



## **Current Logging Practices Impact Coastal Tailed Frog Populations in the Bridge River Valley, British Columbia**

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### **Abstract**

This study in the Hurley River watershed of the Bridge River valley demonstrates that current forest practices are inadequate to conserve Coastal Tailed Frogs (*Ascaphus truei*) in British Columbia. In 2006, 45 Coastal Tailed Frog tadpoles were detected at four stations surveyed on a south-facing tributary of the Hurley River. The stream had an anchored cobble/gravel substrate with stepped pools and was heavily overhung with woody debris and vegetation. It was about 1 m wide, flowing at a 14% gradient through a steep-sided gully in a mature Douglas-Fir - Englemann Spruce stand at 1100 m elevation. The forest was harvested in 2012 with no retention of riparian trees and much of the stream channel was covered in debris. No Coastal Tailed Frogs were detected when the stream was resurveyed in 2013. Under the BC Forest and Range Practices Act, riparian reserves are not legally mandatory for small streams typically used by Coastal Tailed Frogs and logging-related impacts on their populations caused by increased stream sedimentation, alteration of critical riparian habitat, increased temperature, and clogging of the channel with woody debris may be common.

### **Introduction**

Freshwater habitats harbour a disproportionate share of the earth's biota and the importance of riparian areas to the conservation of biodiversity and the protection of water quality is globally recognized (Naiman et al. 1993, Abell et al. 2002, Richardson et al. 2010). These habitats are under assault at a wide

range of scales from many human activities, including logging, hydroelectric projects, stream channelization and diversion, fishing, mining, urbanization and rural settlement, industry, agriculture, pollution, and introduction of exotic species. Large proportions of the world's fish, amphibian, and other aquatic-associated species are presently endangered and the estimated extinction rate of freshwater fauna in North America is five times higher than that of terrestrial species (Ricciardi and Rasmussen 1999). Legislation and regulations have been enacted nationally and locally in Canada and British Columbia to minimize deleterious impacts to riparian and stream habitats during development, especially in relation to fisheries resources (Tschaplinski and Pike 2010). However, shortcomings exist in present protective legislation with respect to smaller, higher-order streams used by Coastal Tailed Frogs (COSEWIC 2011). Results of this study suggest that current forest practices are inadequate to conserve Coastal Tailed Frogs (*Ascaphus truei*) in British Columbia.

Coastal Tailed Frogs occur along the Pacific coast from northern BC to northern California. In BC, reproduction is restricted to clear, cool, mountain streams on the windward and leeward sides of the Coast Mountains from sea level to 2140 m elevation (Green and Campbell 1984, Dupuis et al. 2000, Mallory 2004). Adults tend to be found close to streams, especially during dry weather, and are less likely to occur in logged areas than mature forests (Matsuda and Richardson 2005). Developing tadpoles require stable, perennial streams characterized by regularly spaced pools stepped among anchored cobble or

boulder substrate that can withstand intermittent flooding. Abundance is highest in small streams draining basins  $\leq 10 \text{ km}^2$  (Dupuis and Friele 2003). Distribution is highly clumped and predictive models indicate that, in the BC Interior, presence is associated with south-facing aspects (Rumsey et al. 2003, L. Dupuis, pers. comm.).

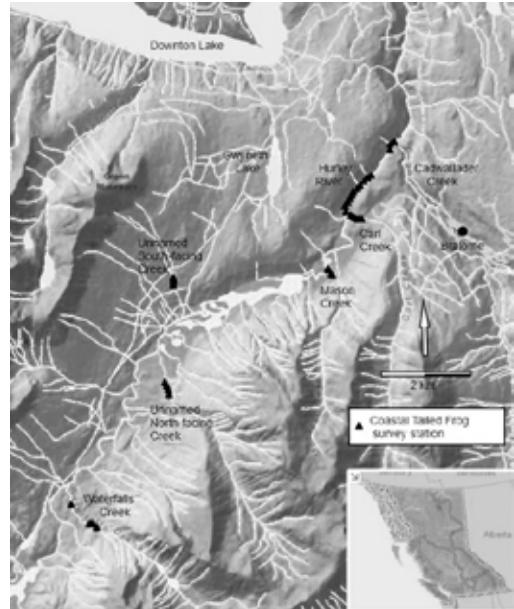
Tailed frogs are the longest-living anuran species (Brown 1989). Tadpoles transform after 2-4 years and reach sexual maturity at 8-9 years. Populations are at risk due to delayed maturity, low reproductive rates, limited dispersal capabilities, and dependence on specialized and limited habitat. Modifications in the landscape that cause erosion, sedimentation, and changes in water temperature adversely affect habitat quality (Dupuis and Steventon 1999, Mallory 2004). Coastal Tailed Frogs are listed as a species of special concern both federally (COSEWIC 2011) and provincially (Blue-listed; BC Conservation Data Centre 2014).

