounced near the dam site
	Duration	Permanent	Downstream fluctuations would occur through the life of the Project
	Frequency	Continuous	The water levels immediately downstream of the dam would fluctuate depending on the power generation needs and tributary inputs to the reservoir.
	Reversibility	Reversible	Many of these sites currently experience some level of seasonal inundation, although not to the extent or frequency expected due to the Project.
	Context	High resilience	Much of the area is within the existing floodplain and experiences flooding annually or every few years.
	Confidence	Low	Hydrology modeling provides an understanding of the extent of flooding, but the reaction by the species affected is difficult to determine.
	Probability	Unknown	The season, extent and speed with which flooding would occur will determine the effect. Species may be able to adapt.

4.4 Mortality

Mortality related to habitat loss cannot be fully avoided for the entire Project but will be reduced with wetland avoidance, the establishment of Environmental Protection Zones, and installation of exclusion fencing at some Project component construction and operation sites. The effects of flooding during both construction and operation could be greater if they occur during hibernation or the breeding season. Effects due to herbicide use can be reduced or avoided with proper planning as per BC Hydro's vegetation management plans.

Table 4.4.1 Characterization of residual effects: mortality

Species Group	Characterization Criteria	Characterization	Rationale for Characterization
Construction			
Western toad and gartersnakes	Direction	Negative	The eventual filling of the reservoir is expected to inundate snake and toad winter hibernacula.
	Magnitude	Moderate	The amount of suitable habitat affected would be variable, depending on the species. A considerable amount of suitable habitat within the LAA would persist allowing for opportunities for viable populations to remain.
	Geographic Extent	Local	The effect would be observed at specific locations within the LAA.
	Duration	Moderate-term	Mortality would occur periodically during construction and then with the filling of the reservoir. Some populations are used to the natural fluctuations in floodplains and populations are likely resilient. Habitat creation, compensation and enhancement will allow for recruitment.
	Frequency	Monthly	The filling of the reservoir would occur once, but temporary flooding upstream of the dam during construction during months of higher water volumes would occur. Road mortality for western toad is more pronounced during migration in early spring and late summer.
	Reversibility	Reversible	Populations should persist or rebound to near current levels. There is a considerable amount of suitable habitat remaining within the LAA and within the region. The reservoir would provide additional aquatic habitat. Habitat compensation will provide opportunities for snake denning.
	Context	Moderate resilience	Some areas would be within the existing floodplain and experience flooding annually or every few years. Other sites would inundated for the first time with the creation of the reservoir.

Species Group	Characterization Criteria	Characterization	Rationale for Characterization
	Confidence	Moderate	Modeling provides a quantitative understanding of habitats lost and extent of flooding. The occurrence of life stages more susceptible to mortality is assumed to be in areas where suitable habitat occurs. Methods to reduce road mortality are expected to be effective.
	Probability	High	The season, extent and speed that flooding will occur would determine the effect.
Operation			
Western toad and gartersnakes	Direction	Negative	The higher flood waters during operation, downstream of the dam site, may inundate habitats used for breeding and foraging.
	Magnitude	Low	The amount of suitable habitat affected would be variable, depending on the amount of water leaving the dam. This would be attenuated further downstream with the influences of other rivers entering the Peace River.
	Geographic Extent	Local	Restricted to habitats immediately adjacent to the Peace River and more pronounced near the dam site. Potentially mortality along the TL is expected to be reduced or avoided with mitigation.
	Duration	Permanent	Downstream fluctuations would occur through the life of the Project.
	Frequency	Continuous	The water levels immediately downstream of the dam would fluctuate depending on the power generation needs and water entering the reservoir.
	Reversibility	Reversible	Many of these sites already experience some level of seasonal inundation, although not to the extent or frequency expected due to the Project.
	Context	High resilience	Much of the area would be within the existing floodplain; this area experiences flooding annually or every few years.
	Confidence	Moderate	Hydrology modeling provides an understanding of the extent of flooding, but the loss of individuals is difficult to determine.
	Probability	Unknown	The season, extent and speed with which flooding would occur will determine the effect. Species may be able to adapt.

5 LITERATURE CITED

Baker, B.J. and J.M.L. Richardson. 2006. The effect of artificial light on male breeding-season behaviour in green frogs, *Rana clamitans melanota*. Canadian Journal of Zoology 84(10):1528–1532.

BC Conservation Data Centre. 2011. BC Species and Ecosystems Explorer. Province of British Columbia. Available at: http://a100.gov.bc.ca/pub/eswp/.

BC Hydro. 2010. Integrated Vegetation Management Plan for Transmission Rights-of-Way. Available at: http://www.bchydro.com/etc/medialib/internet/documents/safety/pdf/safety_-_ivmp_web.Par.0001.File.IVMP-transmission-nov-4-10-final.pdf.

BC Hydro. 2012. Pest Management Plan for Management of Vegetation at BC Hydro Facilities. BC Hydro. Available at: http://www.bchydro.com/etc/medialib/internet/documents/safety/pdf/safety_pest_management_plan_for_management_of_vegetation.Par.0001.File.safety_pest_management_plan_for_management_of_vegetation.pdf.

BC Hydro, British Columbia Transmission Corporation, BC Ministry of Environment and Fisheries and Oceans Canada. 2009. Protocol Agreement for Work in and Around Water Associated with BC Hydro & BCTC Infrastructure. Available at: http://www.bchydro.com/etc/medialib/internet/documents/bctc_documents/work_practices_in.Par.0001.File.Workinaroundwater_protocol2009.pdf.

BC Hydro, British Columbia Transmission Corporation, British Columbia Ministry of Water, Land, and Air Protection and Fisheries and Oceans Canada. 2003. Approved Work Practices for Managing Riparian Vegetation. Available at: http://www.bchydro.com/etc/medialib/internet/documents/bctc_documents/work_practices_riparian.Par.0001.File.managing_riparian_vegetation.pdf.

BC Ministry of Environment. 2012. Develop With Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia. Revised. BC Ministry of Environment, Victoria, BC. Available at: http://www.env.gov.bc.ca/wld/documents/bmp/devwithcare2012/index.html.

BC Ministry of Water, Land and Air Protection. 2004. Standards and Best Practices for Instream Works. Available at: www.env.gov.bc.ca/wld/documents/bmp/iswstdsbpsmarch2004.pdf.

Becker, C.G., C.R. Fonseca, C.F.B. Haddad, R.F. Batista and P.I. Prado. 2007. Habitat split and the global decline of amphibians. Science 318(5857):1775–1777.

Blaustein, A.R., J.J. Beatty, D.H. Olson and R.M. Storm. 1995. The Biology of Amphibians and Reptiles in Old-Growth Forests in the Pacific Northwest. Forest Service, USDA Department of Agriculture, Portland, OR.

Blood, D.A. 1979. Peace River Site C Hydroelectric Development Environmental and Socioeconomic Assessment: Wildlife Sub-Report. Report to British Columbia Hydro and Power Authority.

Chen, C.Y., K.M. Hathaway and C.L. Folt. 2004. Multiple stress effects of Vision herbicide, pH, and food on zooplankton and larval amphibian species from forest wetlands. Environmental Toxicology and Chemistry 23(4):823–831.

Chilibeck, B., G. Chislett and G. Norris. 1992. Land Development Guidelines for the Protection of Aquatic Habitat. Habitat Management Division, Department of Fisheries and Oceans and the Integrated Management Branch of the BC Ministry of Environment, Lands and Parks. Available at: www.dfo-mpo.gc.ca/Library/165353.pdf.

COSEWIC. 2002. COSEWIC Assessment and Status Report on the Western Toad *Bufo Boreas* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. Available at: dsp-psd.pwgsc.gc.ca/Collection/CW69-14-346-2003E.pdf.

Cox, R.K. and J. Cullington. 2009. Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia. Chapter 3: Agriculture.

deMaynadier, P.G. and M.L. Hunter, Jr. 1995. The relationship between forest management and amphibian ecology: a review of the North American literature. Environmental Reviews 3(3-4):230–261.

Edginton, A.N., P.M. Sheridan, G.R. Stephenson, D.G. Thompson and H.J. Boermans. 2004. Comparative effects of pH and Vision® herbicide on two life stages of four anuran amphibian species. Environmental Toxicology and Chemistry 23(4):815–822.

Eigenbrod, F., S.J. Hecnar and L. Fahrig. 2008. The relative effects of road traffic and forest cover on anuran populations. Biological Conservation 141(1):35–46.

Fraker, M.A. and V.C. Hawkes. 2000. Peace River Wildlife Surveys. Report to BC Hydro and Power Authority.

