Community-based Amphibian Monitoring Program in Multi-use Landscapes in South-central BC, 2011 – 2015

Final Report

Columbia Spotted Frog

Great Basin Spadefoot

Western Toad

Prepared by

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Cover photographs by Kristiina Ovaska; other photos in this report by Lennart Sopuck and Kristiina Ovaska.

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EXECUTIVE SUMMARY

Amphibians are an excellent flagship group for wetland conservation and stewardship. This project helps to address knowledge gaps on distributions, population status, and threats through a collaborative amphibian monitoring program that involves local residents, landowners, and scientists in the Nicola area of south-central BC near Merritt. The goal is to improve management of wetlands in multi-use areas by addressing the following objectives: (1) document distribution patterns and identify important amphibian breeding habitats; (2) assess and help mitigate threats to amphibian habitats and populations; and (3) foster stewardship through participation. This report provides a summary of results obtained during five field seasons, from 2011 – 2015.

To obtain information on distributions of amphibians across the landscape, we used an atlas approach and surveyed wetlands within 10 x 10 km grid cells throughout the 7200 km^2 study area. With help from volunteers (a total of 1580 volunteer hours logged), we surveyed 214 wetlands (some with sub-sites) and/or carried out night-time frog call surveys within a total of 54 grid cells; 43 wetlands were surveyed in more than one year and 17 had multiple surveys in the same year, resulting in a total of 406 wetland surveys. We detected all five pond-breeding amphibian species known from the region. The Pacific Treefrog was found in 75.9%, Columbia Spotted Frog (COSEWIC candidate list) in 59.3%, Western Toad (Special Concern) in 53.7%, Great Basin Spadefoot (Threatened) in 16.7%, and Long-toed Salamander in 35.2% of the grid cells surveyed. The Great Basin Spadefoot was found only in grasslands the Upper Nicola drainage, while the other species were widely distributed across the study area.

Amphibian breeding sites were in a variety permanent and temporal water bodies, often in their shallowest and warmest portions, such as flooded margins of lakes and wetland pools. Pacific Treefrogs were widespread and abundant within the study area, and breeding probably occurred in all 81 water bodies where it was found. Long-toed Salamanders were detected in 25 water bodies, but the species is cryptic and breeding sites are probably widely distributed across the study area. Western Toads breed communally, often in large numbers, and following tips from residents proved to be effective for locating breeding aggregations. We found Western Toads in 84 wetlands, and observed major breeding aggregations (often with tens of thousands of tadpoles) at 31 sites. We found Columbia Spotted Frogs in 84 wetlands, including 20 sites with large breeding aggregations. From 2011 – 2015, a total of 23 breeding sites of the Western Toad and 22 of the Columbia Spotted Frog were visited multiple times and during more than one year. Both species repeatedly used these sites, and in many cases breeding was observed in all years when a site was visited. Lack of observations in some years was attributed to observer bias and timing of surveys, especially for Columbia Spotted Frogs that breed very early in the season; in a few cases, a drop in water level or disturbance had deteriorated habitats.

Call surveys were the most effective method for locating Great Basin Spadefoots and allowed us to map distributions from public roads across the landscape, but some accessible wetlands were also surveyed visually using pond survey methods. During night surveys, Great Basin Spadefoots were detected 117 times at listening posts and visually on roads or trails 48 times (representing 35 adults and 81 juveniles), all within the Upper Nicola drainage. Two standard call survey transects, along Pennask Lake Road and Douglas Lake Road (each with 10 listening stations 800 m apart and listening time 5 min/post) in Upper Nicola grasslands were surveyed multiple times

each year from 2011 – 2015. Spadefoots continued to breed in wetlands along both routes during each of the five years, but the frequency of both the maximum number of points where calls were heard and the intensity of the chorus varied greatly among years, possibly in response to fluctuating water levels in ephemeral breeding sites and weather conditions during the breeding period. The number of stations with a full chorus was the highest in 2011 along both transects. Breeding sites were found in natural grassland wetlands that did not have water in all years, as well as in dug-outs and flooded fields, which also received sporadic use.

During surveys of wetlands, we continued to record surrounding land uses and potential threats to amphibians. The most common threats were from free-range cattle and roads, each comprising ~30% of the threats, followed by recreational activities at 22% (ranging from light use with no expected impacts to high impact off-road vehicle use in and around wetlands) and logging at 12%. Many sites were also modified by dams, deepening of ponds, or beaver activity. Free-range cattle are ubiquitous in the Nicola area, and cattle or their signs were frequently encountered at amphibian breeding sites throughout the study area. Management of stocking densities, and in some cases exclusion of cattle, is required to minimize contamination of breeding sites with dung, excessive disturbance to the shoreline vegetation and bottom substrate, and direct mortality of embryos, tadpoles, or metamorphosed young through trampling. Amphibians are vulnerable to roadkill where roads intercept their seasonal migration routes to and from breeding sites. Activities to mitigate Western Toad roadkill were undertaken in 2011 – 2015 in Kentucky-Alleyne Provincial Park as part of this project, leading to the installation of a wildlife underpass by BC Parks in spring 2013 and subsequent monitoring of its effectiveness by Nicola Naturalist Society volunteers.

Nicola Naturalist Society personnel organized and coordinated volunteer activities and solicited new participants to the project through the society's website, local media, word-of-mouth, and personal communications. Volunteers logged a total of 1580 hours and participated in roadkill mitigation and monitoring, including the construction of drift fences, conducted wetland surveys, monitored known breeding sites of Western Toads, and participated in frog call surveys to detect and monitor Great Basin Spadefoots. Training was provided to the participants in identification of amphibians, survey and monitoring methods, and assessing habitat quality and threats. Participant input was sought through workshops and questionnaires. Biologist-led outings provided an effective method for enhancing volunteer participation and experience.

Summary of the outcomes of the project include the following:

- Distributions and habitats of all five species of pond-breeding amphibians within the study area were documented using an atlas-type approach, filling in a significant information gap. This information provides a baseline for monitoring trends in populations and habitats, which is particularly important in light of multiple threats that amphibians face from emerging diseases, roadkill, land conversions, and various human activities. It can be used to guide management actions and to protect important wetland sites.
- Results of the survey and monitoring activities were provided to the BC Ministry of Environment for inclusion in the provincial Conservation Data Centre, SPI and BC

FrogWatch databases. This will ensure that the data are available for regulators and land managers, as well as for other researchers.

- The study provides a model for a community-based amphibian monitoring program that could be expanded to other regions of BC and adjusted to particular situations based on lessons learned. Information about the project was disseminated to BC Nature clubs across the province through Spring BC Nature Camp, hosted by Nicola Naturalist Society in 2014, and article in BC Nature magazine, and to land managers through guided field trips.
- Roadkill mitigation structures (underpass and associated drift fencing) were installed in Kentucky-Alleyne Provincial Park as a direct result of this project, with follow up monitoring of the effectiveness of the structures conducted in two years. This project served as a demonstration project of amphibian roadkill mitigation.
- Outreach associated with the project included participation in surveys, monitoring, and mitigation activities, landowner contacts, and interpretive outings for community members, land managers, educators, and students. These activities, together with media articles and interviews, contributed to raising awareness of amphibians and their habitats and threats facing them among local communities, landowners, and the public.

1.0 INTRODUCTION

Aquatic-breeding amphibians play an important role in forest and wetland food webs and can be viewed as sentinels of ecosystem health because of their sensitivity to stressors. Declines in amphibian populations are a global phenomenon (Stuart *et al*. 2004; AmphibiaWeb 2016), and many amphibians in British Columbia are also of conservation concern: 64% of our frog species and 30% of salamander species are listed as at risk either federally or provincially (Ovaska and Govindarajulu 2010). Unfortunately, baseline information on patterns of distribution and abundance of amphibians is lacking over much of British Columbia, hindering conservation efforts and making it difficult to detect possible declines in a timely manner.

This community-based amphibian monitoring program around Merritt and surrounding areas began in 2011 in collaboration with Nicola Naturalist Society and Biolinx Environmental Research Ltd. biologists (Ovaska *et al*. 2011, 2013a, 2014, 2015). The aim of the project is to improve management of wetlands in multi-use landscapes by documenting distribution patterns and identifying important amphibian breeding habitats, identifying threats and problem areas, and fostering stewardship through participation. The study focuses on amphibians breeding in lakes, ponds, and wetland (lentic) habitats. Five such species occur in the study area: Great Basin Spadefoot (*Spea intermontana* – federal status Threatened; COSEWIC 2007); Western Toad (*Anaxyrus boreas* – federal status Special Concern; COSEWIC 2013); Columbia Spotted Frog (*Rana luteiventris* – COSEWIC candidate list; not currently listed); Pacific Treefrog (*Pseudacris regilla*; not listed); Long-toed Salamander (*Ambystoma macrodactylus*; not listed). Here we report the results of the project conducted annually from 2011 – 2015.

2.0 OBJECTIVES

The objectives were as follows:

- Document distribution patterns and monitor important amphibian breeding habitats within multi-use landscapes.
- Assess and help mitigate threats to amphibian habitats and populations.
- Foster stewardship and education by involving local community members in monitoring amphibian populations and by engaging landowners in wetland management.

3.0 SURVEYS AND MONITORING

3.1 Baseline Data on Distribution Patterns

Information on distributions and habitats is extremely important for identifying important areas for management and protection and a first, essential step for mitigating threats. We used an atlas approach for documenting the distribution of amphibians within a 7,200 km^2 study area and for identifying breeding sites. The study area was divided into 10 x 10 km UTM grids, corresponding to grids used in the Atlas of the Breeding Birds in British Columbia (2016) that was completed in the area in 2012, and the Ontario Herp Atlas (2011). The intention of the grid system was to spread survey efforts over a wide area. Wetlands within particular grids were prioritized for surveys based on preliminary assessment of their habitat suitability from

GoogleEarth imaging and accessibility considerations. High elevation sites with no or poor road access were usually eliminated. Also, accessing wetlands on private lands were included only where permission from landowners was obtained. Additional opportunistic observations were obtained from local residents and volunteers.

Surveys were carried out annually by Biolinx Environmental Research Ltd. biologists and Nicola Naturalists Society volunteers during five field seasons, from April to August, from 2011 – 2015. In total, 214 water bodies were surveyed within 54 10x10 m grid cells (Table 1; Figure 1). Eleven of these sites had subsites, i.e., wetted margins in different parts of the water body joined at high water or in close proximity (<500 m apart) and part of the same wetland complex. Forty three sites were surveyed in more than one year, and 17 sites had multiple surveys in the same year, resulting in a total of 406 surveys at these sites (see Appendix 1 for a list of wetlands surveyed and species found).

Table 1. Summary of wetland surveys for amphibians conducted by Biolinx Environmental Research Ltd. biologists and Nicola Naturalist Society volunteers in 2011 – 2015.

Note: The numbers differ somewhat from previous interim reports due to the way water bodies are counted. Here, sites within the same water body, joined at high water, or part of a wetland complex are excluded.

	2011	2012	2013	2014	2015	Total
No. new wetlands	65	60	54	28	7	214
No. with wetlands with repeat visits from previous years	0	14	14	28	31	87
Total number of surveys	89	99	85	81	51	406

The Pacific Treefrog, Columbia Spotted Frog, and Western Toad were widespread within the study area and found in 76% - 54% of the 54 grids searched. The Long-toed Salamander was also widespread, found in 35% of the grid cells, but its cryptic behaviour affected its detectability. The Great Basin Spadefoot was found only in the Upper Nicola grasslands in the northeast corner of the study area despite searches in grassland and open woodland habitats elsewhere (see maps in Figure 2 – 6 for distribution by grid cell for all five species and Figure 7 and 8 for summaries). The number of individual water bodies where each species was found is shown in Table 2. Most observations for the Great Basin Spadefoot were from night-time call surveys, not included in the Table 2 (see Figure 5 and Section 3.4 for these observations).

Figure 1. Survey coverage in the Nicola area, 2011 – 2015, showing grid cells, wetlands surveyed (red symbols), and night survey routes or points (purple symbols). Each grid cell corresponds to a 10 x 10 km UTM grid. Note: Points outside the study area are opportunistic observations.

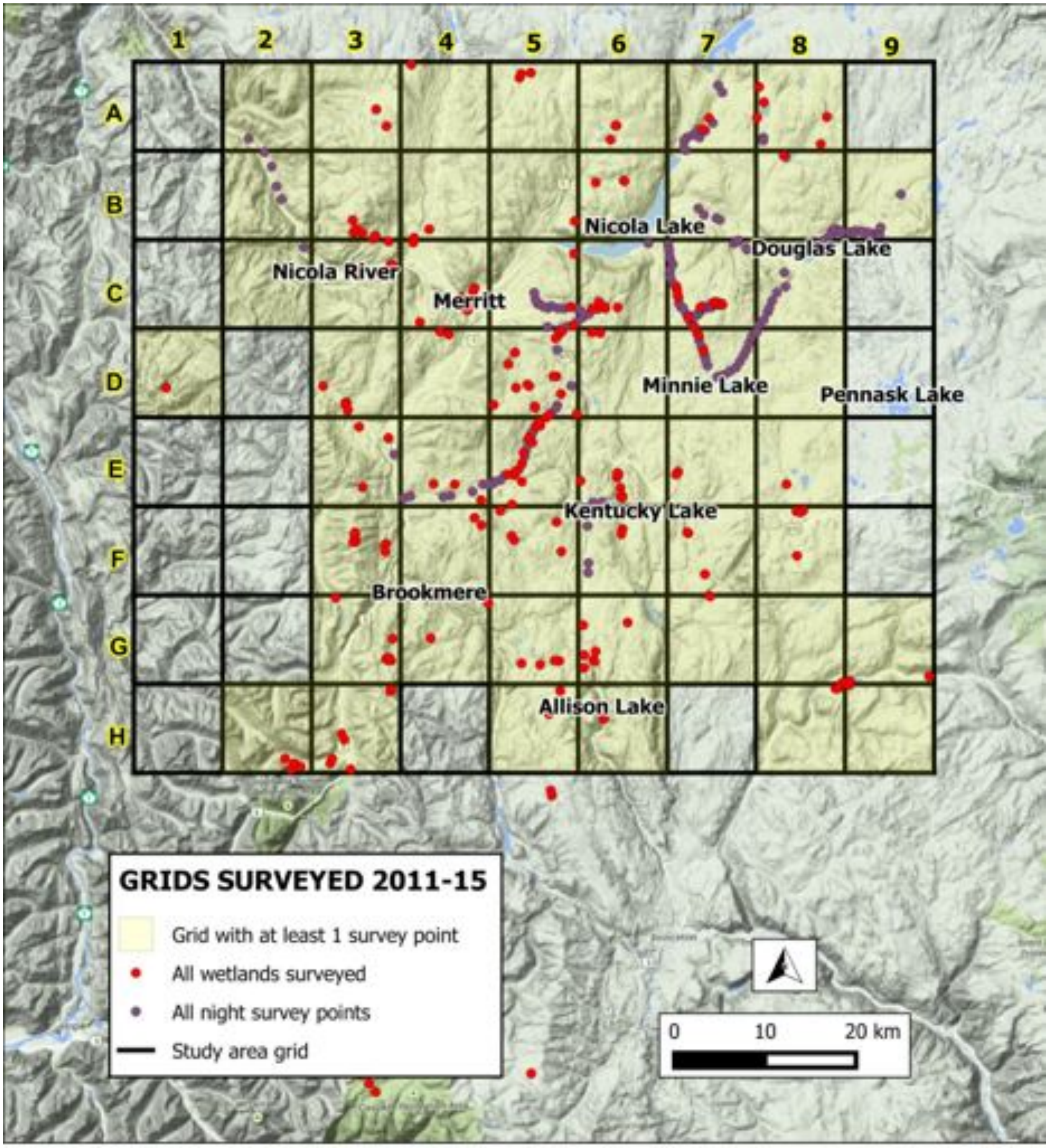


Figure 2. Distribution of the Pacific Treefrog, based on surveys from 2011 – 2015 in the Nicola area, showing grid cells, wetlands (red symbols), and night survey points (purple symbols) where the species was found.