Coastal Tailed Frogs were surveyed in the Hurley River drainage as part of a preliminary wildlife assessment for a proposed independent power project on the Hurley River conducted in 2006. Following the release and permission to publish those data from the power companies involved, we conducted a follow-up survey in 2013. The study area in the Hurley River drainage was located above the confluence with Cadwallader Creek in the Bridge River watershed (Figure 1). Coastal Tailed Frogs had been reported farther east in the Bridge River valley in two higher-order tributaries in 2000 (Leupin 2000), but those populations were not present during a subsequent study by Wind (2009). Closest extant records of occurrence are from the upper, south end of the Hurley watershed (Wind 2009). To the southeast, Coastal Tailed Frogs have been found in the Cayoosh Ranges between Pemberton and Lillooet and as far east as Cathedral Provincial Park and Penticton (Dupuis et al. 2000, Leupin 2000, Gyug 2001, Wind 2009, Iredale 2009, Gyug 2012).

## Methods

### *Area background*

The Hurley River is a tributary of the Bridge River near the communities of Bralorne and Gold Bridge, about 170 km north of Vancouver, BC (Figure 1). A long history of mining, logging, and hydro development in the area has created a landscape of highly fragmented forests penetrated by many active and inactive roads and large areas of habitat lost to hydro reservoirs. Placer gold was discovered in the Bridge River drainage in 1858, leading to the development along Cadwallader Creek, a tributary of the Hurley River, of the highly productive Pioneer and Bralorne mines and associated communities of several thousand people (Green 2000). Small dams and lengthy flumes or wood-stave pipelines were constructed along the Hurley and Cadwallader streams to direct water to power early mills and generate electricity. Large-scale hydro development began with the construction of the Mission/Terzaghi and Lajoie dams on the Bridge River between 1946 and 1960 by BC Hydro. Flooding of the valley



**Figure 1.** Locations of Coastal Tailed Frog survey stations in the Hurley River watershed.

and the subsequent creation of the Carpenter and Downton reservoirs resulted in the loss of almost 7000 ha of forested slope, valley-bottom, riparian, and wetland habitat, important to many wildlife species including grizzly and black bear (*Ursus arctos* and *U. americanus*), Moose (*Alces americanus*), bighorn sheep (*Ovis canadensis*), Mule Deer (*Odocoileus hemionus*), small mammals, owls, Harlequin Ducks (*Histrionicus histrionicus*) and other waterfowl (Fish and Wildlife Compensation Program 2011).

The most widespread impacts in the area have come from forest harvesting. Logging has been intensive, especially during the 1980s, by which time most standing timber in the Hurley Valley had been removed (Triton Environmental Consultants, Ltd. 1992 in Griffith 1997). Aerial photographs from 1993 reveal almost complete clearcutting of the Hurley valley above Cadwallader Creek with minimal or no retention of riparian strips (Griffith 1997). Similar harvesting intensity has occurred in the Bridge River valley along the shores of Downton Lake. In the study area, there are remnant patches of mature timber, mostly on steep slopes on the northwest side of the Hurley River valley below Gwyneth Lake and along the west side of Cadwallader Creek. Second-growth forest in the Hurley River area is predominantly 41-140 years old. Much of the Downton Lake area is regenerating forest less than 40 years old (BC Ministry of Sustainable Resource Management 2006a, b).