Gartshore, M.E., M.J. Oldham, R. Van der Ham and F.W. Schueler. 1992. Participant's Manual: Amphibian Road Call Counts. Ontario Task Force on Declining Amphibian Populations. Ontario Field Herpetologists.

Geer, K. and S. Krest. 2000. A new threat to frogs. Endangered Species Bulletin 25:12–13.

Hawkes, V., G.F. Searing, M. Todd, M. Bentley, M.W. Demarchi, J. Muir and M.K. McNicholl. 2006. Peace River Wildlife Surveys: 2005 Habitat Suitability Modeling and Wildlife Inventory. Report to BC Hydro, Burnaby, BC.

Hecnar, S.J. and R.T. M'Closkey. 1997. The effects of predatory fish on amphibian species richness and distribution. Biological Conservation 79:123–131.

Hengeveld, P.E. 2000. Presence and Distribution of Amphibians in the Williston and Dinosaur Reservoir Watersheds. Peace/Williston Fish and Wildlife Compensation Program, Prince George, BC. Available at: www.bchydro.bc.ca/environment/initiatives/pwcp/.

Howe, C.M., M. Berrill, B.D. Pauli, C.C. Helbing, K. Werry and N. Veldhoen. 2004. Toxicity of glyphosate-based pesticides to four North American frog species. Environmental Toxicology and Chemistry 23(8):1928–1938.

Longcore, T. and C. Rich. 2004. Ecological light pollution. Frontiers in Ecology and the Environment 2(4):191–198.

MacKenzie, W. and J.R. Moran. 2004. Wetlands of British Columbia: A Guide to Identification. Land Management Handbook 52. Research Branch, BC Ministry of Forests, Victoria, BC. Available at: http://www.for.gov.bc.ca/hfd/pubs/docs/lmh/lmh52.htm.

Marsh, D.M., G.S. Milam, N.P. Gorham and N.G. Beckham. 2005. Forest roads as partial barriers to terrestrial salamander movement. Conservation Biology 19(6):1523–1739.

Matsuda, B., D. Green and P. Gregory. 2006a. Amphibians & Reptiles of British Columbia Illustrated Edition. Royal British Columbia Museum, Victoria, BC.

Matsuda, B.M., D.M. Green and P.T. Gregory. 2006b. Amphibians & Reptiles of British Columbia Illustrated Edition. Royal British Columbia Museum, Victoria, BC.

Perry, G., B.W. Buchanan, R.N. Fisher, M. Salmon and S.E. Wise. 2008. Effects of artificial night lighting on amphibians and reptiles in urban environments. In: *Urban Herpetology. Herpetological Conservation Number Three*. Society for the Study of Amphibians and Reptiles, Salt Lake City, UT. Pp. 239–256.

Phinney, M. 2007. Amphibian Surveys in the Dawson Creek TSA 2007. Prepared for Louisiana-Pacific Canada Ltd.

Relyea, R.A. 2004. Growth and survival of five amphibian species exposed to combinations of pesticides. Environmental Toxicology and Chemistry 23(7):1737–1742.

Relyea, R.A. 2006. Response to letters to the editor re: The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities. Ecological Applications 16(5):2027–2034.

Relyea, R.A. 2005a. The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities. Ecological Applications 15(2):618–627.

Relyea, R.A. 2005b. The lethal impact of Roundup on aquatic and terrestrial amphibians. Ecological Applications 15(4):1118–1124.

Relyea, R.A. 2005c. The lethal impacts of Roundup and predatory stress on six species of North American tadpoles. Archives of Environmental Contamination and Toxicology 48:351–357.

Resources Inventory Committee. 1998a. Inventory Methods for Pond-breeding Amphibians and Painted Turtle. Version 2.0. Standards for Components of British Columbia's Biodiversity No. 37. BC Ministry of Environment, Lands and Parks, Resource Inventory Branch, Victoria, BC. Available at: http://archive.ilmb.gov.bc.ca/risc/pubs/tebiodiv/.

Resources Inventory Committee. 1998b. Inventory Methods for Snakes. Version 2.0. Standards for Components of British Columbia's Biodiversity No. 38. BC Ministry of Environment, Lands and Parks, Resource Inventory Branch, Victoria, BC. Available at: http://archive.ilmb.gov.bc.ca/risc/pubs/tebiodiv/.

Shine, R., T. Langkilde, M. Wall and R.T. Mason. 2006. Temporal dynamics of emergence and dispersal of garter snakes from a communal den in Manitoba. Wildlife Research 33(2):103–111.

Shine, R., M. Lemaster, M. Wall, T. Langkilde and R. Mason. 2004. Why did the snake cross the road? Effects of roads on movement and location of mates by garter snakes (*Thamnophis sirtalis parietalis*). Ecology and Society 9(1):9.

Stuart, S.N., J.S. Chanson, N.A. Cox, B.E. Young, A.S.L. Rodrigues, D.L. Fischman and R.W. Waller. 2004. Status and trends of amphibian declines and extinctions worldwide. Science 306(3):1783–1786.

Takats, L. 2002. Red-sided Garter Snake *Thamnophis Sirtalis Parietalis* Relocation and Education Project: Final Report. Alberta Sustainable Resource Development, Fish and Wildlife Division, Edmonton, AB.

Thompson, D.G., K.R. Solomon, B.G. Wojtaszek, A.N. Edginton and G.R. Stephenson. 2006. Letters to the editor re: The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities. Ecological Applications 16(5):2022–2027.

Waye, H. 1999. COSEWIC Status Report on the Red-legged Frog *Rana Aurora* in Canada. In COSEWIC Status Report on the Red-legged Frog *Rana Aurora* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON.

Zevit, P. and E. Wind. 2010. BC's Coast Region: Species and Ecosystems of Conservation Concern Western Toad (*Anaxyrus boreas*).

APPENDIX A WESTERN TOAD

A.1 Species - Habitat Model for Western Toad

This account is based upon a species account prepared for the Nicola-Similkameen Innovative Forestry Society by Crystal Swayze and Les Gyug. Text from that account is indicated by indentation.

A.1.1 Species data

Common Name:	Western Toad
Scientific Name:	*Anaxyrus boreas*
Species Code:	A-ANBO
BC Status:	Blue-listed
Identified Wildlife Status:	None
COSEWIC Status:	Special Concern
SARA Status:	Schedule 1

A.1.2 Project data

Area:	Peace River
Ecoprovince:	Boreal Plains (BOP), Sub-Boreal Interior (SBI)
Ecoregions:	Peace River Basin (PRB), Central Alberta Uplands (CAU), Central Canadian Rocky Mountains (CRM)
Ecosections:	Peace Lowlands (PEL), Halfway Plateau (HAP), Peace Foothills (PEF), Heart Foothills (HAF)
BEC Variants:	BWBSmw1, BWBSwk1, ESSFmv2, ESSFwk2, SBSwk2
Map Scale:	1:20,000

A.1.3 Ecology and Habitat Requirements

> The western toad is a large anuran measuring 5.5 - 12.5 cm. Its colour varies from green to dark brown and black. A light stripe runs down the middle of the back. The parotid glands are oval and well separated. Other glands that secrete toxins to ward off predators are located on the back, sides and upper legs. The underside is pale with dark markings on the abdomen (Orchard 1988; Blaustein et al. 1995).
>
> The eggs are black in colour and range in diameter from 1.5 – 1.7 mm. At time of hatching, the tadpoles are black and approximately 10 mm in length. Metamorphic toads are approximately 12 - 13 mm in length (Blaustein et al. 1995).
>
> Tadpoles forage by filtering suspended plant matter and detritus. Metamorphosed toads feed on a variety of small terrestrial invertebrates (BC Conservation Data Centre 2011). Adult toads hunt for prey by waiting on the ground or in depressions in the ground. The diet is composed of bees, beetles, ants, and spiders. Toads are also known to forage on crayfish, grasshoppers and flies (Sullivan 1994).

The timing of reproduction varies greatly depending on elevation and weather conditions. In British Columbia, breeding adults move to traditional breeding ponds from March to April (Davis 2002; BC Conservation Data Centre 2011).

In the Okanagan, breeding is reported to initiate when average daily minimums were greater 0 °C and average daily maximums were greater than 10 °C (COSEWIC 2002). Eggs may be laid from May to July. Gelatinous strings of eggs are laid in masses up to 16,500 per clutch. The developmental rate is primarily dependent on temperature. Tadpoles emerge within 7 – 10 days, with metamorphosis completed within three months. Toads reach sexual maturity within 2 – 6 years and can live up to 11 years (Sullivan 1994; COSEWIC 2002; Davis 2002; BC Conservation Data Centre 2012).