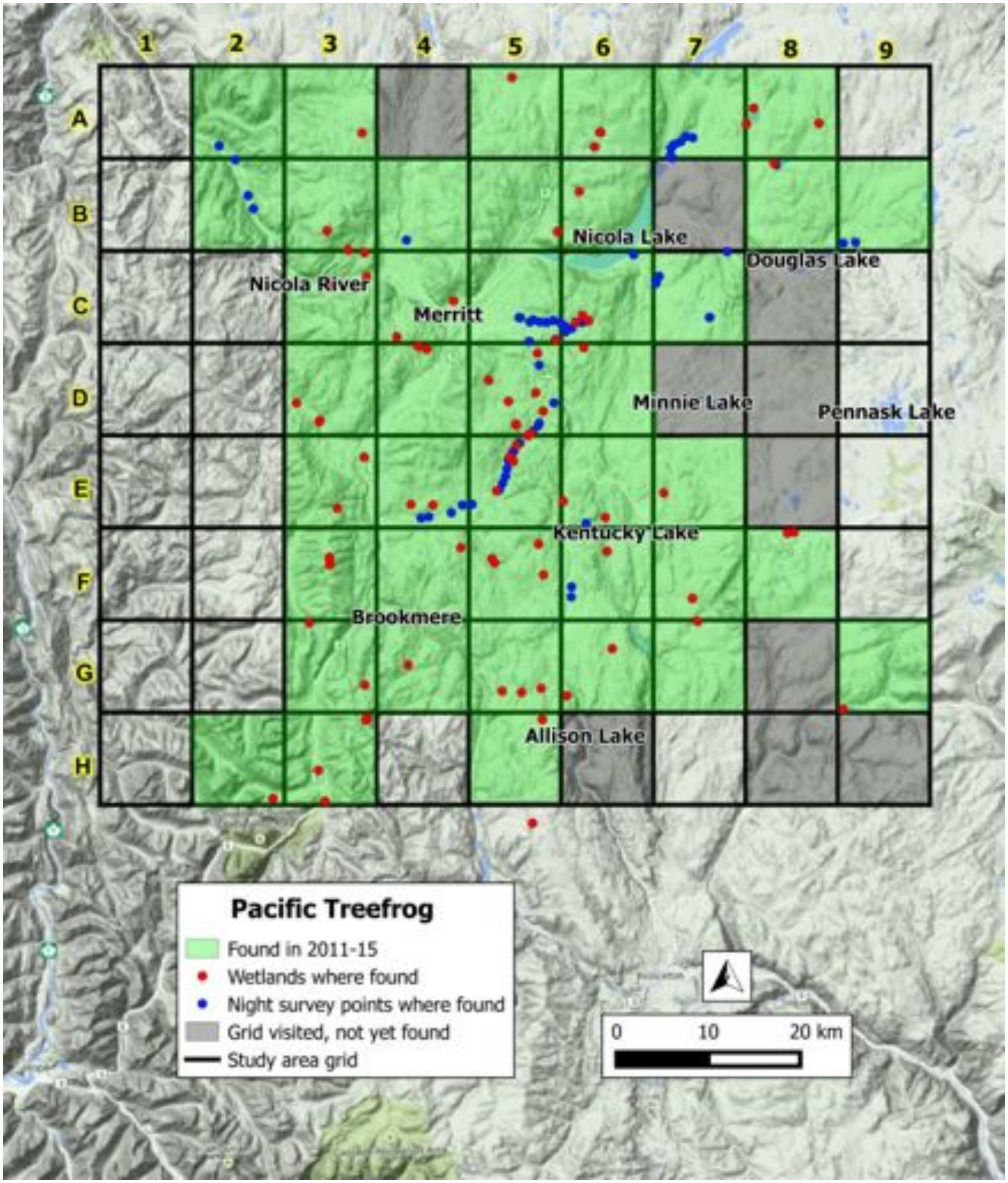


Figure 3. Distribution of the Western Toad, based on surveys from 2011 – 2015 in the Nicola area, based on surveys from 2011 – 2015 in the Nicola area, showing grid cells, wetlands (red symbols), and night survey points (purple symbols) where the species was found.

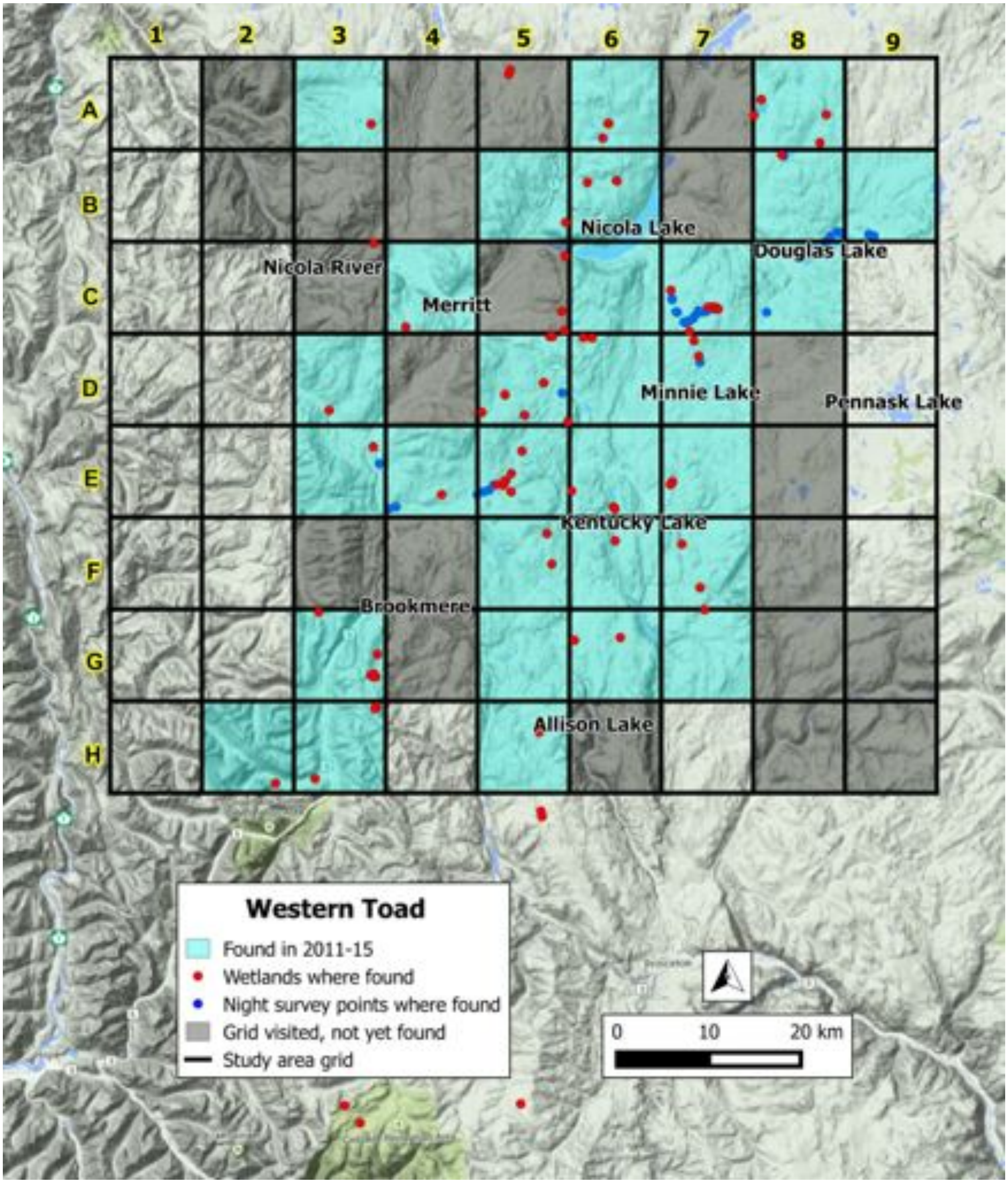


Figure 4. Distribution of the Columbia Spotted Frog, based on surveys from 2011 – 2015 in the Nicola area, showing grid cells, wetlands (red symbols), and night survey points (purple symbols) where the species was found.

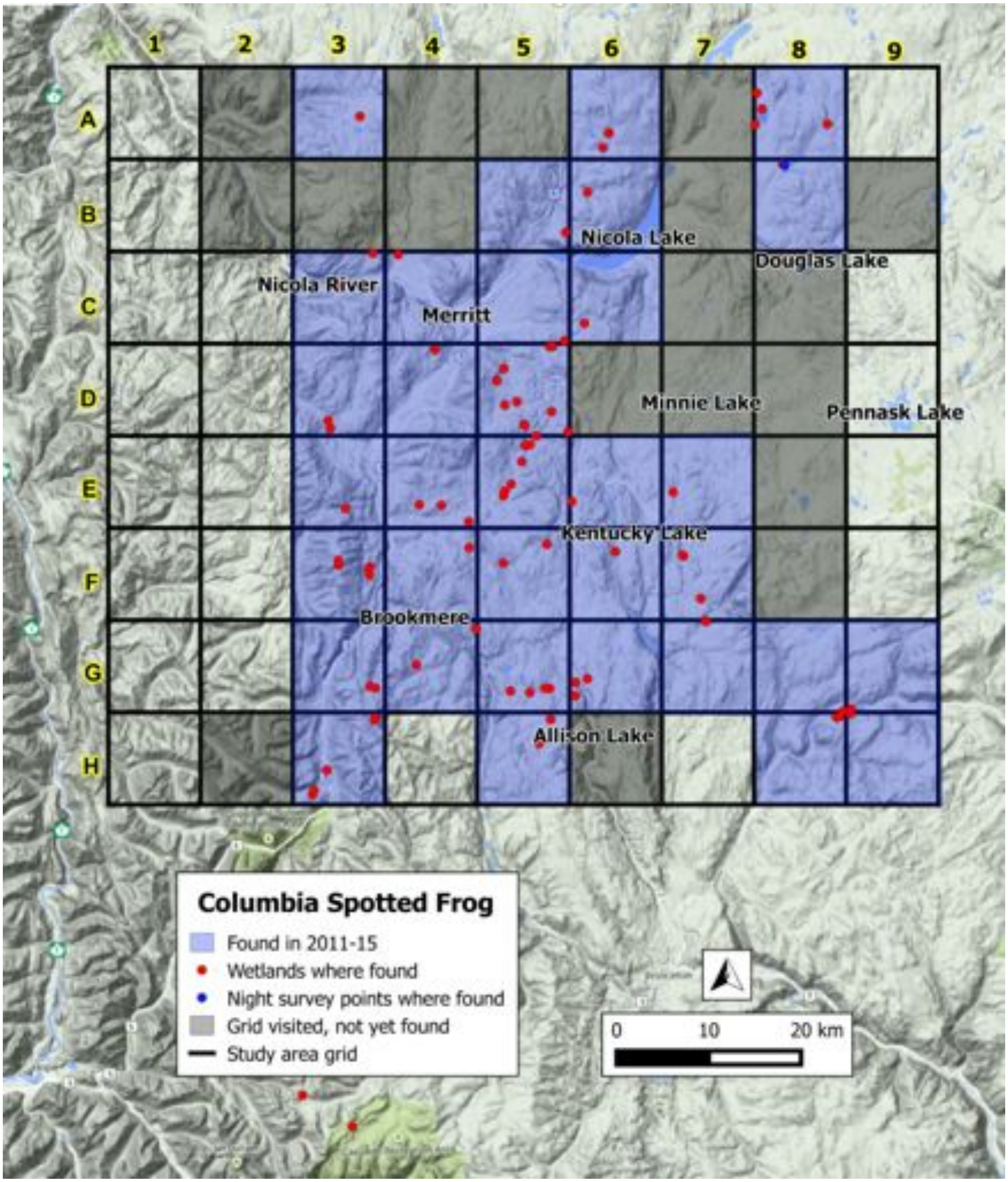


Figure 5. Distribution of the Great Basin Spadefoot, based on surveys from 2011 – 2015 in the Nicola area showing grid cells, wetlands (red symbols), and night survey points (purple symbols) where the species was found.

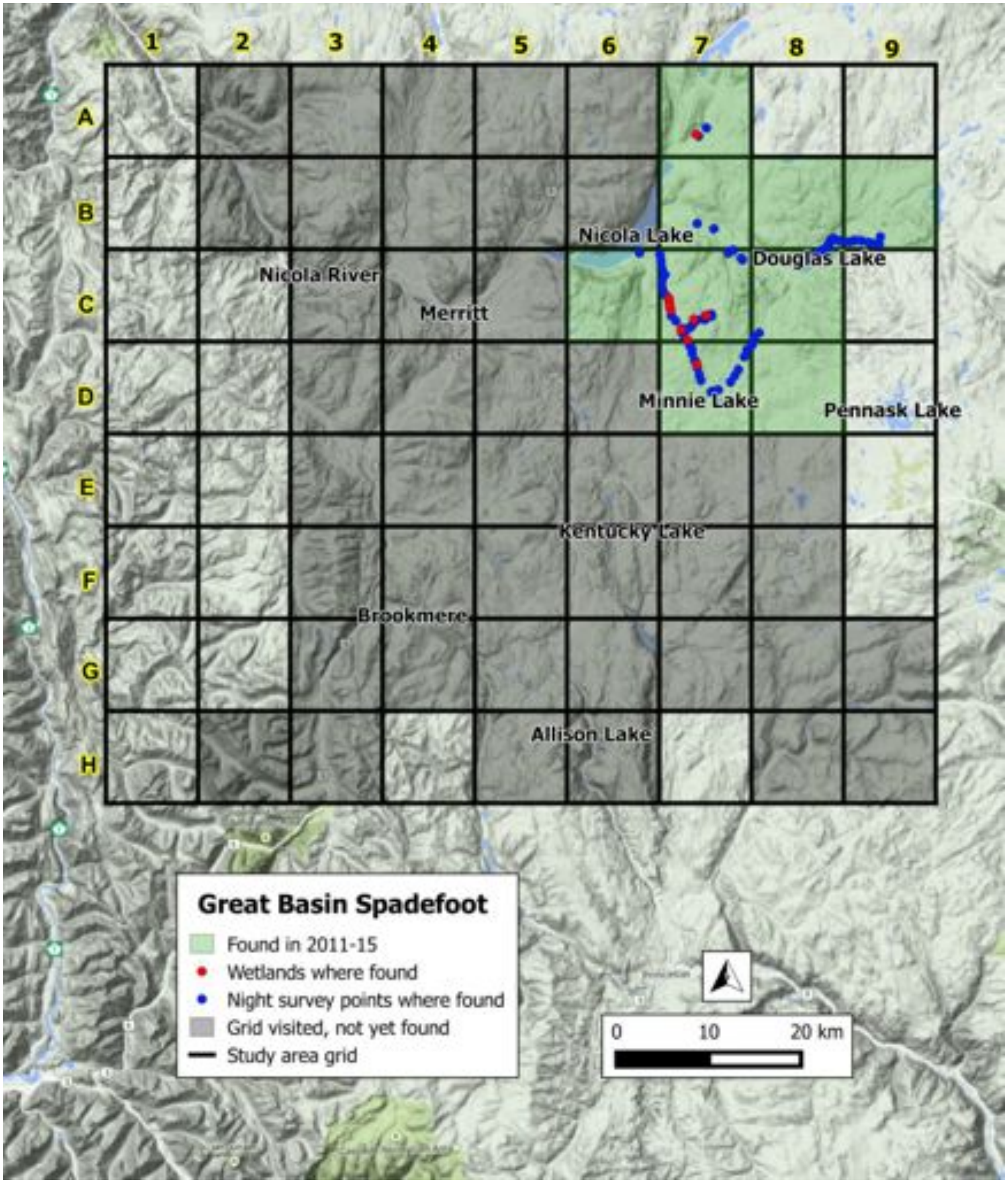


Figure 6. Distribution of the Long-toed Salamander, based on surveys from 2011 – 2014 in the Nicola area showing grid cells, wetlands (red symbols), and night survey points (purple symbols) where the species was found.

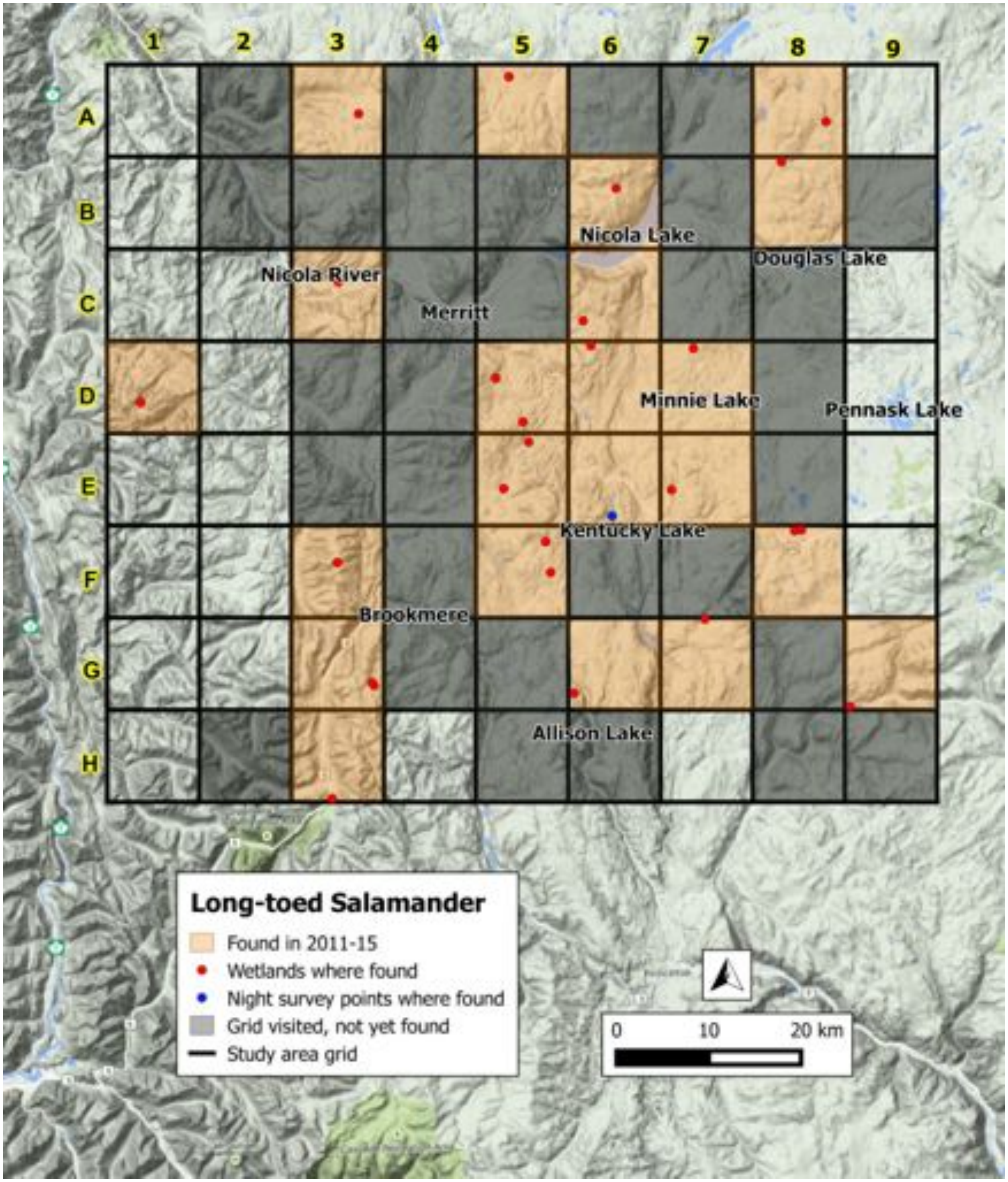


Figure 7. Proportion of 10 x 10 km grid cells surveyed with detections of amphibian species in the Nicola area, 2011 – 2015.