### **Study area**

The study area included the stretch of the Hurley River potentially impacted by the proposed power project, plus five tributaries upstream of the project diversion area (Figure 1). Streams were selected that differed in aspect to maximize the chances of detecting Coastal Tailed Frogs in the Hurley River watershed and to aid in the interpretation of results from the Hurley River. The five tributaries surveyed were Carl Creek, Mason Creek, Waterfalls Creek, the largest unnamed tributary between Mason and Waterfalls creeks, and the unnamed south-facing tributary on the north side of the Hurley River draining from the top of Green Mountain (Figure 1). Based on low expected densities in the Hurley River, 14 survey stations were placed 100 m apart in accessible parts of the proposed in-stream hydro

diversion zone. Four survey stations, spaced at least 30 m apart, were placed in each of the tributaries (Figure 1, Appendix 1).

### **Survey methods**

Presence/not detected data were collected by conducting time-constrained searches for Coastal Tailed Frog adults and tadpoles (Resources Inventory Committee 2000) during dry weather between 25 September and 5 October 2006. We resurveyed the unnamed south-facing tributary on the north side of the Hurley River on 13 October 2013. Fifteen-minute searches were conducted by two people at each survey station. Searches began at the downstream end of the sample area and continued upstream for the allotted time period, focussing on the most suitable microhabitats (pools, areas of numerous, large cover objects, cutbanks, and riffles with large anchored cobbles and boulders). Searches were conducted using the hand-collection method, which involves turning over objects in the stream, raking gravels by hand and sweeping large boulders (taking care not to remove anchored boulders and to replace objects in their original positions), and keeping a dip net positioned immediately downstream of the search area to capture any tadpoles potentially displaced (BC Ministry of Environment Live Capture and Release Permit KA06-24613). An aquascope was used to view the stream bottom and to search in areas that were difficult to reach (e.g., under cutbanks or waterfalls). Stream banks were also opportunistically scanned for adults during searches for tadpoles. When tadpoles were encountered, the microhabitat in which they were first seen, their depth in the water, their position relative to cover objects, size of cover objects, and the tadpoles' estimated length were recorded. Captured tadpoles were measured to the nearest mm by gently immobilizing them at the bottom of a ziplock bag containing water. Tadpoles were released after counts of numbers present at a station were complete. At each survey station, channel wetted width, gradient, aspect, dominant and subdominant substrates, elevation, water temperature, and turbidity were recorded.

## Results

At sample stations on the Hurley River, channel wetted width was 12-14 m with gradients of 3-14% and a consistent temperature of 3 °C. Tributaries sampled were 1-5 m wide with gradients of 12-31% and temperatures of 5-8 °C (Table 1, Appendix 2). No Coastal Tailed Frog adults or tadpoles were detected in the Hurley River or in four of the tributaries surveyed.

In 2006, a total of 45 Coastal Tailed Frog tadpoles was detected at the four stations surveyed in the unnamed south-facing tributary (Table 1, Appendix 1). This stream was the smallest of those surveyed and was approximately 1 m wide, had an anchored cobble/gravel substrate with stepped pools, and flowed at a 14% gradient through a steep-sided gully at 1100 m elevation. It was heavily overhung with woody debris and vegetation (Figure 2) under a mature



**Figure 2.** In-stream habitat before (left, 2006) and after (right, 2013) logging at the south-facing tributary of the Hurley River where Coastal Tailed Frog tadpoles were found on 5 October 2006.

**Table 1.** Results of time-constrained searches for Coastal Tailed Frogs in the Hurley River and five of its tributaries, September and October 2006 (see Figure 1 and Appendix 1 for stream locations).

Stream	No. of sample stations	Stream width range (m)	Elevation range (m)	Aspect	Temp. (°C)	Tadpoles detected	Adults detected
Hurley River	14	12-14	890-950	NE	3	0	0
Waterfalls	4	4-5	1040-1160	W	7	0	0
North facing	4	3	1040-1100	N	8	0	0
Carl	4	2.5-3	970-1000	NW	6	0	0
Mason	4	1.5	965-980	NW	7	0	0
South facing	4	1	1090-1120	S	5	45	0

Douglas-Fir - Englemann Spruce stand (Figure 3). The water was shallow and the flow rate too low to wash displaced tadpoles into the dip net, and using the hand-collection method in these conditions may have damaged tadpoles and stream habitat. We thus conducted an unobtrusive visual search for the allotted time period, and counted tadpoles visible on the streambed (Figure 4) and recorded their microhabitat. The mean ( $\pm$  SD) length of 11 tadpoles captured was  $37 \pm 4$  mm (Appendix 3). Estimated and exact measurements differed by 1 to 3 mm in four cases when they were compared.