Western toads are known to hibernate from 3-6 months depending on their location and elevation. Toads move to overwintering habitat following the end of the breeding season and hibernation typically begins in the fall. During hibernation, western toads maintain an average body temperature of 5–6 °C (COSEWIC 2002) and absorb moisture from their surroundings through the pelvic patch (Matsuda et al. 2006).

The western toad is a year-round resident. Local movements between spring breeding ponds and upland summer habitats commonly range from 1-2 km (Davis 2000; Muths 2003; Bartelt et al. 2004; Bull 2006) but movements of up 5 km (Thompson 2004) and 7.2 km have been observed (Davis 2000). Bull (2006) found one female western toad to travel 6.2 km from the breeding site to summer habitat in northeastern Oregon. Mean distance traveled from breeding site to summer habitat was 2.5 km for females and 1.0 km for males (Bull 2006). These movements were across upland areas. In Montana, adults used stream corridors as movement corridors, with movements of up to 1.5 km observed in 6 days (Adams et al. 2005).

Western toads are known to have distinct home ranges that vary in size depending on quality of habitat. On Vancouver Island, an average summer home range of 0.1 ha has been reported (Davis 2002), but they appeared to average much larger (approximately 4.6 ha) in Colorado (Jones and Goettl 1998).

The western toad is known to have strong home range fidelity, commonly returning to the same microsites (BC Conservation Data Centre 2011; COSEWIC 2002;

Davis 2002). It has also shown strong fidelity to breeding sites and hibernacula (COSEWIC 2002).

A.1.4 Distribution

The northern or boreal subspecies of western toad is found from western British Columbia and southern Alaska south to Washington, Oregon, Idaho, western Montana, and western Wyoming to northern California, Nevada, western Colorado, and western Utah (Sullivan 1994).

A.1.4.1 Provincial Range

The western toad is common throughout BC (Davis 2002) from valley bottoms to sub-alpine and alpine zones (Orchard 1988). In Washington State, the western toad is absent from the large area of dry shrub-steppes in the southeastern portion of the state but is found in all forested or semi-forested areas at all elevations, except the very high un-vegetated portion of the alpine zone (Hallock and McAllister 2005).

A.1.4.2 Distribution on the Project Area

Adult western toads were frequently seen during surveys in the Peace River Valley. They are likely present in the valley in all but the driest and rockiest habitats.

A.1.4.3 Elevation Range

The elevational range is sea level to at or above the treeline (Sullivan 1994).

A.1.5 Food/cover Life Requisites and Habitat-uses

The western toad requires calm, open water for breeding. It is known to use a variety of water sources including the margins of lakes, ponds, or reservoirs, and marshes, swamps, springs or pools in wet grasslands. Breeding populations tend to lay eggs in the same location with areas typically not more than 30 centimetres in depth. The shallow water tends to be warmer, enhancing development. As transformation is completed in a single season, permanent water bodies are not required and ephemeral water sources may be used. Surface cover such as woody debris or submerged vegetation is associated with egg laying habitat (Orchard 1988; Sullivan 1994).

The western toad will use a variety of terrestrial and aquatic habitats including forests, avalanche tracks, open meadows and marshes. Non-breeding habitats generally have some cover and available moisture in the form of standing water, gullies, ditches, or depressions. Western toads use terrestrial habitats up to 90% the time (COSEWIC 2002). Non-breeding habitat is commonly within 2 km of breeding areas but distances of 7.2 km have been recorded (Davis 2002). Bull (2006) found western toads with radio-transmitters to select habitats with little or no canopy, on south-facing slopes, near water, and with high densities of potential refugia such as rodent burrows, rocks and logs.

Body temperature is largely regulated by basking and evaporative cooling. The western toad is largely nocturnal spending the day under the cover of rocks, logs, other surface cover or inside burrows, to avoid evaporative conditions (Sullivan 1994). It is associated with a range of forest types including ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), spruce (*Picea* spp.), larch (*Larix laricina*), and hemlock (*Tsuga* spp.) (Sullivan 1994). Dense shrub cover is important for thermal and hiding cover. Recently harvested areas and dense young forests may be avoided due lack of shrub cover (COSEWIC 2002).

Western toads use a variety of sites as hibernacula. In Oregon, 26 western toads with radio-transmitters overwintered in rodent burrows (38%), under large rocks (27%), under logs or root wads (19%) and under banks adjacent to streams or a lake (15%) (Bull 2006).Seepage areas under willow (*Salix spp.*) or spruce roots, that are associated with a spring, may be used for hibernating. Small mammal burrows, including those made by ground squirrels, are frequently used. Burrows must be deep and moist to avoid freezing and desiccation. Western toads are known to hibernate up to 1.3 m underground (COSEWIC 2002).

Amphibian larva and egg mass surveys were carried out in the Peace River area. Western toads were observed in all life stages in eight different habitat types (**Table A.1.1**). In late April, about 75 adults were found in amplexus (egg fertilization) in a backchannel. The backchannel was approximately 600 square metres with emergent vegetation around the edges. It had high solar exposure resulting in a water temperature of 12°C and was relatively shallow—15 centimetres at one metre from shore. A female was observed laying eggs in the same backchannel. Other observations included congregations of metamorphosed toadlets leaving waterbodies en masse. One site where hundreds of toadlets were observed was an old beaver pond close to the south bank of the river at a site heavily trampled by cattle.

Table A.1.1 Detection by habitat type: western toad – 2006 and 2008

Habitat Type	Technical Study Area
Bog	1
Ditch	2
Fen	2
Gravel Bar	1
Lake	3
Marsh	3
Puddle	0
River	0
River Backchannel	3
Shallow Water	6
Swamp	0
Total	**21**

Life requisites rated for western toad are summarized in **Table A.1.2**.

Table A.1.2 Food/cover life requisite: western toad

Food/cover Life Requisite	Habitat-use	Months	Rating Column Title
Food, Security, and Thermal Habitat	Reproduction-Eggs	May-August	AANBO_RE

A.1.6 Ratings

A four-class ratings scheme will be used (**Table A.1.3**).

Table A.1.3 Habitat capability and suitability rating scheme

<table>
<tr><th>% of Provincial Best</th><th>Rating</th><th>6 Class</th><th>4 Class</th><th>2 Class</th></tr>
<tr><td>100% - 76%</td><td>High</td><td>1</td><td>H</td><td rowspan="4">U</td></tr>
<tr><td>51% - 75%</td><td>Moderately High</td><td>2</td><td rowspan="2">M</td></tr>
<tr><td>50% - 26%</td><td>Moderate</td><td>3</td></tr>
<tr><td>25% - 6%</td><td>Low</td><td>4</td><td rowspan="2">L</td></tr>
<tr><td>5% - 1%</td><td>Very Low</td><td>5</td><td rowspan="2">X</td></tr>
<tr><td>0%</td><td>Nil</td><td>6</td><td>N</td></tr>
</table>

Source: (Resources Inventory Committee 1999)

A.1.6.1 Provincial Benchmark

No provincial benchmark has been set for this species since there is not enough data on densities anywhere in the province to determine the type of areas that may provide benchmark habitat.

High ratings are assumed possible in the study area.

A.1.6.2 Assumptions

Small ephemeral wetlands and possibly suitable breeding sites such as ditchlines are generally not mapped at the 1:20,000 scale. Therefore, there will be many very small potential breeding sites that may not be identified with 1:20,000 TEM mapping.

Fm02 floodplain forest is rated Moderate because of the possibility of breeding in very small or ephemeral wet areas within this habitat type. Assumptions are summarized in **Table A.1.4** and **Table A.1.5**.