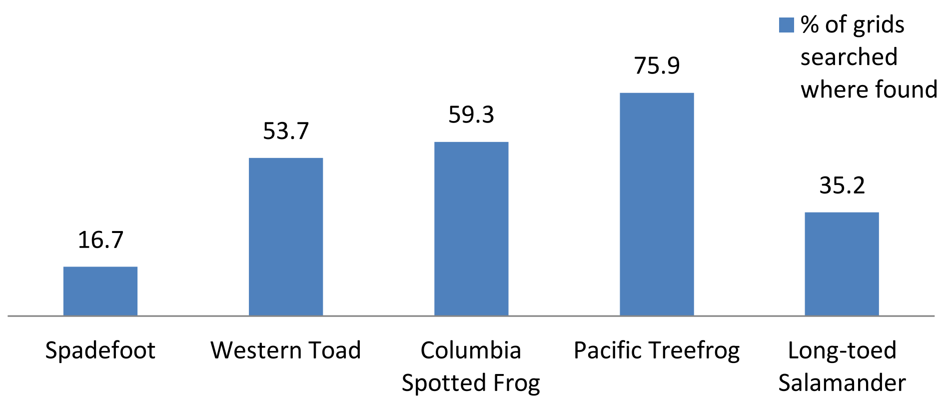


Figure 8. Number of new 10x10 km grid cells where amphibian species were found by year in 2011 - 2015 in the Nicola area.

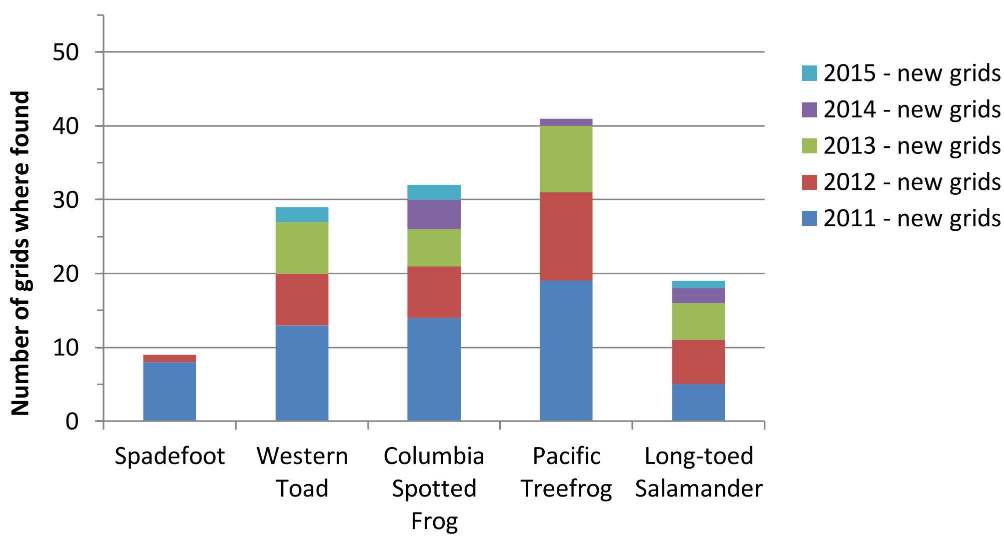


Table 2. Number of water bodies where particular species were found for the first time, based on wetland surveys in 2011 -2015. Repeat detections in subsequent years and night survey observations are not shown. See Appendix 1 for a list of water bodies.

Year	Western Toad	Columbia Spotted Frog	Pacific Treefrog	Great Basin Spadefoot^	Long-toed Salamander
2011	14	25	17	6	5
2012	27	28	30	2	9
2013	21	15	19	0	6
2014	16	14	14	1	5
2015	6	2	2	0	1
Total	84	84	82	9	26

^Additional observation were obtained through call surveys, are not included here.

3.2 Identification of Breeding Sites

Pond-breeding amphibians often breed communally in large numbers in suitable shallow wetlands that may be used traditionally over many generations. It is important to identify and document such sites so that they can be protected from disturbances. We identified amphibian breeding sites based on observations of pairs in amplexus[1], egg masses, or tadpoles/larvae during visual encounter surveys of wetlands and through night-time frog call surveys. Additionally, we deployed funnel traps at four sites within the Kane Valley sites in 2011, 2012 to detect tadpoles and salamander larvae.

From 2011 - 2015, we confirmed breeding at numerous sites for all five focal species (see Table 3 for a summary). Figure 9 shows examples of habitat at breeding sites within the study area. Great Basin Spadefoots were located mostly through call surveys from roads (see Section 3.4), and often it was not possible to pinpoint the exact source of the calls (and breeding sites), especially on private lands where we did not have permit to access. Only water bodies that could be accessed directly are shown in Table 3.

Table 3. Number of water bodies where breeding by different species of amphibians was detected for the first time based on wetland surveys, 2011 - 2015. Sub-sites and repeat detections in subsequent years are not shown.

Year	Western Toad	Columbia Spotted Frog	Pacific Treefrog*	Great Basin Spadefoot^	Long-toed Salamander
2011	11	9	14	6	3
2012	17	18	18	2	7
2013	18	9	12	0	4
2014	12	5	7	1	3
2015	**5**	4	1	0	0
Total	63	45	52	9	17

^Additional breeding observation were obtained through call surveys, are not included here (see Section 3.4).

[1] The copulatory embrace of frogs and toads, during which the male fertilizes the eggs.

Figure 9. Examples of breeding habitat of the five focal species in the Nicola area.

Western Toad breeding site, Harrison Lake, July 2015. Large concentrations of toads were found here each year from 2011 – 2015.

Western Toad breeding site, Kentucky-Alleyne Provincial Park, May 2012. Large concentrations of toads were found here each year from 2011 – 2015.

Columbia Spotted Frog breeding site, Beaver Pond by Harmon Trail, May 2014. Numerous egg masses and juveniles were found in the shallows along the marshy shoreline.

Long-toed Salamander and Pacific Treefrog breeding site, Creighton Lake, May 2013. Numerous egg masses of both species were observed here hugging the fringe of the marshy shoreline.

Great Basin Spadefoot breeding site, natural wetland on Pennask Lake Road, July 2015. Large concentrations of breeding adults and tadpoles were observed here in spring 2011. The pond was dry in 2012, and breeding activity was not observed again until spring 2014.

Great Basin Spadefoot breeding site, Beaver Flats, July 2011. Tadpoles were found here in July 2011, and sporadic calling was heard in subsequent years.

Western Toad –The toads breed communally often in large numbers, and the large aggregations of tadpoles and emerging toadlets are highly visible seasonally to even casual observers. Following tips from residents proved to be effective for locating communal breeding sites of this species. From 2011 – 2015, we identified a total of 63 breeding sites of Western Toads across the study area. At 31 of these sites, we observed major aggregations (often with tens of thousands of tadpoles) (Figure 10). Breeding sites were most frequently in ponds (53% of sites) and lakes (40% of sites) but were occasionally in flooded fields and a ditch (7% of sites). In total, 73% of the sites were in permanent, 15% in semi-permanent, and 12% in ephemeral water. Typically, the breeding sites were in very shallow areas of ponds or lakes with or without emerging vegetation and often with sandy or clay bottom; mats of green algae were usually present, and the tadpoles were observed feeding on these mats. At one site monitored in detail (Harrison Lake), the toads were concentrated in small, specific areas for egg-laying, which later examination revealed as the shallowest (and hence warmest) portions of the lake and had a southerly exposure. We observed amplexing pairs or egg masses from late April - to late May and tadpoles from May – August. Toadlet emergence occurred from late July to August, exact timing varying among years and sites.

Columbia Spotted Frog – This species often breeds communally and very early in the season, sometimes when the water body is still partially covered with ice (Matsuda *et al*. 2006). Females often lay their eggs in close proximity and on top of each other, resulting in large clumps of egg masses with multiple clutches. From 2011 – 2015, we identified 45 breeding sites of this species, including 20 sites with large breeding aggregations (Figure 11). Breeding sites were most commonly in shallow, vegetated margins of lakes (55%) or ponds (41%) and infrequently (4%) in flooded fields or ditches. Most sites (87%) were in permanent water, but small proportions were in semi-permanent (9%) and ephemeral (4%) water. The earliest date when egg masses of this species were detected was 21 April in 2015, but only sporadic surveys were conducted in April to optimize survey timing for multiple species. We encountered mating aggregations, including courting pairs and groups of calling males, on three occasions, on 12 and 14 May 2012 and 10 May 2015. The use of shallow margins of lakes and ponds for egg-laying increases the vulnerability of egg masses to water level fluctuations. We observed stranded egg masses on two occasions at Dodd's Lake (on 13 May 2012 and 6 May 2015) and at Shrimpton Lake (on 5 May 2015) , probably as a result of drought. Tadpoles were generally found from May – July, dispersed across ponds or in shallow, weedy areas near the shoreline of larger water bodies. Metamorphosis probably occurred by August. Timing of events was delayed at high elevation sites: egg masses were found at an alpine lake (Jacobson Lake, 1472 m asl) southeast of the study area, on 7 July 2011, and tadpoles had not metamorphosed when found in two sub-alpine ponds within the study area (~1900 m asl; Thynne Mountain) on 16 August 2012.

Figure 10. Communal breeding sites of the Western Toad detected in 2011 – 2015 in the Nicola area.

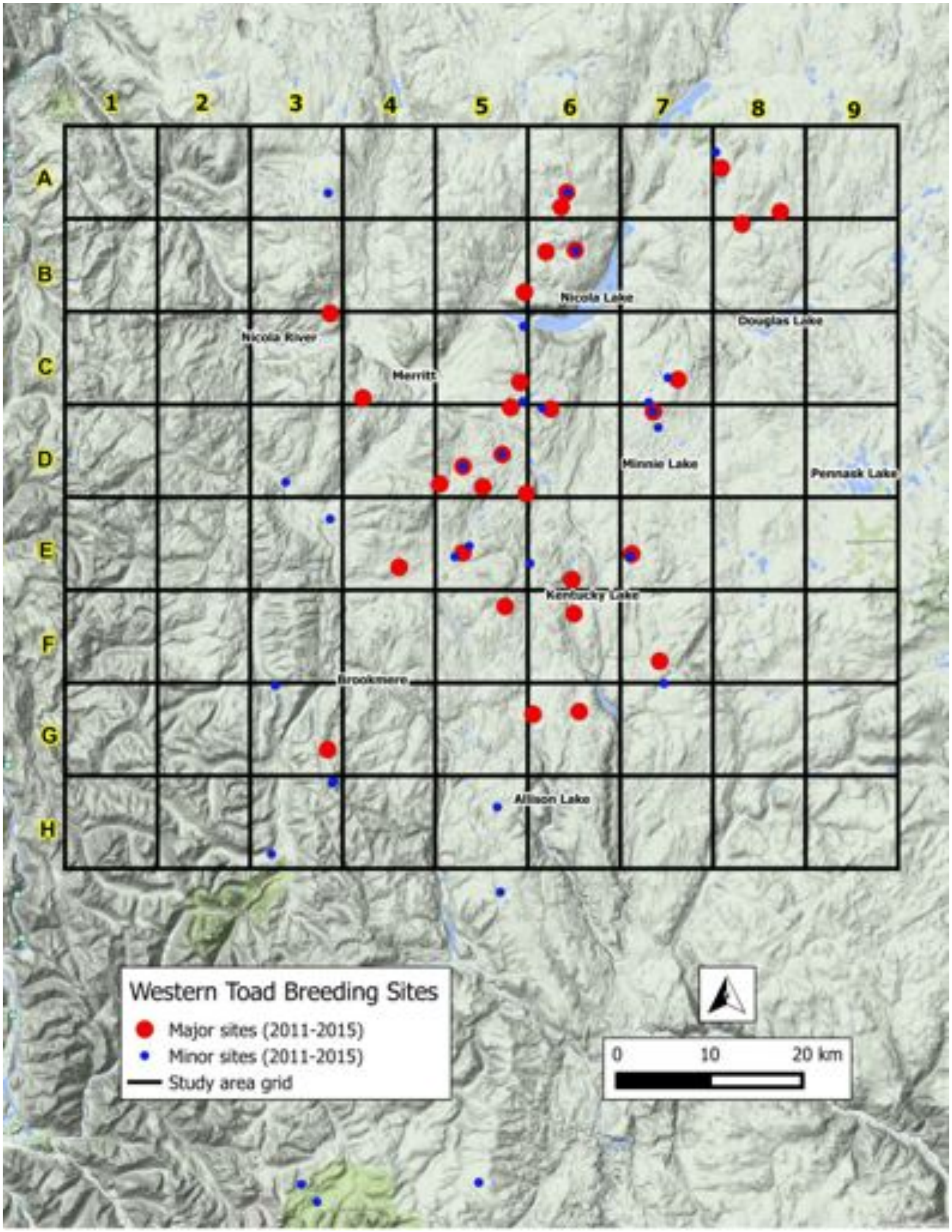
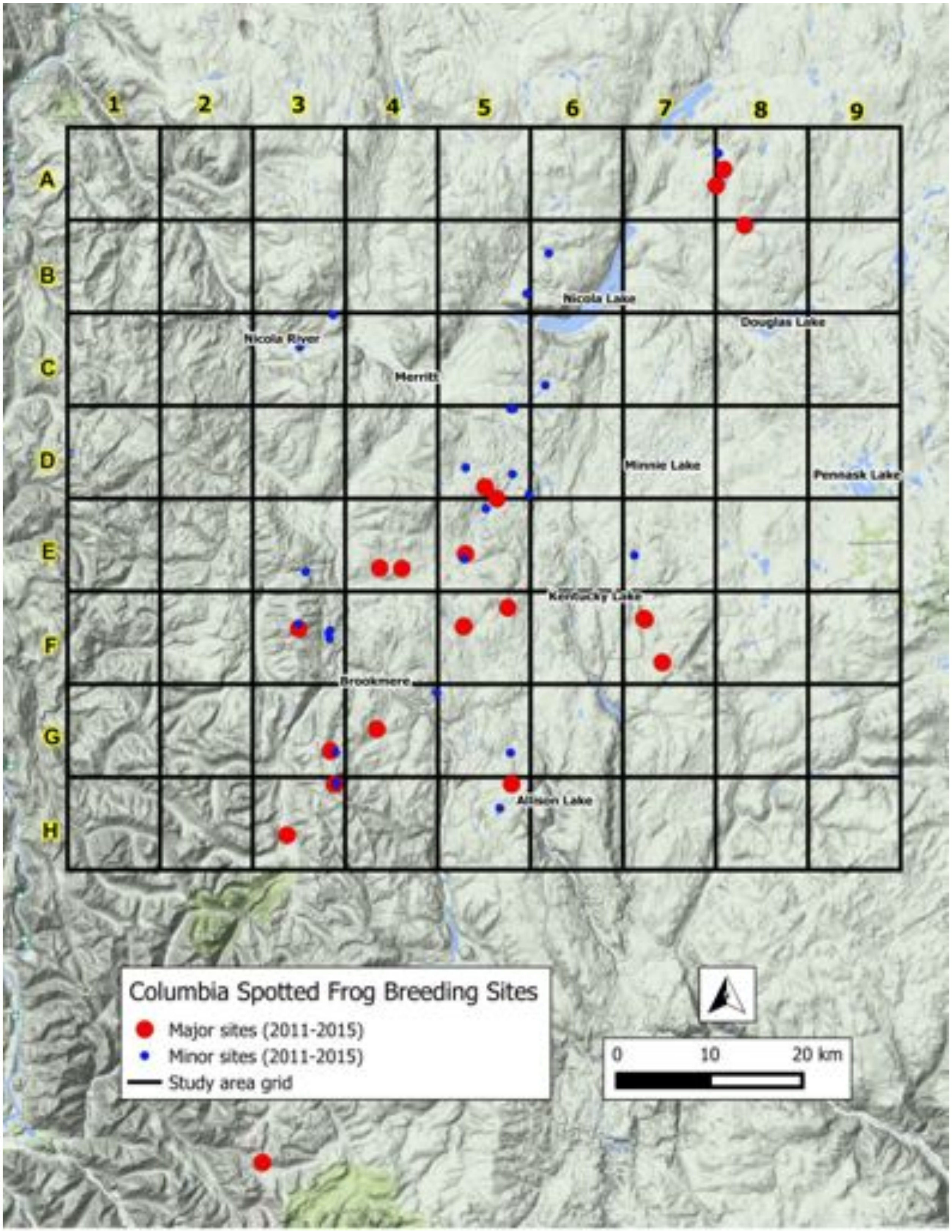


Figure 11. Communal breeding sites of the Columbia Spotted Frog detected in 2011 – 2015 in the Nicola area.