No evidence of Coastal Tailed Frogs was found in the unnamed south-facing tributary in 2013. Forest along the stream had been completely harvested, leaving no riparian strip in the vicinity of the sample stations (Figure 3). Cut logs had been yarded down the streambed using an accepted traditional but currently uncommon technique of “punching and skidding”, in which branches are layered over the creek bed, and logs are hauled across the channel. Debris was left in the creek channel (Figure 2). Informal searches of the stream channel were conducted above and below the cut block, but no sign of adults or tadpoles was found.

### Discussion

Coastal Tailed Frogs were not found in the Hurley River itself, or in the four tributaries with northerly

and westerly aspects. Absence of detections at those locations indicates that if Coastal Tailed Frogs were present, they likely occurred at low densities. John Rithaler (Sigma Engineering, Ltd., pers. comm.) reported sighting a single tadpole in the Hurley River above the confluence of Cadwallader Creek on 25 April 2006. This sighting suggests that Coastal Tailed Frogs may occur in the Hurley River mainstem at low densities, likely because they are periodically washed downstream from the tributaries (Wahbe and Bunnell 2001). The Hurley River is a much larger, more turbid, and colder system with less cover along its banks than the tributary in which Coastal Tailed Frog tadpoles were numerous, and breeding within the Hurley River itself is unlikely (Dupuis and Friele 2006).

High numbers of tadpoles were found in 2006 in the one south-facing tributary surveyed using only a visual search method. Wind (2009) and Dupuis (pers. comm.) also conducted only visual searches in microhabitats with low flows and the technique likely provides effective and reliable estimates of relative abundance in those situations. This small tributary had an anchored cobble/gravel substrate with stepped pools and good vegetative cover under mature forest. Results provide support for predictive models that associate presence of Coastal Tailed Frogs in interior areas with small, south-facing streams (Rumsey et al. 2003, L. Dupuis, pers. comm.), and suggest that it may be useful to target south-facing tributaries within mature forest for future surveys in this region.

No Coastal Tailed Frogs were found in the small, south-facing tributary in 2013, after the riparian forest had been harvested. All trees adjacent to the stream channel had been removed and the channel itself was covered with woody debris (Figures 2 and 3). The negative impacts of logging on small streams inhabited by Coastal Tailed Frogs have been documented within BC (Dupuis and Steventon 1999) and internationally (e.g., Corn and Bury 1989) and include sedimentation, loss of valuable riparian habitat, increased water temperature, and clogging of the channel with woody debris. Logging and associated road construction is known to cause stream sedimentation that reduces aquatic habitat quality by filling in the interstitial spaces required by tadpoles as refugia (Dupuis and Friele 2006, COSEWIC 2011). Riparian habitat plays an important role in moderating riparian moisture

content and stream water temperature through shading, provides a source of nutrients and organic matter to the stream, stabilizes soils and prevents erosion, provides a buffer from sedimentation and pollution (BC Ministry of Environment 2009), and is critical for Coastal Tailed Frog terrestrial life stages and dispersal (COSEWIC 2011).

The possible elimination of Coastal Tailed Frogs from the south-facing tributary may represent a further range contraction of the species in the Bridge River watershed. In 2000, Leupin (2000) reported tadpoles lower in the Bridge watershed in Tommy Creek, a tributary of the Bridge River flowing into the south side of Carpenter Lake, and in the upper reaches of Shulaps Creek, a tributary of the Yalakom River that joins the Bridge River farther east, closer to Lillooet. Coastal Tailed Frogs were not detected



**Figure 3.** Riparian forest before (left, 2006) and after (right, 2013) logging at the south-facing tributary of the Hurley River where Coastal Tailed Frog tadpoles were found on 5 October 2006.