Table A.1.4 Habitat use assumptions: western toad – ecosystem

BEC Variant	Name	Symbol/ Site Series	Maximum Rating
BWBSmw1	$Ac – Cow parsnip	SH:ac/07$	L
	$At – Black Twinberry	SC:ab/05$	N
	$At - Creamy peavine	AM:ap/01$	N
	$At - Kinnikinnick	LL:ak/02$	N
	$At - Labrador tea	BL:al/04$	L
	$At - Soopolallie	SW:as/03$	N
	$Ep – Dogwood	SH:ep/07$	L
	$Ep – Red-osier dogwood	SC:ep/05$	N
	ActSw - Red-osier dogwood	Fm02	M
	Cultivated Field	CF/00	L
	Cutbank	CB/00	N
	Exposed Soil	ES/00	N
	Fuzzy-spiked Wildrye-Wolf willow	WW/00	N
	Gravel Bar	GB/00	N
	Gravel Pit	GP/00	N
	Mine	MI/00	N
	Mine Tailings	RY/00	N
	Pl - Lingonberry - Velvet-leaved blueberry	LL/02	N
	Railway	RN/00	N
	Reservoir	RE/00	L
	River	RI/00	L
	Road	RZ/00	N
	Rock	RO/00	N
	Rural	RW/00	N
	Sb - Labrador tea – Sphagnum	BT/08	M
	Sb - Lingonberry - Coltsfoot	BL/04	L
	Sedge Wetland	SE/00	H
	Shallow Open Water	OW/00	H
	Sw - Currant – Bluebells	SC/06	N

BEC Variant	Name	Symbol/ Site Series	Maximum Rating
	Sw - Currant – Horsetail	SH/07	M
	Sw - Currant - Oak fern	SO/05	N
	Sw - Wildrye – Peavine	SW/03	N
	SwAt – Soopolallie	AS/00	N
	SwAt - Step moss	AM/01	N
	Tamarack-sedge fen	TS/10	H
	Urban	UR/00	N
	Willow – Horsetail – Sedge – Riparian Wetland	WH/00	H
	Willow – Sedge – Wetland	WS/00	H
BWBSwk1	$At – Highbush-cranberry	BL:ah/03$	L
	$At – Labrador tea	SM:al/01$	L
	Pl – Lingonberry – Velvet-leaved blueberry	LL/02	N
	Sb – Lingonberry – Coltsfoot	BL/03	L
	Sw – Huckleberry – Step moss	SM/01	L
	Sw – Wildrye – Peavine	SW/04	N
BWBWmw1	Lake	LA/00	L
	Pond	PD/00	L
ESSFmv2	Alder – Fern avalanche track	AF/00	N
	Bl – Lingonberry	FL/02	N
	Bl – Oak fern – Knight's plume	FO/04	L
	Bl – Rhododendron – Feathermoss	FR/01	N
	BlSb – Labrador tea	BT/03	L
	Alder – Fern avalanche track	AF/00	N
	Bl – Oak fern – Knight's Plume	FO/01	N
	Bl – Oak Fern - Sarsaparilla	FS/02	N
SBSwk2	ActSw - Red-osier dogwood	Fm02	M
	Cultivated Field	CF/00	L
	Gravel Bar	GB/00	N
	Gravel Pit	GP/00	N
	Narrow-leaved cotton-grass - Shore sedge	Wf13	M
	Pl - Huckleberry – Cladina	LH/02	N
	Railway	RN/00	N
	Reservoir	RE/00	L
	River	RI/00	L
	Road	RZ/00	N
	Rock	RO/00	N
	SbPl - Feathermoss	BF/04	N

BEC Variant	Name	Symbol/ Site Series	Maximum Rating
	Scrub birch - Water sedge	Wf02	M
	Shallow Open Water	OW/00	H
	Sxw - Devil's club	SD/05	L
	Sxw - Horsetail	SH/06	L
	Sxw - Huckleberry - Highbush-cranberry	SC/03	N

Table A.1.5 Habitat use assumptions: western toad – structural stage

Structural Stage	Rating
None	H
1 through 3	H
4 through 7	M

A.1.6.3 Reliability Qualifier

During map truthing, western toads were observed in moist to wet forest (SHac, SH, BT and Fm02) and wetland (WH, WS) site series. Western toads were also observed during amphibian surveys and incidentally during wildlife surveys in the Peace River area in 2006 and 2008. During these surveys, western toads were detected at twenty different sites and eight habitat types—bog, ditch, fen, gravel bar, lake, marsh, river backchannel, shallow water. Western toads were most frequently detected in shallow water habitat types (n=6 sites). Western toad tadpoles were observed at 13 different breeding sites in 2006 and 2008.

This model has a moderate reliability qualifier since there is good information about western toad breeding habitat in the area. Due to the 1:20,000 scale of the mapping, not all shallow water breeding sites such as ditches and small ponds can be mapped.

A.1.6.4 Map Themes and Rating Adjustments

The map theme that can be produced for western toad is:

- Reproducing-eggs habitat.

A.1.6.5 Adjustments

No adjustments are specified.

A.1.7 Literature Cited

Adams, S.B., D.A. Schmetterling and M.K. Young. 2005. Instream movements by boreal toads (*Bufo boreas boreas*). Herpetological Review 36(1):27–33.

Bartelt, P., C. Peterson and R. Klaver. 2004. Sexual differences in the post-breeding movements and habitats selected by western toads (*Bufo boreas*) in southeastern Idaho. Herpetologica 60(4):455–467.

BC Conservation Data Centre. 2011. BC Species and Ecosystems Explorer. Province of British Columbia. Available at: http://a100.gov.bc.ca/pub/eswp/.

BC Conservation Data Centre. 2012. BC Species and Ecosystems Explorer. BC Ministry of Environment, Victoria, BC. Available at: http://a100.gov.bc.ca/pub/eswp/.

Blaustein, A.R., J.J. Beatty, D.H. Olson and R.M. Storm. 1995. The Biology of Amphibians and Reptiles in Old-Growth Forests in the Pacific Northwest. Forest Service, USDA Department of Agriculture, Portland, OR.

Bull, E.L. 2006. Sexual differences in the ecology and habitat selection of western toads in northeastern Oregon. Herpetological Conservation and Biology 1(1):27–38.

COSEWIC. 2002. COSEWIC Assessment and Status Report on the Western Toad *Bufo Boreas* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. Available at: dsp-psd.pwgsc.gc.ca/Collection/CW69-14-346-2003E.pdf.

Davis, T.M. 2000. Ecology of the Western Toad (*Bufo Boreas*) in Forested Areas on Vancouver Island. Final Report. Forest Renewal BC, Ministry of Forests, Victoria, BC.

Davis, T.M. 2002. Research Priorities for the Management of the Western Toad, *Bufo Boreas*, in British Columbia. BC Ministry of Water, Land and Air Protection, Biodiversity Branch, Victoria, BC.

Hallock, L.A. and K.R. McAllister. 2005. Western Toad. Washington Herp Atlas. Washington Natural Heritage Program, Washington Department of Fish and Wildlife, USDI Bureau of Land Manangement and US Forest Service. Available at: www.dnr.wa.gov/nhp/refdesk/herp/.

Jones, M.S. and J.P. Goettl. 1998. Henderson/Urad Boreal Toad Studies. Colorado Division of Wildlife, Fort Collins, CO.

Matsuda, B.M., D.M. Green and P.T. Gregory. 2006. Amphibians & Reptiles of British Columbia Illustrated Edition. Royal British Columbia Museum, Victoria, BC.

Muths, E. 2003. Home range and movements of boreal toads in undisturbed habitat. Copeia 2003(1):160–165.

Orchard, S.A. 1988. Species Notes for Amphibians. In: A. P. Harcombe (ed.), *Wildlife Habitat Handbooks for the Southern Interior Ecoprovince*. BC Ministry of Environment and Ministry of Forests, Victoria, BC. Pp. 41.

Resources Inventory Committee. 1999. British Columbia Wildlife Habitat Rating Standards. Version 2.0. BC Ministry of Environment, Lands and Parks, Resource Inventory Branch, Victoria, BC. Available at: http://archive.ilmb.gov.bc.ca/risc/pubs/tebiodiv/.

Sullivan, J. 1994. *Bufo boreas*. In: *The Fire Effects Information System (Data base). Intermountain Fire Sciences Laboratory, Intermountain Research Station*. US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT. Available at: http://www.fs./fed.us/database/feis/animals/amphibian/bubo/introductory/html.

Thompson, P.D. 2004. Observations of boreal toad (*Bufo boreas*) breeding populations in northwestern Utah. Herpetological Review 35(4):342–344.

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APPENDIX B GARTERSNAKES

B.1 Species - Habitat Model for Gartersnakes

This species account is based on one for the common gartersnake prepared for the Nicola-Similkameen Innovative Forestry Society by Brenda Lynn, Aaron Reid, and Mike Sarell. It has been modified for the Project and additional information has been added. As their ecology is similar, both the terrestrial gartersnake and common gartersnake are considered together in this habitat model.

B.1.1 Species data

Common Name:	Common Gartersnake; Terrestrial Gartersnake (also known as Western Terrestrial Gartersnake)
Scientific Name:	*Thamnophis sirtalis*; *Thamnophis elegans*
Species Code:	R-THAM (includes both species)
Identified Wildlife Status:	Not listed
BC Status:	Yellow-listed
COSEWIC Status:	Not listed

B.1.2 Project data

Area:	Peace River Valley
Ecoprovince:	Boreal Plains
Ecoregions:	Peace River Basin
Ecosections:	Peace Lowlands (PEL)
BEC Variants:	BWBSmw1
Map Scale:	1:20,000

B.1.3 Ecology and Habitat Requirements

The body form of the common gartersnake is long and slender (Resources Inventory Committee 1998), with a tail that is less than 27% of its total length (NatureServe 2011). It may grow to be 46 to 137 centimetres in total length (Zimmerman 2002). Snakes in the west tend to be larger on average than eastern populations (Gregory and Larsen 1993) and those in more northerly locations mature at larger body sizes (Larsen et al. 1993).

