Restoring species of conservation concern and cultural value

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Final Report YEAR 1

Prepared for:

Fish and Wildlife Compensation Program, Coastal Program

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EXECUTIVE SUMMARY

In response to 80% loss of wetlands in Katzie traditional territory in the lower Alouette and Pitt River watersheds, we combined scientific and traditional knowledge and values to create an Eco-Cultural Restoration Plan for Katzie territory. Wetland loss has resulted in the extirpation or near extirpation of several species from this area, including several federally-listed species at risk, and loss of access to several species of cultural value to Katzie. Hence, cultural practices that supported sustainable use of these species for food and medicine have also declined. Wapato has been identified as a cultural keystone species for the Katzie First Nation, but is no longer accessible due to the loss of wetland habitat. Our plan prioritizes wetland restoration within the lower Alouette River, the core of Katzie traditional territory. During previous work (2012-2014), we mapped wetland habitat and conducted inventories for species at risk to identify candidate sites for restoration. In this first year of our multi-year project, we implemented our plan by enhancing 1 ha of wetland at two high priority sites along the lower Alouette River for 11 species of conservation concern while also restoring access to plant species of cultural value. Habitat enhancement actions such as installation of large wood, creation of tidal marsh, beach clearing, installation of shelter boxes, and planting of native aquatics and berry-producing shrubs were targeted to priority species of conservation concern, including the great blue heron, painted turtle, and barn swallow, and to improve biodiversity overall. We designed marshes to sustain large patches of wapato and tule, so that members of the Katzie and wider community can learn about and engage in traditional harvesting of these culturally-valued plants. Our actions encompass priority actions under the Alouette Riparian Wetlands Action Plan (FWCP 2011): 1. conduct mapping to determine abundance, distribution, and category of riparian and wetland habitat, 2. identify opportunities for restoration or creation of category 2 areas, and 3. implement riparian and wetland restoration projects that are identified as high priorities through inventory, mapping or assessment

We also initiated a long term effectiveness monitoring program, designed to evaluate restoration success by comparing the vegetation, amphibian, and bird communities at restoration sites pre- and post-restoration, and to control sites along the Alouette River. Pre-restoration inventory shows that the low bench floodplain between the dikes was more than 95% covered by reed canary grass, whereas the inter-tidal zone was dominated by native species. Four provincially 'blue'-listed plant species of conservation concern were found in the intertidal zones. Egg mass surveys conducted in March suggest that native amphibians did not breed at the sites, but a western toad was found incidentally on wood within the reed canary grass bench, and vocalizing non-native bronze frogs were heard later in the season along the river edge. Prior to restoration, only two bird species were determined to hold breeding territories within the sites, the marsh wren and common yellowthroat. The results of point count surveys conducted along the lower Alouette River showed that only one bird, the marsh wren, was observed to primarily use reed canary grass as breeding habitat. Bird species richness was higher where shrubs were present with reed canary grass in the low bench floodplain. These results suggest that our actions to plant shrubs at the restoration sites may broaden the suite of bird species able to find breeding resources, and thus is expected to increase bird species richness over the long term. Future years of monitoring will result in valuable information with which to evaluate restoration success, while also contributing information to regional efforts toward species and habitat conservation.

GOALS AND OBJECTIVES

Long term Goals

1. A watershed-scale restoration plan (available online at www.katzienaturalresources.ca) with practical and successful guidelines for restoration practitioners, including guidelines on the control of invasive species and techniques to create habitat for species at risk, site designs, effectiveness monitoring and prioritization frameworks. The plan includes a transparent and accessible rationale for prioritization and allocation of future restoration efforts toward species and areas, based on scientific principles and cultural values, and refined by surveys to map wetland habitats, and the distributions of priority species and their habitats along the lower Alouette River.
2. Evaluation of restoration success at restoration sites using an adaptive management framework and an effectiveness monitoring program based on a criteria and indicator approach.
3. Establishment of healthy populations of threatened and culturally-valued species, resulting in revitalization of sustainable use of culturally-valued plants by Katzie and the wider community.
4. Opportunities for Katzie and the wider community to engage and learn in a hands-on way about restoration, wildlife monitoring, and Katzie traditional knowledge and sustainable use practices.