**Figure 4.** Coastal Tailed Frog tadpoles in south-facing tributary of the Hurley River on 5 October 2006.

in either of those streams in 2009, suggesting a range contraction (Wind 2009). Occurrence of Coastal Tailed Frogs has been confirmed just south of Railroad Pass towards Pemberton (Conservation Data Centre custom data search) and from the upper, south end of the Hurley watershed near Railroad Pass and Hope Creek (Wind 2009). Those areas may house the last remnants of what was likely a more widely distributed population throughout the Bridge watershed before intensive logging and hydro development eliminated most suitable habitat. Railroad Pass probably serves as a dispersal corridor for Coastal Tailed Frogs from coastal populations into the upper Hurley area covered by our study (Friele and Dupuis 2007) and remnant populations in that area likely constitute an important potential source population for any future recolonization. Dispersal in drier, interior habitats may be primarily along riparian corridors (Dupuis and Friele 2006, Spear and Storfer 2010, COSEWIC 2011), and barriers to dispersal created by BC Hydro reservoirs and other habitat alterations likely impede recolonization. Fragmentation from large-scale timber removal is considered a limiting factor in gene flow of Coastal Tailed Frogs by hindering dispersal (Spear and Storfer 2008) and may disrupt metapopulation functioning (COSEWIC 2011). This may be especially critical where sub-populations exist at low densities, such as towards the northern extent of their range or in areas such as the Bridge River Valley where much suitable habitat has been removed (Dupuis et al. 2000, Wind 2009).

Results of this study exemplify the shortcomings and fuel the long-standing concern over the effectiveness of current forestry practices in protecting

freshwater and riparian habitat for wildlife species such as Coastal Tailed Frog (Tschaplinski and Pike 2010, COSEWIC 2011). Protection of stream and riparian habitat in BC focuses primarily on fish and water quality and derives from the federal Fisheries Act and the provincial Water Act and Fish Protection Act. The Riparian Areas Regulation was enacted under the Fish Protection Act to ensure protection of riparian areas during residential, commercial and industrial development, but does not apply to agriculture, mining or forestry. Forestry practices on crown lands are regulated by the Forest and Range Practices Act (FRPA; formerly the Forest Practices Code). Streams are classified under the FRPA in order of decreasing size and fish-bearing status (s1-s6). Width and retention standards for riparian reserves and management zones vary accordingly, such that riparian reserves are not legally mandatory for the smallest fish-bearing streams (s4) or for non-fish-bearing streams (s5-s6), which comprise most of the streams and the primary habitat for Coastal Tailed Frogs in BC (COSEWIC 2011). Protection of riparian areas may be even more critical for interior Coastal Tailed Frog populations because drier forest conditions result in greater risk of desiccation and dependence on riparian corridors for dispersal. Types of stream crossings used during road building also vary among stream categories. Open-bottomed structures are generally used for fish-bearing streams, whereas closed culverts that damage the streambed and interrupt connectivity are frequently installed on non-fish-bearing streams.

Effectiveness monitoring (Tripp et al. 2009) conducted as part of the Forest and Range Evaluation

Program (FREP) has shown that harvest methods under the current FRPA impact proper stream functioning in a substantial proportion of streams, and fail to maintain proper stream functioning in a large number of small, s6-class streams (Tschaplinski and Pike 2010). Low riparian tree retention, road-delivered fine sediments, and cross-stream falling and yarding were the main factors responsible for impacts to small streams, and Tschaplinski and Pike (2010) suggested that impacts could be substantially reduced if logging practices minimized the introduction of logging debris and sediments into channels, limited physical contact with streambanks and streambeds when falling and yarding, and retained more vegetation in riparian areas. Effectiveness monitoring for streams and riparian areas consider fish and aquatic invertebrates important to fish, but not other wildlife (Tripp et al. 2009, Tschaplinski and Pike 2010). In relation to wildlife resources, the Forest Practices Board (2014) concluded that,

“...FREP has provided limited effectiveness evaluation reporting for the FRPA wildlife resource value. We appreciate the complexity of developing monitoring protocols for this value, but still find it unacceptable that almost a decade after the program was launched, no appreciable progress has been made in this area.”

Coastal Tailed Frog is listed as a Species at Risk under the FRPA, and Wildlife Habitat Areas (WHA) have been established or proposed following an Identified Wildlife Management Strategy for the species. A list of approved WHAs was consulted by the foresters developing plans for the cut-block surrounding the stream impacted in this study, but because that particular stream is not part of a WHA, no information was obtained on the presence of Coastal Tailed Frogs (Mike Carson, Interwest Timber, pers. comm.). Currently, established and approved WHAs will protect less than 0.2% of Coastal Tailed Frog habitat in BC (COSEWIC 2011), and further measures are clearly required. †

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#### **About the Authors**

Michael is a self-employed biological consultant with experience in a variety of biological systems. Much of his work has focused on population and behavioural ecology of seabirds and waterfowl that he has studied on both the east and the west coasts of North America. He has also worked in the logging industry and as a teacher. For years he has partnered with Heidi Regehr conducting wildlife research and assessment.