Colour patterns of the common gartersnake are highly variable geographically (NatureServe 2011). All three sub-species of the common gartersnake in BC have a black to greyish green or brown or olive body (Reptiles of BC 2004). They typically have three light stripes running along the length of the body. The stripes can be white, yellow, blue, greenish, or brown in colour (Zimmerman 2002). Seven upper labials are usually present (Stebbins 2003). Red blotches or a double row of alternating black spots are often present between the stripes (Reptiles of BC 2004). The underside or ventral can be bluish grey, yellow, or black (Resources Inventory

Committee 1998). Some populations have a high percentage of entirely black garter snakes (Zimmerman 2002).

The terrestrial gartersnake grows to 96 centimetres in total length with females generally larger than males (Matsuda et al. 2006). Eight upper labial scales are usually present. The terrestrial gartersnake is grey to brown in colour with a yellow or orange dorsal stripe that is usually wavy but occasionally straight. Additional yellow lateral stripes are present running the length of the body and two rows of darker blotches are located on the sides of the body (Matsuda et al. 2006). The terrestrial gartersnake is variable in colour and pattern across its range (Matsuda et al. 2006).

B.1.3.1 Hibernation

Gartersnakes have distinct periods of activity that include hibernating throughout the winter, spring emergence immediately followed by mating, and dispersion to summer foraging areas. Snakes return to the den in the fall and remain active around the mouth of the den for one or two weeks as long as the weather is clear and warm (Shine and Mason 2004). They retreat inside the den at night and during cool weather and enter the den for the season once the ambient daytime temperature drops below freezing (Krohmer 2004). Gartersnakes hibernate from late October through March or early April in a diversity of sites (Costanzo 1986; Farr 1988; RIC 1998; Takats 2002) and both species may hibernate together in the same den (Matsuda et al. 2006). An hibernacula must provide refugia that penetrate below the frost line to ensure body temperatures remain above freezing.

At the northern end of its range in Manitoba, the common garter snake hibernates for up to nine months of snow cover (Krohmer 2004). Body temperatures of common gartersnakes wintering at a den in northern Manitoba were similar to ground temperatures measured at a depth of 1.5 metres from November through April.

Gartersnakes are mainly solitary but will gather in large numbers at good places to hibernate over the winter (Zimmerman 2002). In some areas thousands may congregate at choice hibernacula (NatureServe 2011). Denning populations fluctuate greatly, possibly due to reproductive failure associated with poor weather (Gregory 1977). Catastrophes such as flooding can also wipe out populations at entire dens (Gregory 1977; Shine and Mason 2004). Mass mortality at hibernacula has also been linked with abnormally low snow cover, leading to deaths of thousands of snakes by freezing (Shine and Mason 2004).

B.1.3.2 Breeding

Common gartersnakes breed once each year and give birth in late summer (Zimmerman 2002). Mating occurs in the spring in most areas (Reptiles of BC 2004) or upon emergence from hibernacula. Gartersnakes may also mate in the fall (Freedman and Catling 1979) and the common gartersnake has occasionally been observed mating as late as August (Reptiles of BC 2004). Males emerge first from hibernacula followed a short time later by females (Sexton and Bramble 1994; Reptiles of BC 2004). As soon as the females leave the hibernacula, males will begin courting (Reptiles of BC 2004). Multiple males will usually pursue a single female, resulting in a mating ball of snakes with a single female in the middle (Reptiles of BC 2004). Mating balls may be so dense that some individuals suffocate in the middle of the ball and females face a significant risk of injury and death (Shine and Mason 2004; Shine et al. 2006). Males are attracted to females by skin pheromones (Shine et al. 2000; LeMaster and Mason 2003) and initiate mating by contact along the length of the female's body (Reptiles of BC 2004).

Once the female has selected a mate and mated, she forms a copulatory plug at the opening to her reproductive tract (Reptiles of BC 2004). It was formerly thought males sensed the presence of this plug and did not pursue females that had already mated; genetic tests on common gartersnake litters in one study found that most—greater than 70%-—of the litters tested had multiple paternity (Schwartz et al. 1989) and a small sample of terrestrial gartersnake litters in BC also revealed half of the litters had multiple paternity (Gamer and Larsen 2005). Females have the ability to store the male's sperm until it is needed and a female may not mate if she does not find a proper partner (Zimmerman 2002). Some males will remain at the den to mate with other emerging females (Zimmerman 2002) and do not feed until after the breeding season (O'Donell et al. 2004). Mating activity lasts about four weeks and is most intensive when air temperatures are above 15°C (Aleksiuk and Gregory 1974). After mating most common gartersnakes migrate to summer hunting grounds (Reptiles of BC 2004).

The common gartersnake is ovoviviparous, giving birth to live, fully developed young instead of laying eggs. The gestation period is two to three months (NatureServe 2011). Large females tend to produce more male young (Dunlap and Lang 1990). The females generally give birth in July or August (Nussbaum et al. 1983; Reptiles of BC 2004), earlier in the south, and as late as October in the north (NatureServe 2011). The female common gartersnake can give birth to two to 85 young (Resources Inventory Committee 1998; Nussbaum et al. 1983) although most litter sizes are reported as 10 to 15 (Nussbaum et al. 1983; Freedman and Catling 1979) or 13 to 26

(NatureServe 2011). Litter size varies geographically and with the size of the female (Zimmerman 2002) with litters generally larger in the east that in the west (NatureServe 2011) and with larger females giving birth to larger litters (Nussbaum et al. 1983; Gregory and Larsen 1993). The gartersnakes in the Peace River Valley are quite small—less than 500 millimetres total length—in comparison to individuals in the south of the province and probably have fewer than 10 young. In Canada, common gartersnakes tend to reproduce less frequently and have larger young than the southern populations (Reptiles of BC 2004). In BC, terrestrial gartersnakes give birth—usually in July or August—to 3 to 24 live young (Nussbaum et al. 1983; Matsuda et al. 2006).

Young gartersnakes are about 12 to 23 centimetres at birth (NatureServe 2011). One neonate observed at Tea Creek in the Peace River Valley in September 2011 was about 16 centimetres long. The newborns are independent but tend to stay around their mother for several hours or days although she provides no parental care or protection (Zimmerman 2002).

B.1.3.3 Lifespan

Most young snakes die within their first year prior to being sexually active. Those that survive become sexually mature at three years for northern populations (Gregory 1977; Zimmerman 2002; NatureServe 2011). Females under 400 millimetre snout to vent length (SVL) are unlikely capable of breeding (Gregory 1977). The growth rate, fecundity, and adult survival of the common gartersnake vary according to prey availability and habitat including access to water (Bronikowski and Arnold 1999).

B.1.3.4 Diet

The common gartersnake is an adaptable species that exhibits a “marked plasticity in ecological traits” (Rossman et al. 1996). Gartersnakes typically eat earthworms, amphibians and their larvae, leeches, slugs, snails, insects, crayfish, small fish, birds and their eggs, small mammals, and reptiles (Nussbaum et al. 1983). Young common gartersnakes seem to live mainly on earthworms until they are large enough to tackle more challenging prey (Nussbaum et al. 1983). The common gartersnake seems immune to the toxic skin secretions of toads (Zimmerman 2002) and newts, which are deadly poisons to most predators (Matsuda et al. 2006). Terrestrial gartersnakes are opportunistic feeders and their diet may vary dramatically in response to local prey availability (Kephart and Arnold 1982).

Gartersnakes are nonvenomous but can produce a mildly toxic secretion from glands (Duvernoy's glands) in the mouth (Hill and Mackessey 2000). Normally prey is simply seized and swallowed alive. The terrestrial gartersnake may restrain small mammals with coils of its body (Gregory et al. 1980).

B.1.3.5 Thermoregulation

The gartersnake uses thermoregulation to control its body temperature. Snakes bask in the sun to maintain a preferred body temperature between 28 and 32°C throughout the day (Zimmerman 2002) and may climb trees to gain access to more preferred ambient temperatures (Shine et al. 2005). The common gartersnake can function at lower temperatures than any other gartersnake (Fitch 1965) and are the first to emerge from hibernacula in the spring and the last to return in the fall. They are tolerant of brief periods of sub-zero temperatures during the active season (Churchill and Storey 1992).