Great Basin Spadefoot – This species breeds both in ephemeral wetlands and permanent water bodies (Matsuda et al. 2006). It has an ability to develop very fast from the egg stage to metamorphosis and is hence capable of exploiting ephemeral water bodies, which may not be available each year, within its arid, grassland habitats (COSEWIC 2007). We were able to confirm breeding in nine accessible wetlands (two of which had sub-sites) (Table 3) but additionally located this species through night-time frog call surveys along roads (see Section 3.4 for details). Road surveys detected a number of other localities where the species was breeding, but the exact water bodies could often not be determined due to access limitations. All sites were in grasslands within the Upper Nicola drainage. Most breeding sites were in upland ponds (6 sites), including natural wetlands in depressions that may have been deepened somewhat for cattle use; two were in small cattle watering dug-outs, and one was in extensive sheet water (very shallow) at the periphery of a permanent pond in a flooded valley bottom. We observed calling males in May and June (amplexing pairs were observed on 14 May 2011), and tadpoles from June to early July; most observations were from 2011, which appeared to be a good year for reproduction by this species.

Pacific Treefrog – This species has a prolonged breeding season, often lasting several months, from mid-spring to early summer (Matsuda et al. 2006). It was widespread and abundant within the study area with 52 breeding sites detected during the wetland surveys, but breeding probably occurred at most if not all of the sites where the species was found; egg masses, in particular, are small and can be difficult to detect. This species was also detected during night-time frog call surveys (see Section 3.4). We found eggs masses from early May to mid-June and tadpoles from May to early August. Breeding sites included small ponds and ditches, as well as more permanent well-vegetated, shallow areas of larger water bodies.

Long-toed Salamander – Evidence of breeding (eggs or larvae) was found in 17 water bodies. We found eggs masses from mid-May to mid-June and larvae from May to early August. Breeding sites included small ponds, as well as more permanent well-vegetated, shallow areas of larger water bodies. An example of use of ephemeral sites is Andy's Lake (Site 58), where larvae were found in deep vehicle ruts adjacent to the lake and in a small roadside pond. The best site was a lake (Creighton Lake; see Figure 9), where at least 70 egg masses were found on 3 June 2012 within about 200 m of stretch of the shoreline searched along the sedge fringe; this same area also contained numerous Pacific Treefrog egg masses.

3.3 Breeding Site Monitoring: Western Toad and Columbia Spotted Frog

Selected amphibian breeding sites were revisited to monitor their use across the years. The focus for volunteer efforts was mass breeding sites of the Western Toad, where breeding activity is detected relatively readily, but Columbia Frog breeding sites were also revisited, usually during biologist-led outings. Some of the sites were used by both species.

Volunteers were provided a prioritized list of previously identified breeding sites and encouraged to visit them preferably at least twice during the field season: during the breeding period in spring and during the migration period when metamorphosed juveniles move away from wetlands in late summer; searches for aggregations of tadpoles in summer were also conducted at some sites but were considered of lower priority. Volunteers recorded areas of shoreline where amphibians were observed, and counted animals; only crude categorization of relative abundance was possible for juveniles (e.g., 10s, 100s, 1000s, 10,000s of animals in different life stages seen). A photographic record of the habitat sites was kept to help monitoring habitat trends. Specific photo points were established in 2014 and 2015 at amphibian breeding sites.

From 2011 – 2015, a total of 23 breeding sites of the Western Toad and 22 of the Columbia Spotted Frog were visited multiple times and during more than one year (Table 4). Ten breeding sites of the Western Toad and eight of the Columbia Spotted Frog were visited in 4 – 5 years; all these sites were considered major breeding sites for the two species. Both species were found repeatedly using monitoring sites visited, and in many cases breeding was observed in all years when a site was visited. The lack of breeding observations in particular years may have been due to detectability and timing of surveys in relation to breeding activities that varied across the years. However, a few cases were related to habitat alteration, including drop in water level from drought or disturbance (see Figure 12 for examples).

Table 4. Frequency of breeding observations across years at breeding sites of the Western Toad and Columbia Spotted Frog, 2011 – 2015. Multiple surveys/year/site were carried out at most sites (not shown).

Western Toad:

# of years with visits	# of sites with breeding in 5 years	# of sites with breeding in 4 years	# of sites with breeding in 3 years	# of sites with breeding in 2 years	# of sites with breeding in 1 year
5	4	1	0	0	0
4	na	1	2	1	1
3	na	na	3	2	1
2	na	na	na	2	5
1	na	na	na	na	40
Total	4	2	5	5	47

Columbia Spotted Frog :

# of years with visits	# of sites with breeding in 5 years	# of sites with breeding in 4 years	# of sites with breeding in 3 years	# of sites with breeding in 2 years	# of sites with breeding in 1 year
5	1	0	1	1	1
4	na	0	2	0	1
3	na	na	2	5	1
2	na	na	na	2	5
1	na	na	na	na	23
Total	1	0	5	8	31

In spring 2013, one of the communal breeding sites of the Western Toad monitored as part of this project in Kane Valley was inadvertently disturbed, when an old dam was removed. The toads bred in the shallow margins of the wetland, which were drained as a result of water level drop. No breeding was observed at this previously productive site in 2013. However, by 2014, the site had recovered somewhat with shallows areas and growth of vegetation developing along the new retreated shoreline, and breeding by Western Toads had resumed. Due to the very soft mud, it was not possible to access the shallows to investigate abundance and length of shore occupied by the species.

At another site in Kane Valley, Western Toads bred and produced large numbers of metamorphs at an ephemeral wetland in a flooded field in 2012, 2013, and 2014. However, in 2015, the site was dry, possibly due to a combination of drought and disturbance by cattle and vehicles, and the breeding habitat was lost.

Substantial water level fluctuations were observed at Dodd's Lake, surveyed in 2012, 2014, and 2015, a major breeding site for both the Western Toad and Columbia Spotted Frog. In May 2015, the water level was very low, exposing emergent vegetation, and the lake had shrunk to about half of what it was during visits in previous years. Low snow pack and warm, dry spring weather probably contributed to the water level drop. A rapid drop in water level in spring had left many Columbia Spotted Frog egg masses stranded on dry land with no chances of survival. Similarly, we observed drying egg masses at this site in May 2012, suggesting that early breeding in very shallow waters is a gamble at sites such as this one subject to large water level fluctuations.

Figure 12. Examples of habitat change at Western Toad and Columbia Spotted Frog breeding sites, 2011 - 2015.

Western Toad breeding site in Kane Valley, 5 July 2011.

Disturbance to the shoreline and breeding habitat in Kane Valley associated with removal of an old dam structure, 24 May 2013.

Pond in flooded field in Kane Valley, 10 May 2014; breeding site of Western Toads.

The same pond in flooded field in Kane Valley, 5 May 2015. The pond was dry with vehicle ruts.

Dodd's Lake, 13 May 2012; breeding site of Western Toads and Columbia Spotted Frogs.

Dodd's Lake, 6 May 2015, showing very low water level. Several stranded egg masses of the Columbia Spotted Frog were found.

3.4 Night Surveys and Spadefoot Monitoring

Call surveys were the most effective method for locating Great Basin Spadefoots and allowed us to map distributions from public roads on lands with restricted access, but some accessible wetland sites were also surveyed visually. The Pacific Chorus Frog was also readily detected during call surveys. Both of these species have loud advertisement calls. The soft encounter calls of the Western Toad may also be heard when not masked by the other two species and only at very short distances. The main challenge was recruiting dedicated volunteers, because of constraints; the surveys must be carried out after dark under suitable, wet conditions at appropriate times of the year, and the routes were in remote locations.

Night surveys included standard frog call surveys along pre-determined routes (each with 10 listening stations 800 m apart and listening time 5 min/post; NAAMP, undated), wetland-based call surveys where the listening posts were at points where the road was close to wetlands (NAAMP, undated), reconnaissance level call points on roads by ponds, walks along trails, and opportunistic observations of amphibians on roads while travelling to and from call routes. Figure 1 shows the areas where night-surveys were conducted.

In total, night surveys resulted in the detection of amphibians on 303 occasions, representing 187 call point observations and 116 visual observations (Table 5). The Pacific Treefrog was heard from a total of 69 call points. In the Upper Nicola, it was heard from water bodies within forest patches or wooded riparian areas rather than from open grassland ponds. This species was encountered only infrequently along the standard call routes established for the Great Basin Spadefoot in the Upper Nicola drainage (3 records each from the Pennask Lake Road and Douglas Lake Road call routes). The Western Toad was sighted frequently on roads and trails surveyed at night; 66 visual observations were made, represented 176 individuals (89 adults and 87 juveniles).

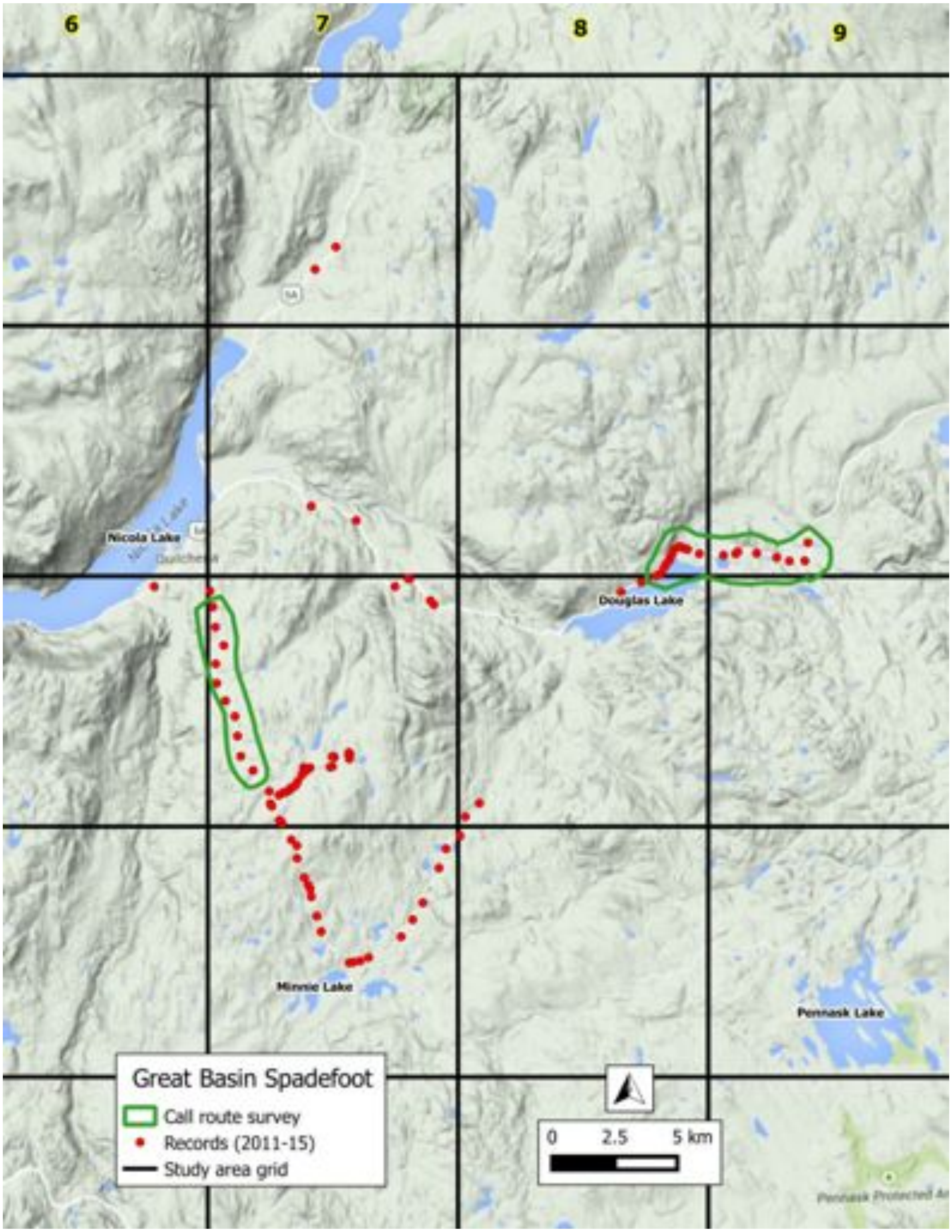
Table 5. Summary of number of occurrences during night survey observations, including standard frog call routes and reconnaissance surveys, 2011 - 2015. Visual observations represent one or more individuals.

Observation type	Great Basin Spadefoot	Pacific Treefrog	Western Toad	Columbia Spotted Frog	Long-toed Salamander
Call points on standard routes	91	53	0	0	na
Call points on reconnaissance surveys	26	16	1	0	na
Visual observations (on roads or trails)	48	0	66	1	1
Total	165	69	67	1	1

The Great Basin Spadefoot was detected both at call points and visually on roads or trails (117 and 48 times, respectively), all within the Upper Nicola drainage (Figure 13; see maps in Figures 2 – 6 for night survey localities for other species). Intensive surveys were carried out in 2013 within Hamilton Commonage where a provincial Wildlife Habitat Area exists for the species (Ovaska *et al*. 2013b). The visual observations represented 116 individuals (35 adults and 81 juveniles). Interesting, second-year young (young of previous year) were encountered on a dirt track during wet nights at Hamilton Commonage, up to approximately 300 m away from nearest pond. A relatively large number of second-year young (~35) were also found on the road surface along Douglas Lake Road just east of Douglas Lake on 4 June 2012; several adults were also found along this stretch of road in other years.

Two standard call survey transects, along Pennask Lake Road and Douglas Lake Road in Upper Nicola grasslands were surveyed multiple times each year since 2011. Additional standard routes in the Upper Nicola area were discontinued either due to roughness of the road that restricted access in wet conditions or lack of sustained volunteer commitment. Routes in areas other than the Upper Nicola were surveyed once, focusing on potential grassland/open woodland habitat for the Great Basin Spadefoot, but were discontinued when the species was not found under conditions deemed optimal.

Figure 13. Observations of the Great Basin Spadefoot, located through wetland and call route surveys in Upper Nicola drainage, 2011- 2015. Two call routes surveyed multiple times each year are circled.



Green polygons indicate the location of two frog call survey routes surveyed multiple times each year. Note that repeated observations at the same site are stacked and obscured.

On the Pennask Lake Road route, there was no clear trend among the five years in the maximum number of stations where calling was heard each year; nor were there any trends in the number of stations where calling was heard from "near" (within ~400 m) or from "far" (>~400 m) (Figure 14). However, there was a slight declining trend across the years in the number of stations with a full chorus. On the Douglas Road route, there was a declining trend from 2013 to 2015 in the total number of stations with calling and the number of stations where calling was from "near". The number of stations with a full chorus was the highest in 2011 along both transects.

The data show that spadefoots continued to breed in wetlands along both routes during each of the five years but that the frequency of both the maximum number of points where calls were heard and the intensity of the chorus varied greatly among years, possibly in response to fluctuating water levels in ephemeral breeding sites and weather conditions during the breeding period.

Along the Pennask Lake Road transect, one of the best Spadefoot breeding sites in 2011 in a natural wetland was dry both in spring 2012 and 2013, hence producing no recruits (Site 31 in Table 6). The pond contained water in spring 2014, but only a single male was heard calling there during multiple visits, and no calling was observed there in 2015, although the site again contained water. Similarly, at other wetlands that could be accessed and surveyed visually, we observed intermittent breeding among years (Table 6). While Spadefoots are adapted to unpredictable rainfall and availability of breeding opportunities, prolonged multi-year droughts during the spring – early summer breeding period and associated lower water tables would threaten viability of populations.