Heidi has been self-employed throughout most of her career in wildlife biology. She began studying small mammals in the boreal forest of the Yukon and Ospreys in the salt marshes of New England, then became focused primarily on marine birds in Newfoundland, where she did a master's degree on Black-legged Kittiwakes, and BC, where she did her Ph.D. work on Harlequin Ducks. At present she works from home as a senior wildlife biologist for Ecofish Research on a variety of assessment, monitoring, and review projects. Current interests include conservation issues of species at risk.

**Appendix 1.** Locations of survey stations and numbers of Coastal Tailed Frogs detected during time-constrained searches in the Hurley River and five of its tributaries, 2006 (see also Figure 1 for stream locations).

Stream	Station	Zone	Easting	Northing	Survey date	Survey start time	Adults detected	Tadpoles detected
Waterfalls	1	10	503900	5619140	25-Sep	16:14	0	0
Waterfalls	2	10	504300	5618660	25-Sep	14:13	0	0
Waterfalls	3	10	504380	5618660	25-Sep	14:47	0	0
Waterfalls	4	10	504460	5618600	25-Sep	15:16	0	0
North facing	1	10	506140	5621800	25-Sep	17:01	0	0
North facing	2	10	506200	5621720	25-Sep	17:28	0	0
North facing	3	10	506220	5621620	25-Sep	17:54	0	0
North facing	4	10	506240	5621520	25-Sep	18:24	0	0
Carl	1	10	510480	5625410	26-Sep	10:26	0	0
Carl	2	10	510560	5625360	26-Sep	10:54	0	0
Carl	3	10	510620	5625330	26-Sep	11:24	0	0
Carl	4	10	510720	5625330	26-Sep	11:49	0	0
Mason	1	10	509920	5624230	26-Sep	14:12	0	0
Mason	2	10	509940	5624190	26-Sep	14:40	0	0
Mason	3	10	509990	5624140	26-Sep	15:08	0	0
Mason	4	10	510010	5624090	26-Sep	13:32	0	0
South facing	1	10	506420	5623980	5-Oct	13:40	0	16
South facing	2	10	506430	5624050	5-Oct	14:28	0	11
South facing	3	10	506440	5624100	5-Oct	15:16	0	7
South facing	4	10	506420	5624150	5-Oct	15:50	0	11
Hurley	1	10	511540	5627000	4-Oct	10:00	0	0
Hurley	2	10	511470	5626960	4-Oct	10:36	0	0
Hurley	3	10	511460	5626840	4-Oct	11:06	0	0
Hurley	4	10	510960	5626270	4-Oct	13:53	0	0
Hurley	5	10	510880	5626220	4-Oct	14:22	0	0
Hurley	6	10	510820	5626150	4-Oct	14:54	0	0
Hurley	7	10	510740	5626060	4-Oct	15:26	0	0
Hurley	8	10	510680	5626000	4-Oct	15:55	0	0
Hurley	9	10	510600	5625930	4-Oct	16:22	0	0
Hurley	10	10	510530	5625860	4-Oct	16:47	0	0
Hurley	11	10	510490	5625780	4-Oct	17:11	0	0
Hurley	12	10	510440	5625700	4-Oct	17:31	0	0
Hurley	13	10	510380	5625620	4-Oct	17:52	0	0
Hurley	14	10	510390	5625480	4-Oct	18:20	0	0

**Appendix 2.** Physical stream characteristics at Coastal Tailed Frog survey stations (see Figure 1 and Appendix 1 for stream locations and survey dates).