B.1.3.6 Home Range and Movement

The home range size of the common gartersnake is variously reported as 0.8 to 14 hectares although they may migrate long distances between summer and winter sites (NatureServe 2011). Migrating snakes use the position of the sun and pheromone trails to find their way back to hibernacula in the fall (Fitch 1965; Heller and Halpem 1982) and may travel on particular routes to return to dens (Shine and Mason 2004). Freedman and Catling (1979) found most recaptured gartersnakes within 160 metres of their original capture sites, which may reflect proximity of hibernacula and foraging areas at their study site. Larsen (1987) reported daily movements of over one kilometre for common gartersnakes in Wood Buffalo National Park. Home ranges of gartersnakes in BC varied from 10 to 100,000 square metres with movements as great as three kilometres recorded (Farr 1988).

The common gartersnake is primarily active during the day or diurnal (Rossman et al. 1996). It may be active both day and night in most of its range and nocturnal activity often occurs during hot weather (NatureServe 2011). Population density estimates in different areas range from about 10 to 100 individuals per hectare (NatureServe 2011).

B.1.4 Distribution

The common gartersnake ranges from the central Northwest Territories (Fort Smith) south to southern California, Florida, and parts of Mexico (Larsen 1987; Russell and Bauer 2000; Government of the Northwest Territories 2005a). The terrestrial gartersnake is found from BC east through Manitoba and south through the western US to the Mexican border (Smith and Brodie Jr 1982). It may occur as far north as the Liard River valley in the Northwest Territories (Government of the Northwest Territories 2005b).

B.1.4.1 Provincial Range

Three sub-species of the common gartersnake occur in British Columbia (Resources Inventory Committee 1998; Biolinx Environmental Research Ltd. & E. Wind Consulting 2003; Reptiles of BC 2004). The red-sided gartersnake (*Thamnophis sirtalis parietalis*) is the subspecies present in the LAA. It occurs in eastern BC, south from the Peace River District (Resources Inventory Committee 1998; Biolinx Environmental Research Ltd. & E. Wind Consulting 2003) and towards the prairie provinces (Reptiles of BC 2004). The common gartersnake has the widest distribution of any snake species in North America (Stebbins 2003).

The single sub-species of terrestrial gartersnake present in BC is *T. e. elegans*, the wandering gartersnake, which has been recorded across the southern half of BC to Vancouver Island and as far north as the Peace River Valley (Nussbaum et al. 1983).

B.1.4.2 Distribution on the Project Area

Both common and western terrestrial gartersnakes are known to be present in the Peace River Valley (Hawkes et al. 2006), which is close to their northeastern distribution limit in the province (Nussbaum et al. 1983). Many gartersnakes have been observed in the Clayhurst Ecological Reserve (Anon 2006).

B.1.4.3 Elevation Range

The elevational range of the common gartersnake is from sea level to 2,450 metres (Resources Inventory Committee 1998).

B.1.5 Food/cover Life Requisites and Habitat-uses

Life requisites rated for gartersnakes are presented in **Table B.1.1**.

Table B.1.1 Food/cover life requisite: gartersnakes

Food/cover Life Requisite	Habitat-use	Months	Rating Column Title
Security and Thermal Habitat	Hibernating	September-May	R_THAM_HI

B.1.5.1 Living

Gartersnakes are often common where prey species and suitable cover are present. Predator avoidance may be a primary feature of habitat choice (Charland and Gregory 1995). Terrestrial gartersnakes are found in marshes, ditches, streams, and pastures (Nussbaum et al. 1983; Rossman et al. 1996) and are most common close to water (Matsuda et al. 2006). Common gartersnakes are often present in wet meadows and near watercourses but can be found far from water in deep coniferous forest (Nussbaum et al. 1983). The frequency of common gartersnakes at sites in California was correlated with the number of amphibian species present (Kephart 1982; Matthews et al. 2002). Gartersnakes may converge on shorelines when amphibians are undergoing mass transformations in order to feed on newly-emerged juveniles (Arnold and Wassersug 1978). Gartersnakes are good swimmers and are capable of crossing rivers. Successful crossing of large rivers depends on the water temperature and aquatic predators present. In southern BC, common gartersnakes have been observed nestled in the rocks in streambeds where presumably they were hunting small fish (M. Sarell pers. obs.).

High levels of cover—vegetation, rocks, trees—are preferred by gartersnakes (Charland 1995). Gravid (pregnant) females tend to remain near rock outcrops, which are used as rookery (breeding colony) sites (Charland and Gregory 1995). Gartersnakes in California preferred to retreat under rocks 20 to 30 centimetres in thickness as these provided a variety of suitable thermoregulatory options (Huey et al. 1989).

Gartersnakes in Manitoba avoided gravel roads and typically changed directions when encountering roads (Shine et al. 2004). Although snakes may be attracted to asphalt roads—typically warmer than the surrounding landscape during the late afternoon and evening—gravel roads may actually be cooler than surrounding habitat due to reflectivity (Shine et al. 2004). Road mortality of gartersnakes is widespread and well documented.

B.1.5.2 Hibernation

There are few data available on physical characteristics of gartersnake hibernacula in BC. The characteristics of suitable hibernation sites for snake species near the northern limits of their range may include structural and thermal stability, access to the water table, depth below frost line, and space within sites to adjust for changing conditions (Harvey and Weatherhead 2006). Gartersnakes hibernate in a variety of sites depending on geographical location and climate conditions. Existing cavities are most commonly used for hibernation (Gregory 1982).The presence of moisture and lack of light may be critical factors for suitable hibernacula (Costanzo

1986; 1989). It is unknown if subsurface standing water is required. Manier and Arnold (2005) noted that populations of *T. sirtalis* and *T. elegans* in California were significantly concentrated around hibernacula associated with water bodies and attributed this to the concentration of prey (amphibians) around water features.

Costanzo (1986) found common gartersnakes hibernating in the crevices of the rock walls of a small cistern 245 centimetres deep, using crevices up to 80 centimetres below the water surface. Talus, fractured bedrock, karst features, and road beds have been reported as hibernaculum sites (Larsen 1987; Farr 1988), as well as tree roots, shale cliffs, road embankments, rock piles, pits and culverts (Resources Inventory Committee 1998; Takats 2002). Shine and Mason (2004) describe dens in limestone sinkholes as small as one square metre at the surface. Earthen dikes are used for hibernation along the Okanagan River (M. Sarell, pers. comm.).

B.1.6 Ratings

There is an intermediate level of knowledge on the habitat requirements of gartersnakes in BC. A 4-class rating scheme will be used (**Table B.1.2**)(Resources Inventory Committee 1998).

Table B.1.2 Habitat capability and suitability rating scheme

<table>
<tr><th>% of Provincial Best</th><th>Rating</th><th>6 Class</th><th>4 Class</th><th>2 Class</th></tr>
<tr><td>100% - 76%</td><td>High</td><td>1</td><td>H</td><td rowspan="4">U</td></tr>
<tr><td>51% - 75%</td><td>Moderately High</td><td>2</td><td rowspan="2">M</td></tr>
<tr><td>50% - 26%</td><td>Moderate</td><td>3</td></tr>
<tr><td>25% - 6%</td><td>Low</td><td>4</td><td rowspan="2">L</td></tr>
<tr><td>5% - 1%</td><td>Very Low</td><td>5</td><td rowspan="2">X</td></tr>
<tr><td>0%</td><td>Nil</td><td>6</td><td>N</td></tr>
</table>

Source: (Resources Inventory Committee 1999)

B.1.6.1 Provincial Benchmark

The provincial benchmark for the gartersnake is in the Northern Okanagan Highland (NOH), in the IDF biogeoclimatic zone in mature black cottonwood riparian habitat (Sinclair et al. 1999).

Since the Peace region is close to the northeastern extent of the provincial range of both species and snake density is relatively low, ratings would normally be assigned to a maximum of moderate. Due to the need to stratify the study area for sampling, ratings have been assigned to high in order to have four classes available for modelling.

B.1.6.2 Assumptions

The ratings for surficial material form the basis of the ratings. The ecosystem ratings will be used as a secondary map theme to refine the terrain ratings. Habitats supporting features that could be used as communal dens—i.e., rock, cutbank—have been rated higher than habitats where snakes are more likely to hibernate singly—i.e., in rodent burrows. Complex polygons will be assigned the maximum rating from their component deciles, rather than an averaged rating.

Generally the terrain ratings should be the main source of the polygon rating. Dry forests—mesic and drier—should be rated a maximum of low in structural stage three. Dry forests in structural stages greater than three should be rated nil unless there is a rapid mass movement R geomorphic process, in which case the polygon should be upgraded to high. Forest wetter than mesic should be rated nil in all structural stages. Grassland polygons should be adjusted to a maximum of moderate unless an R geomorphic process is present in the terrain data (**Table B.1.3** though **Table B.1.6**).