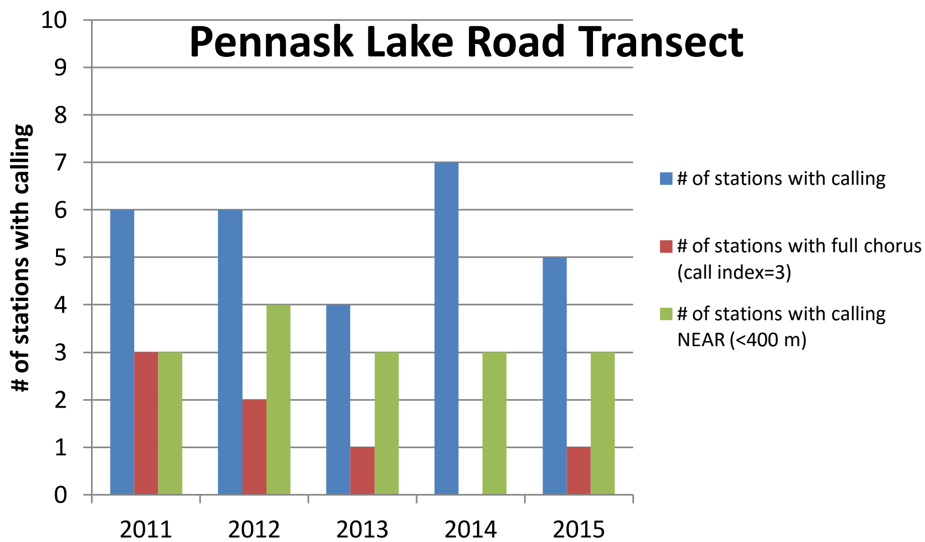
Table 6. Summary of Great Basin Spadefoot breeding sites located through wetland surveys in the Upper Nicola drainage, 2011 – 2015. Additional observations were made during frog call surveys.

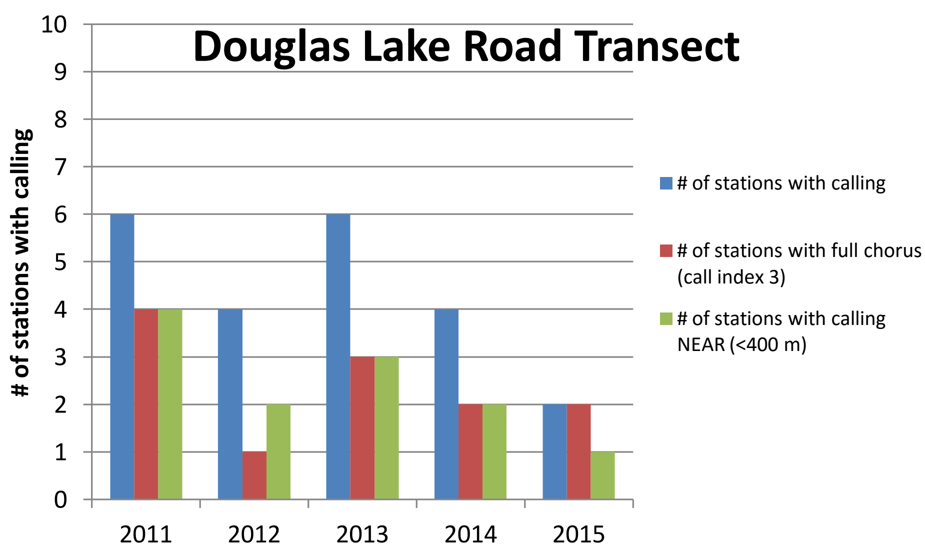
Site ID	Site name	Elev. (m)	Water body type	Water seasonality	# years with visits	# visits breeding observed 2011	# visits breeding observed 2012	# visits breeding observed 2013	# visits breeding observed 2014	# visits breeding observed 2015	# years with breeding obs.
157	Hamilton Commonage, Gate Pond		pond	permanent	2		2		0		1
166	Pennask Lake Rd (pond at 13 -14 km)	1158	pond	semi-permanent	1				2		1
169	Pennask Lake Road, pond near Minnie Lake		pond	unknown	1	1					1
30	Pennask Lake Road (cattle dugout 1)	997	pond	permanent	3	4	0		0	0	1
31	Pennask Lake Road (natural wetland 1)	1059	pond	ephemeral	5	4	0	0	1	0	2
46	Pennask Lake Road (cattle dugout 2)	1032	dugout	semi-permanent	1	1					1
47	Pennask Lake Road (natural wetland 2)	1165	pond	semi-permanent	1	1					1
73_5	Hamilton Commonage, WHA Pond 5 (includes 3 sub-site ponds)	1193	pond	semi-permanent	1		1				1

Site ID	Site name	Elev. (m)	Water body type	Water seasonality	# years with visits	# visits breeding observed 2011	# visits breeding observed 2012	# visits breeding observed 2013	# visits breeding observed 2014	# visits breeding observed 2015	# years with breeding obs.
99	Beaver Flats, sheet water at north end	642	flooded valley bottom	ephemeral	2	1	0				1

Figure 14. Results of call surveys for the Great Basin Spadefoot along two routes surveyed repeatedly at night in the Upper Nicola drainage in 2011 – 2015.

Top of bars represents maximum values of 2 – 3 surveys per season.





3.4 Threats and Mitigation

3.4.1 Overview of threats and mitigation options

During surveys of wetlands, we recorded land uses and potential threats to amphibians, including the presence of livestock, logging activity, proximity to roads, housing developments, or recreational activities, modifications to the hydrology, and fish stocking. These potential threats were also recorded for amphibian breeding sites from 2011 – 2015 (Table 7). In 2011 and 2012, we took water samples from amphibian breeding sites for analysis of contaminants. In addition, we encouraged volunteers to report roadkills and record potential threats when checking amphibian breeding sites.

Table 7. Summary of potential threats to amphibian breeding sites, 2011-2015, as recorded during wetland surveys.

Potential threat	No. of sites	% of threats
Roads, paved	15	3.9
Roads, gravel	110	28.8
Ranching & cattle grazing	117	30.6
Recreation:		
Camping	30	7.9
Hiking & light recreational use	8	2.1
Boating	26	6.8
Fishing	15	3.9
ATV, mountain biking, or mud-bogging	5	1.3
Residential development	11	2.9
Logging	45	11.8

The most common potential threats were from free-range cattle and roads, each comprising ~30% of the threats, followed by recreational activities at 22% and logging at 12%. Many sites were also modified by dams, deepening of ponds, or beaver activity, not included in the summary as these modifications were often difficult to discern on site.

Free-range cattle are ubiquitous in the Nicola area, and cattle or their signs were frequently encountered at amphibian breeding sites throughout the study area. The effects of cattle on amphibian populations are largely unknown but are thought to be mostly negative through disturbance to breeding sites (Bull and Wales 2001). Adverse effects include contamination of breeding sites with dung, excessive disturbance to the shoreline vegetation and bottom substrate, and direct mortality of embryos, tadpoles, or metamorphosed young through trampling, especially when amphibians are concentrated seasonally in the shallows or along the shoreline. While heavy grazing pressure is expected to be detrimental, light to moderate grazing may be beneficial in some situations by opening up heavily shaded shorelines and the introduction of nutrients (Bull and Wales 2001). Spadefoots bred in dug-outs excavated for cattle watering holes, as well as in natural wetlands. Such dug-outs may be beneficial as they relieve cattle damage of natural wetlands, especially in dry years. However, they could act as mortality sinks for Spadefoots that appear to use them readily as breeding sites. At the dug-outs used by Spadefoots, we often noted extreme trampling both in the pond and around the shoreline, erosion of banks, and very turbid water with algae and floating cow dung. Trampling by cows was also noted at Spadefoot breeding sites in natural wetlands (Figure 15).

Figure 15. Examples of disturbance at amphibian breeding sites.

Shoreline of a Spadefoot breeding site in grassland wetland trampled by cows, July 2015.

Cattle watering dug-out where Great Basin Spadefoots bred in 2011. Emergent vegetation was cut and the bottom substrate disturbed by cattle, reducing habitat suitability, July 2015.

Road intersecting wetlands at breeding sites of Western Toads and Columbia Spotted Frogs.

Vehicle ruts in an ephemeral Western Toad breeding site in Kane Valley, May 2015.

Recreational activities ranged from light use to intensive, high impact activities involving motorized, off-road vehicles. While light recreational activities such as hiking are unlikely to affect amphibians, off-road vehicle use along shorelines and in water (mud-bogging) destroys amphibian habitat and can result in direct mortality of eggs and young. Many lakes in the region are popular destinations for recreational activities and are stocked with sport fish. Predatory fish are a threat to the Columbia Spotted Frog and Pacific Treefrog in particular, while the Western Toad seems to be able to coexist with fish; however, stocked fish may transfer diseases to amphibians. Several of the sites have been dammed or are maintained by beaver activity. Removal of dams or culverts can cause sudden water level changes, which may either strand eggs or tadpoles, dislocate them, or obliterate shallows used by amphibians for breeding. Table 8Table 8 shows examples of priority sites with threats from various sources and suggestions for threat mitigation and monitoring.

Table 8. List of priority sites identified for potential threat mitigation.

Site name	Species	Threat	Problem area	Mitigation options	Monitoring needs	Priority
Harrison Lake, Kane Valley	Western Toad	Roadkill during migrations to and from breeding site	Kane Valley Road and Cantlon Road at Harrison Lake	Signage; underpass & fencing	Monitor for roadkill and travel routes of adults. Migration across roads by toadlets in late summer has been monitored for several years.	1
Douglas Lake Road, Upper Nicola	Great Basin Spadefoot	Roadkill during migrations; relatively large numbers of juveniles seen on road close to east end of Douglas Lake	Douglas Lake Rd at east end of Douglas Lake	Signage; underpass & fencing	Monitor for roadkill and delineate "hot spots" of roadkill and travel routes across roads	2
West Pond, Kentucky-Alleyne Provincial Park	Western Toad	Roadkill during migration of toadlets out of the West Pond breeding site	Park road to Kentucky Lake campsites	Signage in preparation; underpass & fencing already installed	Continued monitoring of condition and effectiveness of installed structures; camera monitoring at underpass entry for use by toads and possible problems. Annual inspection and maintenance of drift fences.	2
Glimpse Lake, Upper Nicola	Western Toad	Roadkill during migrations to and from the Glimpse Lake breeding sites	Boat launch and gravel road along NW shore of Glimpse Lake (Glimpse Lake/Lauder Road)	Signage; fencing/culvert may be required	Monitor for road crossing areas and roadkill	2
Peter Hope Lake	Western Toad	Roadkill during migrations to and from the Peter Hope Lake breeding sites	Boat launch, picnic area and gravel road along NE shore of Peter Hope Lake (Peter Hope Lake Rd)	Signage, temporary closure of picnic site	Monitor for road crossing areas and roadkill	2
Hamilton Commonage, Upper Nicola	Western Toad	Intensive cattle grazing and trampling of breeding ponds	Pond at east end of Wildlife Habitat Area #3-126 (Pond 1)	Alternate watering sites for cattle placed away from breeding ponds; fencing of wetland perimeter	Monitor Western Toad breeding areas and determine optimal location of mitigation structures	2
Hamilton Commonage, Upper Nicola	Great Basin Spadefoot	Intensive cattle grazing and trampling of breeding ponds	Pond within Wildlife Habitat Area #3-126 (Pond 2)	Alternate watering sites for cattle placed away from breeding ponds; fencing of wetland perimeter	Monitor Spadefoot breeding areas and determine optimal location of mitigation structures	1

Site name	Species	Threat	Problem area	Mitigation options	Monitoring needs	Priority
Hamilton Commonage, Upper Nicola	Great Basin Spadefoot	Intensive cattle grazing and trampling of breeding ponds	Pond just outside Wildlife Habitat Area #3-126 to the west ("Gate Pond")	Alternate watering sites for cattle placed away from breeding ponds; fencing of wetland perimeter or portion of thereof	Monitor Spadefoot breeding areas and determine optimal location of mitigation structures	1
Dry Lake, 10 km NW of Merritt	Western Toad	Land conversion (planned composting facility for biosolids)	Basin and associated ephemeral wetlands used by Western Toads for breeding	Relocation of proposed facility and protection of the basin and a terrestrial buffer from land conversion	Continued monitoring of Western Toad breeding activity at Dry Lake wetlands	1
Ponds 4.7 km, SW of Merritt off Midday Valley Rd	Pacific Treefrog; possibly also other amphibians	Recreational ATV and vehicle use in wetlands	Set of small ponds at the junction of Midday Valley Road and a gravel service road	Signage; enforcement of regulations	Monitor condition of wetlands	2
Beaver Flats Ranch Wetlands (Ducks Unlimited)	Great Basin Spadefoot	Water regulation	Potential for premature drying of shallow sheet water wetlands to the northeast of the Ducks Unlimited dam site	Working with Ducks Unlimited to ensure compatible scheduling of water release from dam	Monitor water levels and timing of breeding activity by Spadefoots	2

Amphibians are vulnerable to roadkill where roads intercept their seasonal migration routes to and from breeding sites, but such mortality is often undocumented, as amphibians usually travel at night and scavengers rapidly remove carcasses. Species that undertake mass migrations and move long distances, such as the Western Toad, are particularly vulnerable. Volunteers and residents were encouraged to report roadkills to identify possible problem areas. Five sites were identified as priorities for roadkill monitoring and mitigation (Table 7), and mitigation activities were undertaken in 2011 – 2015 in Kentucky-Alleyne Provincial Park as part of this project (see next section for a summary).

3.4.2 Roadkill mitigation at Kentucky-Alleyne Provincial Park

Kentucky Alleyne Provincial Park contains a communal breeding site of the Western Toad, a species listed as Special Concern in Canada and on Schedule 1 of the *Species At Risk Act*. Western toads are particularly vulnerable to disturbances and mortality when congregated at breeding sites and when migrating between breeding sites and foraging and overwintering areas on land. In Kentucky Alleyne Park, newly metamorphosed toadlets leave the breeding pond (referred to as West Pond) *en masse* in late summer (mid-July – early August), when the park receives heavy recreational use, and are vulnerable to roadkill on park roads. Spring migration of adults to the breeding site occurs in April – May when the campsites are still closed, and the park receives minimal visitor activity.

Together with Nicola Naturalist Society volunteers and with support from BC Parks, we engaged in roadkill mitigation for Western Toads in the park from 2011 – 2015. Activities in 2011 and 2012 consisted of documenting movement patterns and problem areas. In May 2013, BC Parks installed a wildlife underpass across a park road, and volunteers installed drift fences to direct toads to the underpass (Figure 16). With help from Nicola Naturalist Society volunteers, we monitored roadkill and the use of the underpass in 2013 and 2014. In 2014, we refined the design of the drift fences to make them longer-lasting and continued monitoring the effectiveness of the structures in reducing roadkill using a wildlife camera and transect surveys. In 2015, monitoring activities were transitioned to BC Parks personnel.

Both the time-lapse camera data and direct observations indicated that toadlets used the underpass extensively, and during the peak migration periods there was a steady stream of toadlets going through the tunnel. While the drift fences were effective in directing movements of toads towards the underpass, as indicated by transect counts along the fence line, some spillage onto the campsites and road occurred, especially around the east end of the fence closest to the pond (see maps in Figures 17 and 18 for examples of monitoring results). Separate reports, including management recommendations, were produced for BC Parks (Biolinx Environmental Research Ltd. and Nicola Naturalist Society 2012, 2013, 2014). These reports are available at Nicola Naturalist Society website (http://www.nicolanaturalists.ca/projects/amphibian-monitoring/).

Figure 16. Western Toad roadkill mitigation project at Kentucky-Alleyne Provincial Park.

Installation of an underpass for Western Toad roadkill mitigation across BC Parks road, May 2013.

The underpass with funnel leading to the entrance.

Drift fencing from the breeding pond towards the underpass.

Masses of toadlets leaving the breeding site

Toadlets moving along the fence.

Figure 17. Overview of migration movements and roadkill locations of Western Toads in Kentucky-Alleyne Provincial Park in 19 July – 5 August 2013. The numbers refer to counts from transect surveys unless otherwise noted.