Stream	Sample station	Channel wetted width (m)	Gradient (%)	Substrate <sup>1</sup>		Elevation (m)	Aspect (°)	Water temperature (°C)	Turbidity <sup>2</sup>
				Dom- inant	Sub- Dom- inant				
Waterfalls	1	5	12	B	C	1040	10	7	C
Waterfalls	2	4	14	B	C	1120	280	7	C
Waterfalls	3	4	21	B	C	1140	280	7	C
Waterfalls	4	4	31	B	C	1160	280	7	C
North facing	1	3	18	C	B	1040	330	7.5	C
North facing	2	3	23	B	C	1060	340	7.5	C
North facing	3	3	29	C	B	1080	348	7.5	C
North facing	4	3	31	C	B	1100	345	7.5	C
Carl	1	3	12	C	G	970	275	5.5	C
Carl	2	2.5	18	C	G	980	307	5.5	C
Carl	3	2.5	27	R	C	990	330	5.5	C
Carl	4	2.5	27	C	G	1000	265	5.5	C
Mason	1	1.5	14	B	G	965	290	6.5	C
Mason	2	1.5	18	C	G	970	310	6.5	C
Mason	3	1.5	19	C	G	975	330	6.5	C
Mason	4	1.5	25	C	G	980	340	6.5	C
South facing	1	1	14	C	G	1090	180	5	C
South facing	2	1	14	C	G	1100	190	5	C
South facing	3	1	12	C	G	1110	180	5	C
South facing	4	1	16	C	G	1120	190	5	C
Hurley	1	12	7	B	F	890	70	3	M
Hurley	2	12	11	B	F	895	350	3	M
Hurley	3	12	9	B	F	900	30	3	M
Hurley	4	14	14	B	G	940	70	3	M
Hurley	5	14	12	B	G	941	70	3	M
Hurley	6	14	11	B	G	942	60	3	M
Hurley	7	12	9	B	G	943	50	3	M
Hurley	8	12	9	B	G	944	50	3	M
Hurley	9	14	9	B	F	945	50	3	M
Hurley	10	14	9	B	C	946	60	3	M
Hurley	11	14	9	B	C	947	40	3	M
Hurley	12	14	9	B	C	948	40	3	M
Hurley	13	14	7	C	G	949	50	3	M
Hurley	14	14	3	C	B	950	340	3	M

<sup>1</sup> F - fines, G - gravel, C - cobble, B – boulder, R - rock.

<sup>2</sup> C – clear, M – moderately turbid.

**Appendix 3.** Coastal Tailed Frog tadpole observations in the south-facing tributary of the Hurley River on 5 October 2006 (see Figure 1 for tributary location).

Sample station	Observation number	Micro-habitat <sup>1</sup>	Depth in water (cm)	Position relative to cover objects <sup>2</sup>	Cover object size <sup>3</sup>	Total tadpole length <sup>4</sup> (mm)
1	1	R	5	N	3	45*
1	2	R	7	U	3	34*
1	3	R	4	N	3	30
1	4	R	6	N	3	35
1	5	R	5	N	2	35
1	6	P	8	N	3	35
1	7	P	10	N	3	30
1	8	P	15	N	3	45
1	9	P	10	U	3	30
1	10	P	10	N	3	38
1	11	P	8	N	3	30
1	12	P	12	N	3	30
1	13	Z	0	N	3	33*
1	14	P	8	N	3	34*
1	15	R	3	N	2	35*
1	16	R	1	N	3	35
2	1	U	7	N	3	36*
2	2	U	6	N	2	33
2	3	U	7	N	3	44*
2	4	U	6	N	3	40
2	5	R	7	U	2	40
2	6	U	5	N	2	38
2	7	U	4	N	2	32
2	8	R	7	N	3	45
2	9	R	1	N	4	43*
2	10	R	3	N	4	35
2	11	P	5	N	3	45
3	1	R	3	N	2	40
3	2	P	8	N	3	44
3	3	P	9	N	3	36*
3	4	P	10	N	3	35
3	5	R	3	N	2	40
3	6	R	4	N	2	38
3	7	R	2	N	2	35
4	1	R	4	N	2	37
4	2	P	5	N	2	35*
4	3	R	4	N	2	35
4	4	R	3	N	2	36
4	5	R	5	N	3	38
4	6	R	10	N	3	37
4	7	R	2	N	3	36
4	8	R	1	N	3	37
4	9	P	10	N	3	38
4	10	P	12	N	1	42
4	11	P	5	N	2	35*

<sup>1</sup> R - riffle, P - pool, U - run, Z - splash zone.

<sup>2</sup> N - on substrate, U - under substrate.

<sup>3</sup> 1 - fines, 2 - gravel, 3 - cobble, 4 - boulder.

<sup>4</sup>\* - measurement of captured individual taken, otherwise length is an estimate.