Table B.1.3 Habitat use assumptions: gartersnakes – surficial material

Surficial Material	Symbol/Site Series	Maximum Rating
Anthropogenic Materials	A	M
Colluvium	C	H
Fluvial	F	M
Glaciofluvial	FG	M
Glaciolacustrine	LG	M
Lacustrine	L	N
Morainal	M	M
Organic	O	N
Rock	R	H
Undifferentiated	U	M
Volcanic	V	M
Waterbody	N	N

Table B.1.4 Habitat use assumptions: gartersnakes – ecosystem

BEC Varient	Name	Symbol/Site Series	Maximum Rating
BWBS/SBS: all Subzones	Cultivated Field	CF/00	N
	Cutbank	CB/00	H
	Exposed Soil	ES/00	N
	Gravel Bar	GB/00	N
	Gravel Pit	GP/00	L
	Lake	LA/00	N
	Mine	MI/00	L

BEC Varient	Name	Symbol/Site Series	Maximum Rating
	Mine Tailings	RY/00	N
	Pond	PD/00	N
	Railway	RN/00	N
	Reservoir	RE/00	N
	River	RI/00	N
	Road	RZ/00	L
	Rock	RO/00	H
	Rural	RW/00	L
	Shallow Open Water	OW/00	N
	Urban	UR/00	L
BWBSmw1	$Ac – Cow parsnip	SH:ac/07$	N
	$At – Black Twinberry	SC:ab/05$	N
	$At - Creamy peavine	AM:ap/01$	L
	$At - Kinnikinnick	LL:ak/02$	L
	$At - Labrador tea	BL:al/04$	N
	$At - Soopolallie	SW:as/03$	L
	$Ep – Dogwood	SH:ep/07$	N
	$Ep – Red-osier dogwood	SC:ep/05$	N
	ActSw - Red-osier dogwood	Fm02/09	N
	Fuzzy-spiked Wildrye-Wolf willow	WW/00	M
	Pl - Lingonberry - Velvet-leaved blueberry	LL/02	L
	Sb - Labrador tea – Sphagnum	BT/08	N
	Sb - Lingonberry - Coltsfoot	BL/04	N
	Sedge Wetland	SE/00	N
	Sw - Currant – Bluebells	SC/06	L
	Sw - Currant – Horsetail	SH/07	N
	Sw - Currant - Oak fern	SO/05	N
	Sw - Wildrye – Peavine	SW/03	L
	SwAt – Soopolallie	AS/00	L
	SwAt - Step moss	AM/01	L
	Tamarack-sedge fen	TS/10	N
	Willow – Horsetail – Sedge – Riparian Wetland	WH/00	N
	Willow – Sedge – Wetland	WS/00	N

BEC Varient	Name	Symbol/Site Series	Maximum Rating
BWBSwk1	$At-Highbush-cranberry	$01/SM:hc	L
	$At-Soopolallie-Sarsaparilla	$04/SW:ss	L
	Sb - Lingonberry – Coltsfoot	04/SW	L
	Sw - Huckleberry - Step moss	01/SM	L
ESSFmv2	all		N
SBSwk2	ActSw - Red-osier dogwood	Fm02/09	N
	Alder-Fern avalanche track	AF/00	N
	Narrow-leaved cotton-grass - Shore sedge	Wf13	N
	Pl - Huckleberry – Cladina	LH/02	L
	SbPl – Feathermoss	BF/04	N
	Scrub birch - Water sedge	WF02	N
	Sxw - Devil's club	SD/05	N
	Sxw - Horsetail	SH/06	N
	Sxw - Huckleberry - Highbush-cranberry	SC/03	L
	Sxw - Oak fern	SO/01	L

Table B.1.5 Habitat use assumptions: gartersnakes – modifiers

Modifier	Symbol/Site Series	Maximum Rating
Active floodplain	a	N
Cool aspect, gentle slope	k, q, j	L

Table B.1.6 Habitat use assumptions: gartersnakes – structural stage

Structural Stage	Maximum Rating
1 to 3	H
4 to 7	N

B.1.6.3 Reliability Qualifier

Field-truthing took place May 12 to 15 and September 8 to 16, 2011.Two biologists, including an experienced snake biologist, conducted ground transects and road surveys to search for snakes and roadkills, conducted spot-checks of particular sites that had been identified by local residents, and conducted field-truthing of habitat ratings. Surveys were primarily done on the north side of the river.

Ratings were revised for a number of individual polygons in the snake ratings theme based on field ratings. The limestone substrate around Hudson's Hope was rated high as there are multiple features within this formation that could potentially be used for denning (see Shine and Mason 2004). The rating for the WW ecosystem unit was revised to moderate and those for forested polygons were dropped to nil for structural stages greater than three. Although the rating for cutbank remained high, many of the cutbanks assessed either had no visible crevices or burrows or were actively eroding. Suitability of cutbanks was quite variable.

Although gartersnakes may den on a variety of aspects throughout their range, the fact that gartersnakes reach their northern distribution limit in the Peace region suggests that it may be important for snakes to emerge from hibernacula as early as possible in order to maximize the length of their active season. Gentle slopes and cool aspects retain snow cover longer than warm aspects. Aspect was added as an adjustment factor and sites on cool aspects were rated a maximum of low. An additional adjustment was applied to upgrade suitability for polygons with a geological process modifier 'R'. This modifier was noted to be present on polygons rated high in the field.

B.1.6.4 Map Themes and Rating Adjustments

The map theme that will be produced for gartersnakes is:

- Highest value habitat for Hibernating during the winter

B.1.6.5 Adjustments

Polygons that have geologic process R (rapid mass movement) and are on warm aspects should be upgraded from moderate or low to high. Polygon ratings assigned in the field should be used instead of calculated ratings wherever they are available.

B.1.7 Literature Cited

Aleksiuk, M. and P.T. Gregory. 1974. Regulation of seasonal mating behavior in *Thamnophis sirtalis parietalis*. Copeia 1974(3):681–689.

Arnold, S.J. and R.J. Wassersug. 1978. Differential predation on metamorphic anurans by garter snakes (*Thamnophis*): social behavior as a possible defense. Ecology 59(5):1014–1022.

Biolinx Environmental Research Ltd. & E. Wind Consulting. 2003. Species Accounts for Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in BC. Available at: www.env.gov.bc.ca/wld/BMP/herptile/HerptileBMP_appendix1_final.pdf.

Bronikowski, A.M. and S.J. Arnold. 1999. The evolutionary ecology of the life history variation in the garter snake *Thamnophis elegans*. Ecology 80(7):2314–2325.

Charland, M.B. 1995. Thermal consequences of reptilian viviparity: thermoregulation in gravid and nongravid garter snakes (*Thamnophis*). Journal of Herpetology 29(3):383–390.

Charland, M.B. and P.T. Gregory. 1995. Movements and habitat use in gravid and nongravid female garter snakes (Colubridae: *Thamnophis*). Journal of Zoology 236(4):543–561.

Churchill, T.A. and K.B. Storey. 1992. Freezing survival of the garter snake *Thamnophis sirtalis parietalis*. Canadian Journal of Zoology 70(1):99–105.

Costanzo, J.P. 1989. Effects of humidity, temperature, and submergence behavior on survivorship and energy use in hibernating garter snakes, *Thamnophis sirtalis*. Canadian Journal of Zoology 67(10):2486–2492.

Costanzo, J.P. 1986. Influences of hibernaculum microenvironment on the winter life history of the garter snake (*Thamnophis sirtalis*). Ohio Journal of Science 86(5):199–204.

Dunlap, K. and J. Lang. 1990. Offspring sex ratio varies with maternal size in the common garter snake, *Thamnophis sirtalis*. Copeia 1990(2):568–570.

Farr, D.R. 1988. The Ecology of Garter Snakes *Thamnophis Sirtalis* and *T. Elegans* in Southeastern BC. M.Sc. Thesis. University of Victoria, Victoria, BC.

Fitch, H.S. 1965. An ecological study of the garter snake *Thamnophis sirtalis*. University of Kansas Publications, Museum of Natural History 15:493–564.

Freedman, B. and P.M. Catling. 1979. Movements of sympatric species of snakes at Amherstburg, Ontario. The Canadian Field-Naturalist 93(4):399–404.

Gamer, T.W.J. and K.W. Larsen. 2005. Multiple paternity in the western terrestrial garter snake, *Thamnophis elegans*. Canadian Journal of Zoology 83(5):656–663.