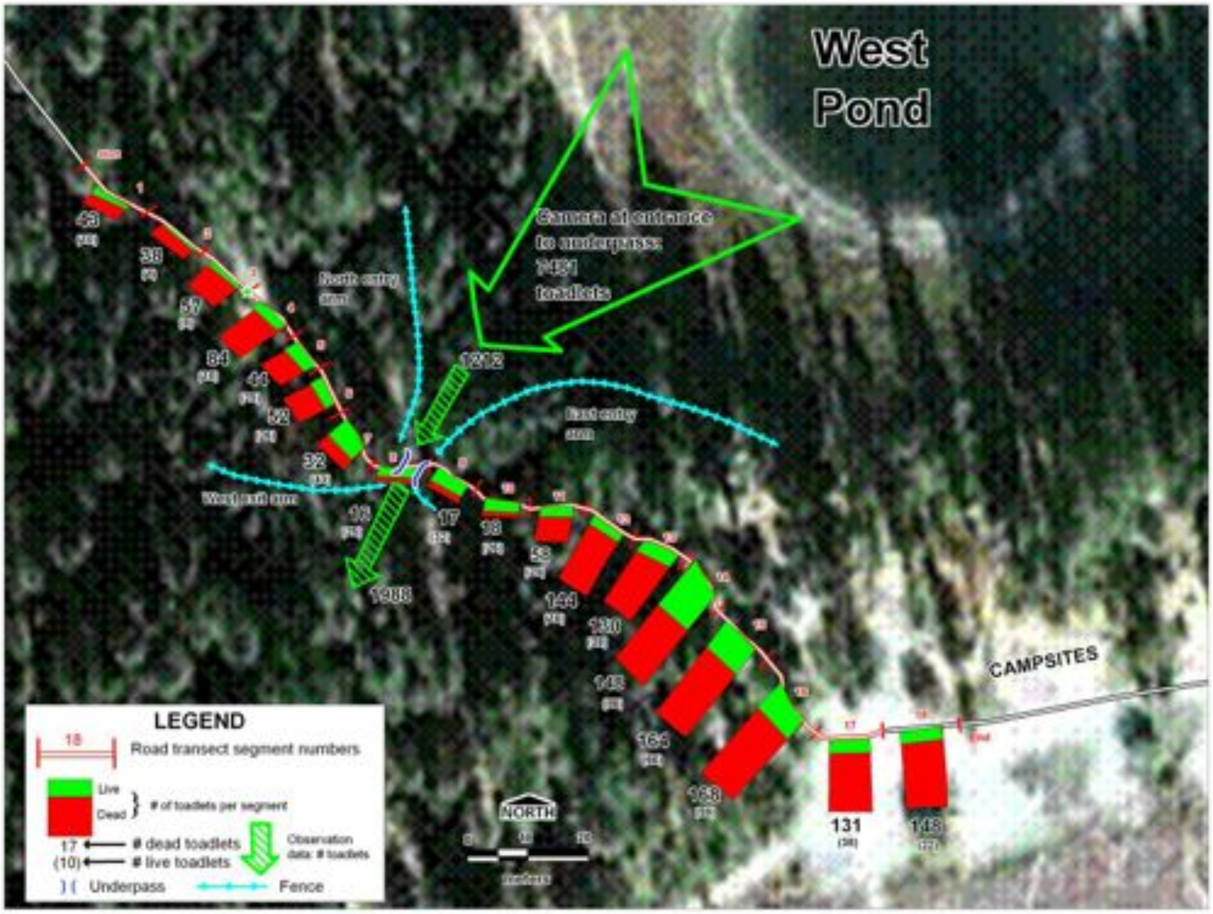
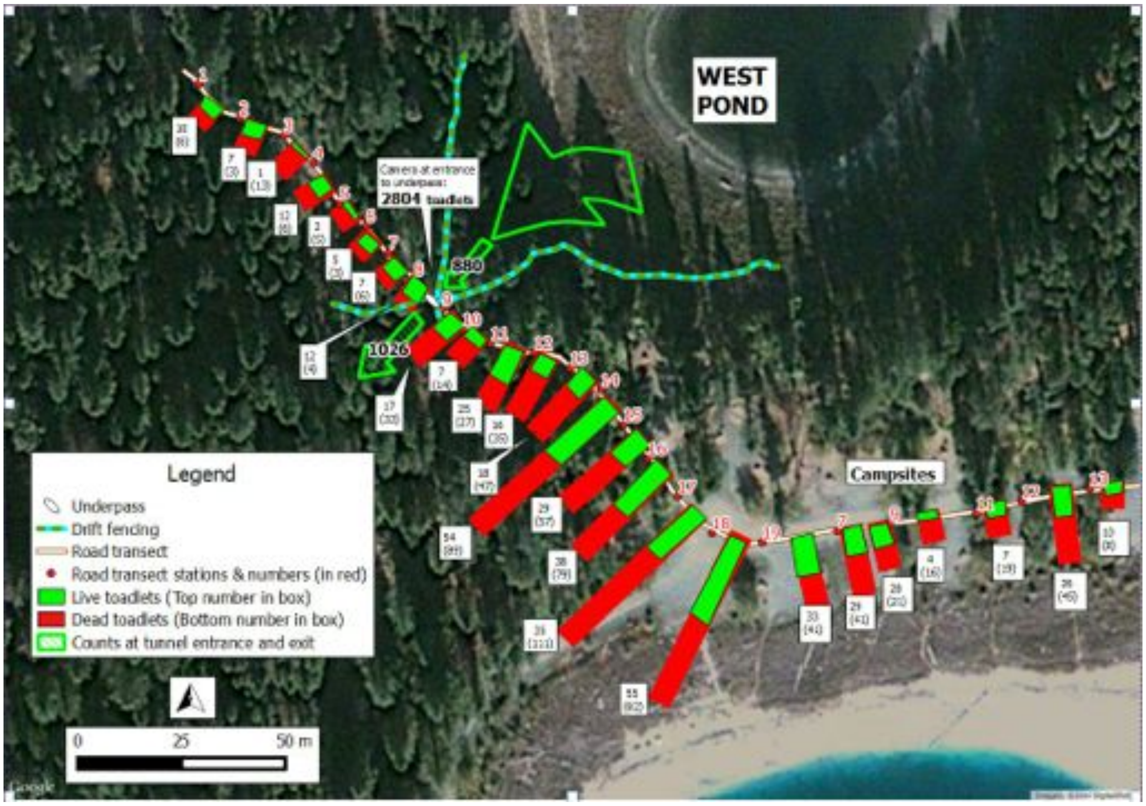


Figure 18. Location of dead and live toadlets based on road transect counts on Kentucky Campsite road in July - August 2014.



3.4.3 Water quality sampling

We conducted water quality sampling at amphibian breeding sites in 2011 and 2012. On 5 – 6 July 2011, we sampled water from areas where tadpoles were present in four Western Toad sites (pond in Kentucky Alleyne Provincial Park, Glimpse Lake, Peter Hope Lake, and Hills homestead pond in Kane Valley), two Columbia Spotted Frog sites (Davis Lake in Voght Valley, Harrison pond in Kane Valley), one site with both Western Toad and Columbia Spotted Frog (Harrison Lake in Kane Valley), and four Great Basin Spadefoot sites (all in the Upper Nicola, including two dug-outs). In 2012, the focus was on grassland ponds within the Hamilton Commonage in the Upper Nicola and on two woodland ponds in Kentucky-Alleyne Provincial Park. At the Hamilton Commonage, we sampled two ponds where only Spadefoots bred, two ponds where only Western Toads bred, one pond where both species bred, and five ponds where neither species bred. At Kentucky-Alleyne, we sampled two adjacent ponds, where Western Toads have consistently bred in only one of the ponds, but no breeding has been observed in the other pond. Water sampling in 2012 took place during two periods, 31 May – 1 June and 21 – 22 June.

We recorded ph and dissolved oxygen (DO) in the field with YSI Professional Plus® and YSI ProDO® instruments, respectively. We collected and stored water samples in glass jars that were kept in cool and dark conditions until analysis for contaminants. We used YSI 9500®

photometer to record water clarity (absorbance and transparency in comparison to clear deep well water) and deployed the reagent tablet system for nitrites, nitrates, and phosphates.

Amphibian breeding sites were alkaline (ph: 7.5 – 9.8), as is typical of water bodies in the area, with the highest ph values in the ponds in the Upper Nicola grasslands. As expected, DO varied greatly among sites and was very low in the small, shallow ponds with Spadefoot tadpoles. Grassland ponds in the Upper Nicola, including Spadefoot breeding sites, tended to have relatively high specific conductivity, indicating high concentration of dissolved salts, and low transparency, i.e., high absorbancy), reflecting amounts of dissolved organic matter. At the Hamilton Commonage, highest values for absorbance and lowest values of dissolved oxygen were in ponds with no amphibian breeding, but there was much variability. While turbid water may shield eggs and tadpoles from deleterious effects of solar UV, turbidity can also indicate eutrophication and excess nutrients. The clearest water (>97% transparency) was found at Columbia Spotted Frog breeding sites.

Nitrites and nitrates occur naturally in water bodies as a result of breakdown of organic matter, but anthropogenic sources from sewage and chemical fertilizers, and in the case of nitrates, from livestock dung, can elevate concentrations to levels that are toxic to amphibians and other aquatic life forms. While nitrites are more toxic to aquatic life than nitrates, they are rapidly converted to more stable and longer lived nitrates, which therefore provide a better measure of nitrogen pollution in water bodies (Rouse et al. 1999). Nitrate levels were very low in the woodland ponds and lakes examined but relatively high in two Spadefoot breeding sites in 2011 and in most grassland ponds in the Hamilton Commonage in 2012, reaching 11.5 mg/l NO_3 in one of the ponds (Pond 2A) where spadefoots bred. Values of 10 mg (USA federal maximum level for drinking water) or even lower have been found to have adverse effects on some freshwater invertebrates, fish, and amphibians (Camargo et al. 2005). However, there is much variability in tolerance among amphibian species (Ortiz et al. 2004). In contrast, both ponds sampled at Kentucky-Alleyne Park had clear water and low specific conductivity and very low nitrate concentrations. There were no obvious differences in water quality in the parameters measured between the two ponds, only one of which was a Western Toad breeding site. A summary of the water quality data collected in 2011 and 2012 are shown in Appendices 2 and 3 (see Ovaska et al. 2011, 2013a for further details and analyses).

4.0 STEWARDSHIP AND EDUCATION

This project was conducted collaboratively by the Nicola Naturalist Society and Biolinx Environmental Research Ltd. biologists. Nicola Naturalist Society personnel organized and coordinated volunteer activities and solicited new participants to the project through the society's website, local media, word-of-mouth, and personal communications. Volunteer contributions were significant, making this project possible. The total volunteer time was 1580 hours with the greatest efforts in 2013 and 2014, when extra help was needed to construct drift fences and monitor the effectiveness of Western Toad roadkill mitigation in Kentucky-Alleyne Provincial Park (Table 9). In addition to roadkill mitigation, volunteer activities included helping with wetland surveys, monitoring known breeding sites of Western Toads, and participating in frog call surveys to detect and monitor Great Basin Spadefoots. Training was provided to the participants in identification of amphibians, survey and monitoring methods, and assessing habitat quality and threats.

Table 9. Summary of volunteer effort, 2011 - 2015.

Year	No. of hours	No. of volunteers
2011	253	24
2012	334	22
2013	452	20
2014	426	28
2015	115	17
TOTAL	1580	

Outreach activities associated with the project in the local community and beyond included the following:

- Two workshops featuring the project were conducted in Merritt (on 18 May 2011 and 25 May 2013). Topics included introducing participants to the role of amphibians in wetland ecosystems, identification of local species, survey methodologies, and approaches to monitoring. Participant input was sought through a round table discussion. A field training session followed the presentations and discussions.
- Biologist-led surveys were conducted during multiple sessions each year from 2011 – 2015. Working with individuals and small groups in the field continued to be an effective approach to train volunteers and encourage participation.
- In June 2012, we collaborated with an Esh-kn-am First Nations group, conducting surveys, and providing training to a field crew in amphibian identification and survey methods, and discussing opportunities and approaches for coordinating efforts.
- The project was featured in the Spring BC Nature Camp (29 May – 1 June 2014) with 24 participants from various clubs across the province, hosted by Nicola Naturalist Society (http://www.nicolanaturalists.ca/2014/06/03/spring-camp-2014-nicola-naturalists-host-bc-nature-visitors/). During the "amphibian day", activities included presentations, visits to field sites, and a group discussion.
- We collaborated with BC Parks to implement roadkill mitigation of Western Toads in Kentucky-Alleyne Provincial Park. This project generated much interest and provided an opportunity to disseminate information to various groups and park visitors on threats facing amphibians and their mitigation. It has also served as a demonstration project for guided visits to land managers and community groups.
- Several guided outings were carried out by Nicola Naturalist Society to increase awareness of amphibians and their habitat protection needs by community members, land managers, educators, and students. These included guided tours on 8 May 2015 for 10 BC Parks rangers to the Western Toad monitoring and mitigation site at Kentucky-Alleyne Provincial Park, as part of their field training, and for three members of the Central Okanagan Land Trust to several amphibian breeding sites to learn methods for

finding, identifying and monitoring amphibians. They intend to apply similar methods to their conservation lands.

- Nicola Naturalist Society led guided visits with Merritt High School students on 13 June 2012 and 5 June 2013 and conducted an outing for local teachers and students, as part of the Royal BC Museum and City of Merritt Recreation Program on 28 July 2015.
- A description of the project and updates of activities, including photographs and video clips, are posted on the Nicola Naturalist Society website (http://www.nicolanaturalists.ca/category/projects/)
- The project was featured in conferences to disseminate information to the scientific community and land managers: CARCNET (Conservation of Amphibians and Reptiles Network) annual meeting, Thunder Bay, September 2011; BC Protected Areas Research Forum conference, Kamloops, 3 December 2013 (poster presentation); annual meeting of the Canadian Herpetological Society, Calgary, September 2014.
- The project was featured at Nicola Naturalist Society's booth at the Water Festival in Merritt on 4 June 2012.
- The project and plight of amphibians was highlighted in articles in local newspapers and BC Nature magazine, and in several CBC radio interviews, from 2011 – 2015. A Shaw TV broadcast of project activities was produced in 2011 (http://www.youtube.com/watch?v=IoLO3Ew7RGE).
- Results of the survey and monitoring activities were provided to BC Ministry of Environment for inclusion in the provincial SPI and BC FrogWatch databases. This will ensure that the data are available for regulators and land managers, as well as for other researchers.

A questionnaire was distributed to Nicola Naturalist Society participants to help direct volunteer activities (Appendix 4). Sixteen persons returned the questionnaire, all of whom had participated in field activities for this project (see Table 10 for summary). The results of the questionnaires confirmed our impression that organized activities led by biologists or other experienced "froggers" are needed. Suggestions from participants to improve the project included the following:

- Involve schools in the program
- Word-of-mouth is great for promoting interest
- Encourage and provide a way for forestry field crews working in the area to report incidental sightings
- Creating a fillable PDF form for an i-phone/tablet /i-Pad device would make data collection easier.

Table 10. Responses of volunteers to a questionnaire about project activities and training needs.

Questionnaire topic	Positive response
Confident in identifying following species:	
Western Toad	13
Columbia Spotted Frog	9
Pacific Treefrog	13
Great Basin Spadefoot	10
Long-toed Salamander	11
Additional training requirements:	
More training in field	8
ID pamphlets or hand-outs	5
Information on Nicola Naturalist Society website	5
Confirmation of identification from photos sent to biologists	10
Future participation in field activities:	
Guided surveys with biologists or experienced froggers	16
Surveys with a friend or partner	11
Independent surveys	9
Interest in leading field trips:	
Interest as trip leader with present knowledge	1
Interested if additional training was provided	5
Types of activities of interest:	
"Atlas" surveys (clarifying distribution across the landscape)	11
Western toad breeding sites monitoring	13
Frog call surveys for Great Basin Spadefoot	9
Reporting incidental observations	13

5.0 RECOMMENDATIONS

- Expanding "atlassing" of amphibian distributions to other areas of British Columbia should be explored, using the framework developed during this project and a centralized data storage and retrieval system.
- In the Nicola study area, re-surveys of the grids are recommended after ten years to examine changes in long-term distribution patterns.
- Continued monitoring of priority amphibian breeding sites and established frog call survey routes is desirable at an interval of 3 – 5 years.
- Volunteers can greatly increase the survey coverage for amphibians but must be trained in species identification and wetland survey methods. The number of volunteers can be increased by organizing regular outings led by a biologist or a trained trip leader.

- Wetland surveys during organized field trips are an excellent way to introduce people of all ages to the diversity of amphibians, the threats they face and wetland ecosystems in general.
- Adopting and making a cell phone application available to volunteers would increase volunteer participation and accurate documenting of incidental observations.
- Mitigation projects such as the one implemented at Kentucky-Alleyne Provincial Park can be very effective in reducing threats at amphibian breeding sites and can provide excellent public educational and outreach opportunities.