Government of the Northwest Territories. 2005a. NWT Red-sided Garter Snake (*Thamnophis sirtalis*). Available at: http://www.enr.gov.nt.ca/_live/pages/wpPages/Red_Sided_Garter_Snake.aspx.

Government of the Northwest Territories. 2005b. Terrestrial Garter Snake (*Thamnophis elegans*). Available at: http://www.enr.gov.nt.ca/_live/pages/wpPages/Terrestrial_Garter_Snake.aspx.

Gregory, P.T. 1977. Life History Parameters of the Red-sided Garter Snake (*Thamnophis Sirtalis Parietalis*) in an Extreme Environment in the Interlake Region of Manitoba. National Museum of Canada, Ottawa, ON.

Gregory, P.T. 1982. Reptilian Hibernation. In: C. Gans and F. H. Pough (eds.), *Biology of the Reptilia*. Academic Press, London. Pp. 53–154.

Gregory, P.T. and K.W. Larsen. 1993. Geographic variation in reproductive characteristics among Canadian populations of the common garter snake (*Thamnophis sirtalis*). Copeia 1993(4):946–958.

Gregory, P.T., J.M. Macartney and D.H. Rivard. 1980. Small mammal predation and prey-handling behavior by the garter snake *Thamnophis elegans*. Herpetologica 36(1):87–93.

Harvey, D.S. and P.J. Weatherhead. 2006. Hibernation site selection by eastern Massasauga rattlesnakes (*Sistrurus catenatus catenatus*) near their northern range limit. Journal of Herpetology 40(1):66–73.

Hawkes, V., G.F. Searing, M. Todd, M. Bentley, M.W. Demarchi, J. Muir and M.K. McNicholl. 2006. Peace River Wildlife Surveys: 2005 Habitat Suitability Modeling and Wildlife Inventory. Report to BC Hydro, Burnaby, BC.

Heller, S. and M. Halpem. 1982. Laboratory observations of aggregative behavior of garter snakes, *Thamnophis sirtalis*: roles of the visual, olfactory, and vomeronasal senses. Journal of Comparative Physiology and Psychology 96(6):984–999.

Hill, R. and S. Mackessey. 2000. Characterization of venom (Duvernoy's secretion) from twelve species of colubrid snakes and partial sequence of four venom proteins. Toxicon 38(12):1663–16687.

Huey, R.B., C.R. Peterson, S.J. Arnold and W.P. Porter. 1989. Hot rocks and not-so-hot rocks: retreat-site selection by garter snakes and its thermal consequences. Ecology 70(4):931–944.

Kephart, D.G. 1982. Microgeographic variation in the diets of garter snakes. Oecologia 52(2):287–291.

Kephart, D.G. and S.J. Arnold. 1982. Garter snake diets in a fluctuating environment: a seven-year study. Ecology 63(5):1232–1236.

Krohmer, R. 2004. The male red-sided garter snake (*Thamnophis sirtalis parietalis*): reproductive pattern and behavior. ILAR Journal 45(1):65–74.

Larsen, K., P. Gregory and R. Antoniuk. 1993. Reproductive ecology of the common garter snake *Thamnophis sirtalis* at the northern limit of its range. American Midland Naturalist 129(2):336–345.

Larsen, K.W. 1987. Movements and behavior of migratory garter snakes, *Thamnophis sirtalis*. Canadian Journal of Zoology 65(9):2241–2247.

LeMaster, M.P. and R.T. Mason. 2003. Pheromonally mediated sexual isolation among denning populations of red-sided garter snakes, *Thamnophis sirtalis parietalis*. Journal of Chemical Ecology 29(4):1027–1043.

Manier, M.K. and S.J. Arnold. 2005. Population genetic analysis identifies source–sink dynamics for two sympatric garter snake species (*Thamnophis elegans* and *Thamnophis sirtalis*). Molecular Ecology 14(13):3965–3976.

Matsuda, B.M., D.M. Green and P.T. Gregory. 2006. Amphibians & Reptiles of British Columbia Illustrated Edition. Royal British Columbia Museum, Victoria, BC.

Matthews, K.R., R.A. Knapp and K.L. Pope. 2002. Garter snake distributions in high-elevation aquatic ecosystems: is there a link with declining amphibian populations and nonnative trout introductions? Journal of Herpetology 36(1):16–22.

NatureServe. 2011. NatureServe Explorer: An Online Encyclopedia of Life [web Application]. Version 7.1. Available at: http://www.natureserve.org/explorer. Accessed April 2011.

Nussbaum, R.A., E.D. Brodie, Jr. and R.M. Stom. 1983. Amphibians and Reptiles of the Pacific Northwest. University of Idaho Press, Moscow, ID.

O'Donell, R.S., R. Shine and R.T. Mason. 2004. Seasonal anorexia in the male red-sided garter snake, *Thamnophis sirtalis parietalis*. Behavioral Ecology and Sociobiology 56(5):413–419.

Reptiles of BC. 2004. Western Terrestrial (Wandering) Garter Snake, *Thamnophis Elegans Vagrans. The Reptiles of British Columbia. Thompson Rivers University and BC Ministry of Water, Land and Air Protection. Available at: http://www.bcreptiles.ca/snakes/westterrgarter.htm.*

Resources Inventory Committee. 1999. British Columbia Wildlife Habitat Rating Standards. Version 2.0. BC Ministry of Environment, Lands and Parks, Resource Inventory Branch, Victoria, BC. Available at: http://archive.ilmb.gov.bc.ca/risc/pubs/tebiodiv/.

Resources Inventory Committee. 1998. Inventory Methods for Snakes. Version 2.0. Standards for Components of British Columbia's Biodiversity No. 38. BC Ministry of Environment, Lands and Parks, Resource Inventory Branch, Victoria, BC. Available at: http://archive.ilmb.gov.bc.ca/risc/pubs/tebiodiv/.

Rossman, D.A., N.B. Ford and R.A. Siegel. 1996. The Garter Snakes: Evolution and Ecology. University of Oklahoma Press.

Russell, A.P. and A.M. Bauer. 2000. Amphbians and Reptiles of Alberta: a Field Guide and Primer of Boreal Herpetology. University of Calgary Press, Calgary, AB.

Schwartz, J.M., G.F. McCracken and G.M. Burghardt. 1989. Multiple paternity in wild populations of the garter snake, Thamnophis sirtalis. Behavioral Ecology and Sociobiology 24(4):269–273.

Sexton, O. and J. Bramble. 1994. Post-hibernation behavior of a population of garter snakes (*Thamnophis sirtalis*). Amphibia-Reptilia 15(1):9–20.

Shine, R., T. Langkilde, M. Wall and R.T. Mason. 2006. Temporal dynamics of emergence and dispersal of garter snakes from a communal den in Manitoba. Wildlife Research 33(2):103–111.

Shine, R., M. Lemaster, M. Wall, T. Langkilde and R. Mason. 2004. Why did the snake cross the road? Effects of roads on movement and location of mates by garter snakes (*Thamnophis sirtalis parietalis*). Ecology and Society 9(1):9.

Shine, R. and B. Mason. 2004. Patterns of mortality in a cold-climate population of garter snakes (*Thamnophis sirtalis parietalis*). Biological Conservation 120(2):205–214.

Shine, R., D. O'Connor and R.T. Mason. 2000. The problem with courting a cylindrical object: How does an amorous male snake determine which end is which? Behaviour 137(6):727–739.

Shine, R., M. Wall, T. Langkilde and R.T. Mason. 2005. Scaling the heights: thermally driven arboreality in garter snakes. Journal of Thermal Biology 30(3):179–185.

Sinclair, B., U. Lowrey, R. McKay, G. Burns and M. Ketcheson. 1999. Species Account: Summary of Habitat and Life Requisites for *Thamnophis Sirtalis* (common Garter Snake). BC Ministry of Environment. EcoCat: The Ecological Reports Catalogue.

Smith, H.M. and E. Brodie Jr. 1982. Reptils of North America: A Field Guide to Identification. Golden Press, New York, NY.

Stebbins, R.C. 2003. A Field Guide to Western Reptiles and Amphibians 3rd ed. Houghton Mifflin Harcourt.

Takats, L. 2002. Red-sided Garter Snake *Thamnophis Sirtalis Parietalis* Relocation and Education Project: Final Report. Alberta Sustainable Resource Development, Fish and Wildlife Division, Edmonton, AB.

Zimmerman, R. 2002. "*Thamnophis Sirtalis*" (On-line), Animal Diversity Web. Available at: http://animaldiversity.ummz.umich.edu/site/accounts/information/Thamnophis_sirtalis.html. Accessed November 2012.

Anon. 2006. Ecological Reserves of Northern BC - Part 1. Friends of the Ecological Reserves Newsletter (FERN).

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