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Appendix 1. List of wetland survey sites and species found, 2011 - 2015. The values in the cells indicate the number of years when the species was found.
Note that number of survey years was variable and ranged from 1 - 5 per site. Sites with pink highlight had one or more sub-sites (not shown).
UTM-Zone 10, NAD 83
ANBO – *Anaxyrus boreas* (Western Toad), RALU-*Rana luteiventris* (Columbia Spotted Frog), PSRE-*Pseudacris regilla*(Pacific Treefrog). SPIN-*Spea intermontanus* (Great Basin Spadefoot), AMMA-*Ambystoma macrodactylum* (Long-toed Salamander)

Site ID	Site name	UTM East	UTM North	Elev. (m)	Water body type	ANBO	RALU	PSRE	SPIN	AMMA
1	Allison Lake (south end)	672888	5506066	880	lake	0	0	0	0	0
10	Alleyne Lake	674737	5532078	990	lake	0	0	0	0	0
100	Leech Lake (south of Mab Lake; not Sheep Lake; Helmer exit)	673614	5571260	1310	lake	2	2	1	0	0
101	Lundbom Lk Rd, Unnamed lake N of Lundbom L	673073	5552277	1128	pond	0	0	0	0	0
102	Spearing Creek, Kane Valley Road	654424	5519880	966	stream	0	0	1	0	0
103	Juliet Cr (Pond 1), off Mine Cr FSR	643389	5504408	1095	pond	0	0	0	0	0
104	Juliet Cr (Pond 2), off Mine Cr FSR	643695	5503735	1096	pond	0	1	1	0	0
105	Coquihalla Lakes, north lake	644408	5500388	1106	lake	0	0	1	0	1
106	Fen NE of Harrison Lake	663675	5534760	1068	pond	1	1	0	0	0
107	Hills SW of Merritt (ponds by road junction)	655447	5549319	860	pond	0	1	1	0	0
108	Zum Peak Rec Site (Upper Coldwater FSR)	637674	5500423	1231	stream	0	0	0	0	0
109	Upper Coldwater FSR	637031	5501619	1200	stream	0	0	0	0	0
110	Upper Coldwater FSR (Wetland 1)	638015	5501060	1213	stream	1	0	0	0	0
111	Upper Coldwater FSR (Wetland 2)	638180	5501009	1213	pond	0	0	0	0	0
112	Upper Coldwater FSR (Wetland 3)	638761	5500690	1207	ditch (burrow pit)	0	0	1	0	0
113	Upper Coldwater FSR (Wetland 4)	642111	5501074	1127	stream	0	1	0	0	0
114	Upper Coldwater FSR (Wetland 5)	642304	5501563	1124	beaver pond	1	1	0	0	0
115	Fig Peak (Wetland 1)	644957	5525980	1848	pond	0	1	1	0	1
116	Fig Peak (Wetland 2)	644683	5525965	1820	pond	0	0	0	0	0

Site ID	Site name	UTM East	UTM North	Elev. (m)	Water body type	ANBO	RALU	PSRE	SPIN	AMMA
117	Fig Peak (Wetland 3)	644911	5526480	1860	pond	0	1	1	0	0
118	Fig Peak (Wetland 4)	644849	5526778	1855	pond	0	0	0	0	0
119	Fig Peak (Wetland 5)	644895	5526816	1850	pond	0	0	1	0	0
11.1	West Pond, between Kentucky & Alleyne lakes	674791	5531120	990	pond	5	0	1	0	0
11.2	East Pond, between Kentucky & Alleyne lakes	674974	5531158	995	pond	0	0	0	0	0
12	Kentucky Lake	674958	5530932	990	lake	1	0	0	0	0
120	Fig Peak (Wetland 6)	644888	5527059	1851	pond	0	0	0	0	0
121	Dog Forest Road ("Norm's Pond")	669620	5562090	1032	pond	1	1	1	0	0
122	Pleasant Valley (east of Mill Creek Rd)	671972	5566425	1083	pond	1	1	1	0	0
123.1	Pleasant Valley (east of Mill Creek Rd); "Pipeline Wetland"	675128	5566624	1179	pond	1	0	0	0	0
123.2	Pleasant Valley (east of Mill Creek Rd); "Pipeline Lake"	675194	5566575	1185	pond	1	0	0	0	1
124	Eve Creek, 1 km upstream (SE) of Rey Lake	664645	5578763	1441	pond	0	0	1	0	0
125	Eve Creek, 400 m upstream (SE) of Rey Lake	663393	5578203	1356	stream	1	0	0	0	0
126	Rey Lake, Unnamed lake just SE of (junction of Rey & Eve Creeks)	663576	5578668	1347	lake	1	0	0	0	1
127	Powerline road, 7 km NW of Helmer Lake	664645	5578763	1411	pond	0	0	1	0	0
128.1	Quilchena Falls Rd, (from Loon L exit 97c) (Pond 1)	681080	5533666	1197	pond	1	0	0	0	0
128.2	Quilchena Falls Road, Pond 2 (from Loon L exit 97c)	681138	5533770	1194	pond	1	0	1	0	0
128.3	Quilchena Falls Rd, Pond 3 (from Loon L exit 97c)	681207	5533860	1190	pond	2	0	0	0	1
128.4	Quilchena Falls Road, Pond 4 (from Loon L exit 97c)	681236	5533882	1194	pond	2	1	0	0	0
128.21	Quilchena Falls Rd, Pond A (from Loon L exit 97c)	680982	5533564	1197	pond	1	0	0	0	0

Site ID	Site name	UTM East	UTM North	Elev. (m)	Water body type	ANBO	RALU	PSRE	SPIN	AMMA
129	Loon Lake on Bates Rd	676698	5529412	1218	lake	0	0	0	0	0
13	Kidd Lake	670251	5532870	1145	lake	1	2	1	0	0
130	Fox Farm Road, Small pond 11 km up	662896	5547290	1137	pond	0	1	0	0	0
131	Fox Farm Road, Small pond 11 km up	662131	5545976	1319	pond	0	1	1	0	1
132	Promontory Road, Dry Lake	648661	5559790	797	flooded field	1	1	1	0	0
133	Promontory Road, small pond in powerline ROW	644710	5560818	1434	pond	0	0	0	0	0
134	McDiarmid Lake along Pike Mtn Road	667966	5509228	1303	lake	0	1	1	0	0
135	Pike Mtn Rd, Unnamed lake 5 km south of McDiarmid Lake	666705	5506629	1285	lake	1	1	0	0	0
136	Pike Mtn Rd about km 23, roadside flooded area, actually just outside study area	667050	5497455	1405	ditch	1	0	0	0	0
137	Pike Mtn Rd about km 22, roadside flooded area, actually just outside study area	666922	5498019	1400	ditch	1	0	1	0	0
138	Promontory Road, Wetland 1	646928	5560085	955	dugout	0	0	1	0	0
139	Promontory Road, Wetland 2	644622	5562185	1722	pond	0	0	1	0	0
14	Kump Lake (slough at southern end)	670640	5511809	1127	lake	0	1	2	0	2
140	Promontory Road, Wetland 3	645032	5561185	1401	stream	0	0	0	0	0
141	Promontory Road, Wetland 4	647226	5560395	961	pond	0	0	0	0	0
142	Seymour Lake	656101	5532465	1094	lake	3	2	3	0	0
143	Englishman Lake	663835	5536025	1095	lake	0	0	0	0	0
144	Iron Mountain Rd, Lake 2 at 3.3 km	667200	5544623	1206	lake	1	0	0	0	0
145	Honeymoon Peak, pond below peak enroute to cabin	623651	5543330	1769	pond	0	0	0	0	1
146.01	Dewdney Trail on Warburton Loop	647219	5464092	1442	pond	1	0	0	0	0
147.01	Warburton Loop Trail	646470	5465059	1498	pond	0	1	0	0	0
149.01	Manning Park	664699	5466168	1512	pond	1	0	0	0	0

Site ID	Site name	UTM East	UTM North	Elev. (m)	Water body type	ANBO	RALU	PSRE	SPIN	AMMA
15	Beaver Flats, Laurie Guichon Memorial Grassland Interpretive Site, near Merritt	667445	5548905	656	pond	0	0	1	0	0
150.01	Whitehead Lake	645547	5465983	1515	lake	1	0	0	0	0
152	Coldwater Road, pond on east side	648641	5537664		flooded field	1	0	1	0	0
153	Lundbom Lk road, Wetland at 8 km	673014	5552405	1120	lake	0	0	1	0	0
154	Lundbom Lake, small pond West of lake on north side of road	667884	5549673	1118	pond	1	1	0	0	0
155	Coldwater Rd at Suttie Rd junction	648660	5537644	836	pond	1	0	1	0	0
156.1	Edna Lake Rd at km 3 (Pond A)	667546	5544603	1201	pond	0	0	0	0	0
156.2	Edna Lake Rd at km 3.3 (Pond B)	667238	5544620	1198		3	0	2	0	0
157	Hamilton Commonage, Gate Pond	683752	5552409	1170	pond	0	0	0	1	0
158	Hamilton Lake	669150	5552392	1075	lake	1	0	0	0	0
159.1	HWY 8, private wetland 1	649148	5557111	553	ditch	0	0	0	0	0
159.2	HWY 8, private wetland 2	648900	5556916	552	flooded river pools	0	0	1	0	0
159.3	HWY 8, private wetland 3	648919	5557194	549	pond	0	0	1	0	0
160	Link Lake (pond at N end at outlet)	699670	5510130	1100	lake	0	1	0	0	0
161	Lundbom Rd (last lake to E before Douglas L Ranch lands)	674419	5552361	1119	lake	0	0	0	0	0
162	Lundbom Rd, 6.8 km, East Arm (Wetland 2C)	671985	5552213	1136	lake	0	0	0	0	0
163	Lundbom Rd, 6.5 km N	672326	5552982	1165	pond	0	0	1	0	0
164	Osprey Lake (ditch at W end)	700478	5509878	1102	ditch	0	1	0	0	0
165	Osprey Lake (roadside ditch)	700585	5510360	1094	ditch	0	1	1	0	1
166	Pennask Lake Rd (pond at 13 -14 km)	683071	5550222	1158	pond	1	0	0	1	0
167	Pennask Lake Rd (pond at 14-15 km), before Douglas L border	683571	5549211	1230	pond	2	0	0	0	1
168	Pennask Lake Rd (pond at 16-17km)	684094	5547514	1143	pond	1	0	0	0	0
169	Pennask Lake Road, pond near Minnie Lake	684091	5547504	1143	pond	1	0	0	1	0

Site ID	Site name	UTM East	UTM North	Elev. (m)	Water body type	ANBO	RALU	PSRE	SPIN	AMMA
16.1	Aberdeen Road (Site 1)	651496	5559831	627	pond	0	0	0	0	0
16.2	Aberdeen Road (Site 2)	651539	5560218	631	pond	0	0	0	0	0
16.3	Aberdeen Road (Site 3)	651435	5559655	621	pond	0	1	0	0	0
17	Central Park Trail	658170	5554118	595	slough	0	0	0	0	0
170	Secret Lake	698962	5509461	1090	lake	0	1	0	0	0
171	Secret Lake (pond by road towards)	699274	5509526	1102	pool	0	1	0	0	0
172	Sunshine Valley Rd, W bridge ponds	647921	5556019	828	ditch	0	1	0	0	0
173	Thirsk Lake (reservoir)	709465	5510869	1027	lake	0	0	0	0	0
174.1	Thynne Mt (Pond 1, below summit)	648993	5509263	1903	pond	1	1	1	0	0
174.1	Thynne Mt (Pond 2, below summit)	648984	5509414	1896	lake	1	1	1	0	0
174.3	Thynne Mt (Pond 3)	648832	5509212	1918	pond	1	1	1	0	0
175	Promontory Road, Small pond	645725	5560733	1215	pond	0	0	0	0	0
176	"Mar-Lun" Lake, between Lundbom and Marquat Lakes	669449	5550310	1138	lake	1	1	1	0	0
177	Marquart Lake	668160	5549661	1135	lake	2	2	0	0	0
178	Quilchena golf course (#2 Fairway slough)	669526	5558406	638	pond	1	0	0	0	0
179	Pennask Lake Road (Pond 6)	683558	5549232	1230	pond	1	0	0	0	0
18	Coldwater Creek Park, off Nicola River	657656	5552754	593	creek	0	0	0	0	0
180	Round Pond, Edna Lake Rd km 7.1 (1.8 km below lake)	664285	5543686	1273	pond	0	1	1	0	0
19	Merritt, Greaves Avenue	658346	5554565	629	pond	0	0	1	0	0
2	Gypsum Lake, Aberdeen FSR	651232	5579693	1460	lake	0	0	0	0	0
20	Merritt, Sewage ponds	656819	5553501	584	pond	0	0	0	0	0
21	Midday Valley Road (west side of Tolco Mill)	657534	5552039	605	flooded field	0	0	0	0	0
22	Peter Hope Lake (Combined)	690887	5575455	1082	lake	4	5	1	0	0
23	Goose Lake, Pike Mt Recreational Area	663605	5512313	1084	lake	0	1	1	0	0
24	Robertson Lake, Pike Mt Recreational Area	667848	5512602	1143	lake	0	2	1	0	0

Site ID	Site name	UTM East	UTM North	Elev. (m)	Water body type	ANBO	RALU	PSRE	SPIN	AMMA
25	Pike Mt Recreational Area, Pond 1	665711	5512168	1155	pond	0	1	1	0	0
26	Skuhun-Pimainus FSR (Site 1), N of Tyner Lake	648420	5572763	1340	pond	1	0	1	0	0
27	Skuhun-Pimainus FSR (Site 2), N of Tyner Lake	647277	5574656	1347	pond	0	0	0	0	1
28	Summit Lake, Princeton-Merritt HWY 5A (Gulliford recreational area)	670661	5513238	1000	lake	0	1	0	0	0
29.1	HWY 8 from Merritt - Agate, Site 1 "Duck Pond"	645085	5556325	540	pond	0	1	1	0	0
29.2	HWY 8 from Merritt - Agate, Backyard pond	645063	5556421	552		0	0	0	0	1
29.3	Nicola River, Site 2, HWY 8 from Merritt - Agate	645091	5556264	540	oxbow	0	0	0	0	0
29.4	Nicola River, Site 3, HWY 8 from Merritt - Agate	645078	5556093	540	slough off river	0	0	0	0	0
30	Pennask Lake Road (cattle dugout 1)	681050	5554704	997	dugout	1	0	0	1	0
31	Pennask Lake Road (natural wetland 1)	681264	5553448	1059	pond	0	0	0	2	0
32	Davis Lake (combined)	662799	5526207	1015	lake	0	2	1	0	0
33	Boss Lake (back waters in SE end)	662489	5526666	1022	lake	0	0	1	0	0
34	Vogt Valley, Pond 1	659076	5530697	1022	pond	0	1	0	0	0
35	Voght Valley, Pond 2	661236	5529493	1022	lake	0	0	0	0	0
36	Shea Lake	662547	5530201	1034	lake	0	0	0	0	0
37	Glimpse Lake (Combined)	693122	5569436	1172	lake	5	3	2	0	2
38.1	Vinson Lake	684727	5519937	1378	lake	1	1	0	0	0
38.2	Vinson Lake (small pond)	684814	5519856	1387	ditch	0	1	1	0	1
39	Buck Lake (7 km from Loon Lake Exit 97C)	684236	5522339	1355	lake	3	4	2	0	0
3.1	Hornet FSR, Pond 1 off 1st spur	671729	5512719	1104	pond	0	0	0	0	0
3.2	Hornet FSR, Pond 2 off 1st spur	671855	5512514	887	pond	0	0	0	0	0
40	Lower Kane Lake	665199	5538910	1074	lake	0	1	1	0	0
41	Patchett Rd, off Coldwater Road	641305	5543512	849	pond	0	0	1	0	0

Site ID	Site name	UTM East	UTM North	Elev. (m)	Water body type	ANBO	RALU	PSRE	SPIN	AMMA
42	Hill's Homestead	669824	5540382	1238	lake	4	4	0	0	0
43	Ponderosa Ponds	662829	5533496	1054	pond	1	1	0	0	0
44	Beaver Flats, north pond	684690	5573692	651	pond	0	0	0	0	0
45	Upper Kane Lake	665724	5539048	1113	lake	0	2	0	0	1
46	Pennask Lake Road (cattle dugout 2)	681170	5553920	1032	dugout	0	0	0	1	0
47	Pennask Lake Road (natural wetland 2)	682371	5551269	1165	pond	0	0	0	1	0
48	Chicken Ranch Lake	666380	5539978	1124	lake	0	3	2	0	0
49	Fig Lake	648378	5525800	1138	Lake	0	1	0	0	0
5	HWY 97C, Merritt - Logan Lake (Pond 1)	653235	5561165	712	pond	0	0	0	0	0
50	Pipeline Rd N of Fig Lk Combined	648211	5525526	1135	flooded field/ ditch	0	1	0	0	0
52	Fig Lake Rd, S of lake (Junction with fibre optic cable)	648295	5524915	1146	lake	0	1	0	0	0
54.01	Jacobsen Lake	641054	5468469	1474	lake	0	1	0	0	0
55.01	Duck Range Road Pritchard to Monte L/Westwood), E of Kamloops				pond	1	0	0	0	0
56	Big Lake (Combined)	672461	5549501	1219	lake	4	0	2	0	2
57	"Alan's Lake", Off North Shovelnose L.R.	659126	5527862	2111	pond	0	1	1	0	0
58	Andy's Lake	648952	5512657	1537		1	1	0	0	1
59.1	Beaver Pond, Harmon Trail	665099	5541234	1286	pond	0	4	3	0	1
59.2	Beaver Pond, small roadside pond to the south, Harmon Trail	665131	5541115	1276	Pond	2	2	1	0	0
61	Bob's Lake (S end)	693432	5532474	1524	lake	0	0	0	0	0
62	Brook Creek, by Brook Lake (at 10 km, by bridge)	649109	5515077	1500	stream	1	0	0	0	0
63	Brook Lake	648384	5512810	1508	lake	1	1	0	0	0
64	Coley Creek, beaver pond	659901	5519067	1128	pond	0	1	0	0	0
65.1	Conant Lake (main body) (Helmer exit)	674302	5572833	1354	lake	1	1	1	0	0

Site ID	Site name	UTM East	UTM North	Elev. (m)	Water body type	ANBO	RALU	PSRE	SPIN	AMMA
65.2	Conant Lake, small pond in Conant Creek (at inflow to lake; Helmer exit))	674197	5572823	1370	pond/stream	1	2	2	0	0
66.1	Creek between Andy & Brook Lake	648607	5512654	1517	stream	1	0	0	0	0
67.1	Creighton Lake	695290	5529523	1580	lake	0	0	1	0	1
67.2	Creighton Lake FRS, roadside pond at 2 km marker	694548	5529427	1580	pond	0	0	1	0	1
67.3	Creighton Lake FRS, roadside pond at ca. 3 km	694982	5529309	1580	pond	0	0	0	0	0
69	Dodd's Lake, Random Wetland 1	667566	5528227	1195	lake/pond	3	3	3	0	3
6	Harrison Lake (combined)	663000	5534000	1060	lake	5	5	5	0	1
70	Edna Lake (East end, by parking lot)	663002	5543320	1240	lake	4	4	0	0	0
70.2	Edna Lake, Pond E of lake (S side of road)	664285	5543685	1240	Pond	0	1	0	0	0
70.3	Edna Lake, side pond on N of road	663001	5543337	1240	pond	1	0	0	0	0
71	Figlenski Rd wetlands (Neilson Flats)	653718	5532517	1047	pond	0	3	1	0	0
72	Gillis Lake wetland	645739	5532139	1162	lake	0	1	1	0	0
73.1	Hamilton Commonage, WHA Pond 1 combined	686222	5552665	1230	pond	1	0	0	0	0
73.2	Hamilton Commonage, WHA Pond 2 combined	685650	5552874	1230	pond	1	0	0	0	0
73.4	Hamilton Commonage, WHA Pond 4A	685322	5552975	1199	pond	0	0	0	0	0
73.5	Hamilton Commonage, WHA Pond 5 combined	685116	5552870	1193	pond	1	0	0	1	0
74.2	Hills SW of Merritt ("Jared's pond")	654470	5549646	970	pond	0	0	1	0	0
75	Ketcham Lake	675550	5516916	1268	lake	1	0	1	0	0
76	Roth Lake, east of Edna Lake	664480	5543521	1310	lake	0	0	0	0	0
77	Little Peter Hope Lake, alternate to wetland 2	690083	5573722	1095	lake	2	3	1	0	0
78	Loosemore Lake (recreation site)	671955	5513658	1080	lake	0	1	0	0	0
79	Menzies Lake	668070	5542620	1180	Lake	0	1	1	0	0
7.1	Kane Lake Ranch (Pond 1)	665644	5539458	1131	pond	0	0	0	0	0

Site ID	Site name	UTM East	UTM North	Elev. (m)	Water body type	ANBO	RALU	PSRE	SPIN	AMMA
7.2	Kane Lake Ranch (Pond 2)	665563	5539430	1131	pond	0	0	0	0	0
8	Lower Second Lake	666736	5540251	1128	lake	0	0	1	0	0
80	N Shovelnose Rd, burrow pit	658332	5528695	1181	burrow pit	0	0	0	0	0
81	Alleyne Lake, North Pond, by N end of lake	674339	5533240	1006	pond	0	0	0	0	0
82.1	Paul's Basin, Site 1A (N end of main wetland)	643947	5541663	795	pond	0	0	0	0	0
82.2	Paul's Basin, Site 1B (pool in field)	643842	5541623	795	pond	1	0	1	0	0
82.3	Paul's Basin, Site 1C (creek in field)	643805	5541639	795	stream/ ditch	0	1	0	0	0
82.4	Paul's Basin, Site 1D (wet field)	643770	5541457	795	flooded field	0	0	1	0	0
82.5	Paul's Basin, Site 1E	644104	5540823	795	pond	0	1	0	0	0
82.6	Paul's Basin, Site 1F	645346	5538927	795	stream	0	0	0	0	0
83	Alleyne Lake, NW of, Pond 2 ("Andrea's Pond")	674508	5533657	1006	pond	0	0	0	0	0
84	Alleyne Lake, Pond 3 NW of lake	674406	5533753	989	Pond	0	0	0	0	0
85	Pond west of Harrison Lake	662105	5533572	1060	flooded field	3	0	0	0	0
86	Roadside pond near Brook Lake	648721	5512977	1510	pond	1	0	1	0	1
87	Secret Lake (off Harrison Campsite)	664831	5537201	1100	lake	1	1	1	0	0
88.2	Shrimpton Cr, unnamed wetland (Pond 2)	682365	5526965	1210	pond	0	2	0	0	0
88.1	Shrimpton Cr, unnamed wetland (Pond 1)	682249	5527076	1213	pond	1	2	0	0	0
89	Siwash Lake	694592	5524426	1574	lake	0	0	0	0	0
9	Kane Slough, Unnamed lake	664422	5537722	1114	lake	0	0	1	0	0
90	Glimpse Lake, 5 km NE of, Unnamed lake (random Wetland 2)	697957	5573809	1309	pond	1	1	1	0	1
91	Lundbom Lk Rd., Unnamed Lk (combined)	671604	5552208	1119	lake	0	2	2	0	1
93	Murray Lake, Unnamed wetland N of	642717	5519694	1083	pond	1	0	1	0	0

Site ID	Site name	UTM East	UTM North	Elev. (m)	Water body type	ANBO	RALU	PSRE	SPIN	AMMA
94	Dodd's Lake, Unnamed wetland S (Random Wetland 2, main lake)	668096	5524903	1125	lake	1	0	1	0	1
95	Thynne Mountain Rd	653397	5515153	1310	pond	0	1	1	0	0
96	Lundbom area near powerline	671525	5549559	1219	pond	1	0	0	0	0
97	Skuhun-Pimainus FSR (Site 2), N of Tyner Lake	647277	5574656	1347	pond	0	1	0	0	0
98	Tommy Lee Lk (by Robertson Lake), Pike Mt Recreational Area	667353	5512622	1130	lake	0	1	0	0	0
99	Beaver Flats, sheetwater at north end	684026	5572423	642	flooded valley bottom	0	0	0	1	0
181	Batstone Lake & associated ponds	670558	5516611	1061	lake	1	0	0	0	0
182	Gwen Lake, 5 km E from Comstock Exit South	660488	5541428	1238	lake	1	0	0	0	0
183	Cantlon Road Pond	663653	5532766	1072	pond	1	0	0	0	0
184	Bluey Lake (pond by lake)	674983	5527446	1002	pond	1	1	1	0	0
185	Bluey Lake	674848	5526865	1008	lake	0	0	0	0	0
186	Midday Valley Pond	652187	5550692	983	pond	1	0	1	0	0
187	Blue Lake	697279	5570743	1223	lake	1	0	0	0	0
188	Peter Hope Lake Road, pond NW of Peter Hope Lake)	690329	5577178	1063	pond	0	1	0	0	0

Appendix 2. Analysis of water samples collected on 5-6 July 2011 at amphibian breeding sites.

Site ID	Site name	Species^	Temp (°C)*	DO (%)	ph	Nitrite (mg/l N)	Nitrite (mg/l NO2)	Nitrate (mg/l N)	Nitrate (mg/l NO3)	Phosphate (mg/l P)	Phosphate (mg/l PO4)
11	Kentucky-Alleyne	ANBO	21.8	72	8.82	0.004	0.004	0.039	0.173	0.02	0.07
6A	Harrison Lake, Kane Valley	ANBO&RALU	24.2	77.0	8.16	0.002	0.002	0.048	0.213	0.03	0.1
22	Peter Hope Lake	ANBO	23.2	20.3	7.69	0.002	0.002	0.095	0.421	0.22	0.68
37	Glimpse Lake	ANBO	24.6	99.1	8.36	0.004	0.004	0.007	0.031	0.04	0.11
42	HH Pond, Kane Valley	ANBO	26.6	96.5	8.75	0.004	0.004	0.016	0.071	0.15	0.44
32	Davis Lake, Voght Valley	RALU	13.9	45.2	7.5	0.001	0.001	0.01	0.044	0.03	0.1
6H	Harrison pond, Kane Valley	RALU	23.6	75.3	8.10	0.002	0.002	0.025	0.111	0.09	0.27
30	Pennask dug-out 1, Upper Nicola	SPIN	26	10	7.64	0.010	0.010	0.038	0.168	0.12	0.35
44	Sheet water, Upper Nicola	SPIN	26.1	87.2	8.55	0.000	0.000	0.55	3.2	0.32	0.35
31	Pennask wetland 1, Upper Nicola	SPIN	25.3	7	7.73	0.001	0.000	0.01	2.43	0.19	0.96
46	Pennask dug-out 2, Upper Nicola	SPIN		3.8	7.7	0.000	0.001	0.72	0.044	0.12	0.57

^*Breeding site of Great Basin Spadefoot (SPIN), Western Toad (ANBO), or both species
*temperature when DO was measured.

Appendix 3. Water quality data collected at Hamilton Commonage and Kentucky Alleyne Provincial Park in 2012.

A. ph, specific conductivity (SPC), and dissolved oxygen content:

Site name	Pond ID	Species^	Session	Date	Sample #	Temp*; C°	ph	Conduct. SPC	DO (%)	DO (mg/l)
Hamilton Commonage	WHA-Pond 1B	ANBO	1	31-May-12	1	20.2	8.3		97.1	8.8
Hamilton Commonage	WHA-Pond 1B	ANBO	2	21-Jun-12	2	20.8	8.3	1659.0		
Hamilton Commonage	WHA-Pond 1C	ANBO	1	31-May-12	1	17.5	8.3		85.5	8.1
Hamilton Commonage	WHA-Pond 1C	ANBO	2	22-Jun-12	2	19.6	8.7	2263.7		
Hamilton Commonage	Pond-5B	ANBO-SPIN	1	01-Jun-12	1	16.9			77.0	7.6
Hamilton Commonage	Pond-5B	ANBO-SPIN	2	22-Jun-12	2	21.9	8.1	1986.3		
Hamilton Commonage	Gate pond	SPIN	1	01-Jun-12	1					
Hamilton Commonage	Gate pond	SPIN	2	22-Jun-12	2	21.9	9.8	6078.0		
Hamilton Commonage	Pond-5C	SPIN	1	01-Jun-12	1	16.7			82.7	8.0
Hamilton Commonage	Pond-5C	SPIN	2	22-Jun-12	2	22.1	8.3	1367.3		
Hamilton Commonage	WHA-5A	SPIN	1	01-Jun-12	1	15.9	7.6		60.7	6.0
Hamilton Commonage	WHA-Pond 2A	SPIN	1	31-May-12	1	18.2	8.1		95.6	9.0
Hamilton Commonage	WHA-Pond 2A	SPIN	2	22-Jun-12	2	21.3	8.6	4427.3		
Hamilton Commonage	Pond 2B	NONE	1	31-May-12	1	18.0	7.6		50.6	4.6
Hamilton Commonage	Pond-5D	NONE	1	01-Jun-12	1	15.5			84.8	8.5
Hamilton Commonage	Pond-5E	NONE	1	01-Jun-12	1	17.1			86.7	8.1
Hamilton Commonage	WHA-4	NONE	1	31-May-12	1	16.9	7.4		62.1	5.9
Hamilton Commonage	WHA-Pond 1A	NONE	1	31-May-12	1	18.5	8.0		91.7	8.6
Hamilton Commonage	WHA-Pond 1A	NONE	2	22-Jun-12	2	21.4	8.1	3724.7		
Hamilton Commonage	WHA-Pond 1D	NONE	1	31-May-12	1	7.2			43.3	
Hamilton Commonage	WHA-Pond 3	NONE	1	31-May-12	1	13.9	7.7		48.3	5.1
Hamilton Commonage	WHA-Pond 3	NONE	2	22-Jun-12	2	18.3	7.9	1766.3		
Kentucky-Alleyne	West Pond	ANBO	2	21-Jun-12	1	21.5	8.7	681.7		
Kentucky-Alleyne	East Pond	NONE	2	21-Jun-12	1	22.0	8.7	544.0		

B. Absorbance (nm) and Nitrate concentrations:

Site name	Pond ID	Species^	Date	Sample #	Abs - 650	Abs - 600	Abs - 570	Abs - 550	Abs - 500	Abs - 450	Nitrate (mg/l N)	Nitrate (mg/l NO_3)
Hamilton Commonage	WHA-Pond 1B	ANBO	30-May-12	1	0.002	0.003	0.006	0.009	0.028	0.054		
Hamilton Commonage	WHA-Pond 1B	ANBO	21-Jun-12	2	0.011	0.013	0.012	0.016	0.039	0.064		
Hamilton Commonage	WHA-Pond 1C	ANBO	30-May-12	1	0.004	0.003	0.01	0.011	0.021	0.045		
Hamilton Commonage	WHA-Pond 1C	ANBO	22-Jun-12	2	0.029	0.035	0.032	0.035	0.061	0.091	1.04	4.6
Hamilton Commonage	Pond 5B	ANBO-SPIN	1-Jun-12	1	0.013	0.018	0.024	0.031	0.069	0.132		
Hamilton Commonage	Pond 5B	ANBO-SPIN	22-Jun-12	2	0.01	0.014	0.022	0.026	0.075	0.138	0.54	2.4
Hamilton Commonage	Gate pond	SPIN	1-Jun-12	1	0.027	0.033	0.033	0.038	0.037	0.074		
Hamilton Commonage	Gate pond	SPIN	22-Jun-12	2	0.026	0.034	0.036	0.039	0.083	0.117	1.32	5.84
Hamilton Commonage	Pond 5B	SPIN	24-Jul-12	3	0.014	0.02	0.027	0.033	0.072	0.14	0.715	3.16
Hamilton Commonage	Pond 5C	SPIN	1-Jun-12	1	0.01	0.015	0.014	0.019	0.035	0.078		
Hamilton Commonage	WHA-Pond 2A	SPIN	30-May-12	1	0.006	0.009	0.016	0.018	0.033	0.082		
Hamilton Commonage	WHA-Pond 2A	SPIN	22-Jun-12	2	0.005	0.012	0.013	0.016	0.041	0.086	2.6	11.52
Hamilton Commonage	WHA-Pond 2A	SPIN	24-Jul-12	3	0.004	0.005	0.011	0.013	0.038	0.074	1.88	8.32
Hamilton Commonage	WHA-Pond 5A	SPIN	1-Jun-12	1	0.012	0.012	0.025	0.028	0.048	0.1		
Hamilton Commonage	Pond 2B	NONE	30-May-12	1	0.021	0.022	0.035	0.045	0.08	0.163		
Hamilton Commonage	Pond 5C	NONE	22-Jun-12	2	0.009	0.012	0.017	0.02	0.048	0.088		
Hamilton Commonage	Pond 5E	NONE	1-Jun-12	1	0.016	0.022	0.033	0.039	0.083	0.161		
Hamilton Commonage	WHA-Pond 1A	NONE	30-May-12	1	0.008	0.013	0.019	0.023	0.059	0.128		
Hamilton Commonage	WHA-Pond 1A	NONE	22-Jun-12	2	0.01	0.019	0.02	0.023	0.066	0.128		
Hamilton Commonage	WHA-Pond 3	NONE	30-May-12	1	0.005	.003	0.014	0.017	0.027	0.059		
Hamilton Commonage	WHA-Pond 3	NONE	22-Jun-12	2	0.024	0.035	0.043	0.051	0.105	0.193		
Hamilton Commonage	WHA-Pond 4	NONE	30-May-12	1	0.025	0.038	0.04	0.049	0.095	0.183		
Kentucky-Alleyne	West Pond	ANBO	21-Jun-12	1	0.004	0.006	0.005	0.006	0.017	0.024		
Kentucky-Alleyne	West Pond	ANBO	25-Jul-12	2	0.005	0.005	0.009	0.008	0.01	0.015	0.077	0.341
Kentucky-Alleyne	East Pond	NONE	21-Jun-12	1	0.029	0.029	0.026	0.032	0.048	0.058		

^Breeding site of Great Basin Spadefoot (SPIN), Western Toad (ANBO), or both species
*temperature when DO was measured.

Appendix 4. Amphibian project questionnaire.

1. Are you on the Nicola Naturalist "frogging list"? Yes____ No____;
   If No, would you like to be? Yes____ No____

2. Which of the 5 species of amphibians are you able to identify?
   - Western Toad: Yes____ No____
   - Columbia Spotted Frog: Yes____ No____
   - Pacific Chorus Frog /Treefrog Yes____ No____
   - Great Basin Spadefoot Yes____ No____
   - Long-toed Salamander: Yes____ No____

3. If you cannot identify any of these species, how can we assist you?
   - I would like more training in the field Yes____ No____
   - I would like to receive an identification pamphlet or handout Yes____ No____
   - I would like to access identification information on the NNS website Yes____ No____
   - I would like to rely on my camera and get confirmation of the species from others Yes____ No____

4. Which of the following activities would you like to participate in?
   - Field visit with experienced froggers Yes____ No____
   - Independent field trip with a friend Yes____ No____
   - Field visit on your own Yes____ No____

5. Would you be interested in leading a field trip to find amphibians? Yes____ No____
   - If not, would you like additional training so you could become a leader? Yes____ No____

6. Which aspect of the amphibian project would you be interested in participating?
   - Amphibian "atlassing" only (checking out new wetlands and under-surveyed grids) Yes____ No____
   - More intensive monitoring of specific breeding sites for:
     a. Western Toads or Columbia Spotted Frogs (wetland surveys) Yes____ No____
     b. Great Basin Spadefoot (night time call route surveys) Yes____ No____
   - Reporting incidental observations of amphibians only Yes____ No____

8. Please provide any suggestions on how to increase volunteer participation in the amphibian project or make the experience more enjoyable:

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