Objectives for 2016-2017

1. Creation of marsh habitat and habitat enhancement at two low bench sites, and planting of cottonwood trees for priority species along the Alouette River (Table 1 and 2).
2. Initiation of an effectiveness monitoring and adaptive management framework to evaluate restoration success and prioritize sites for future restoration efforts.
3. An outreach program including a website, public presentations, participation in community events, a community feast, and signage at restoration sites.
4. Capacity building in the Katzie First Nation in wetland restoration planning, design and implementation, and vegetation and wildlife inventory and monitoring.

INTRODUCTION

The Katzie people are the original inhabitants and stewards of the lands and waters within an area that includes the Pitt, Alouette, and Stave watersheds. The Katzie are known for successful ecological management through millennia, including sustainable management of wapato, oolichan, and salmon. Approximately 80% of wetland habitat in Katzie territory has been lost since European settlement due to damming, the construction of dikes for agriculture, and urban development (Boyle 1997; Katzie First Nation, unpublished data). This has resulted in the extirpation or near extirpation of several species from this area, including several federally-listed species at risk. The loss of wetland habitat has also resulted in declining populations of several species of cultural value to the Katzie. Hence, cultural practices that supported sustainable use of these species for food and medicine have also declined. Wapato has been identified as a cultural keystone species for the Katzie First Nation, but one that is no longer accessible due to the loss of wetland habitat (Garibaldi and Turner 2004; Leon 2014). The Katzie First Nation want to preserve and enhance culturally-valued plants of wetland riparian habitats to promote food sovereignty and cultural revitalization.

We have recognized that restoration success in Katzie territory can be improved with clear goals and priorities, and a bioregional scale of planning based on the principles of ecosystem and adaptive management. Of particular importance is priority to traditional knowledge and values. With collaboration from 8 community groups and 3 municipalities, we combined scientific and traditional knowledge and values to create an Eco-Cultural Restoration Plan for Katzie territory.

The Alouette watershed represents the core of the territory of the Katzie First Nation since time immemorial. The Alouette River were first diked in 1894 (Collins 1975), without permission from Katzie. Currently, the floodplain of the Alouette is restricted to a narrow, low bench meadow, about 300 m at its widest and approximately 90% covered by invasive reed canary grass (Katzie First Nation, unpublished data). Because most restoration efforts have so far occurred within the upper Alouette River (e.g. Hyrhorczuk 2009), our Eco-cultural Restoration Plan prioritizes wetland habitat restoration along the lower Alouette River, specifically the area of the Pitt Polder between 224th Street and Harris Road on the North and South Alouette River. Priority species include 11 terrestrial species of conservation concern, five species of cultural significance to Katzie, and two keystone species (Table 1). Planning for habitat enhancement is targeted to priority species (Table 2).

This document reports on Year 1 of a multi-year project to restore wetland habitat along the lower Alouette River, enhance habitat for species of conservation concern, and to plant culturally-valued species to create opportunities for people to learn about and revitalize traditional practices that promote healthy ecosystems and communities.

Table 1. Rationale for prioritizing species and recommended species recovery actions addressed by this project.

SPECIES	RATIONALE	RECOMMENDED ACTIONS FOR SPECIES RECOVERY
Cultural value		
Wapato (*Sagittaria latifolia*)	Sacred, cultural keystone species, highly valued as traditional food	
Tule (*Schoenoplectus acutus*)	Highly valued for basket making	
Beaked hazelnut (*Corylus cornuta*)	Highly valued as traditional food	
Bog cranberry (*Vaccinium oxycoccos*)	Highly valued as traditional food	
Sandhill Crane (*Grus canadensis*)	Sacred	
Conservation Concern		
Vancouver Island beggarticks (*Bidens amplissima*)	Special Concern	Conduct and encourage research on habitat needs and propagation guidelines to re-introduce extirpated populations and restore diminished populations. Test techniques for reintroduction and management by establishing and monitoring experimental populations (Vancouver Island Beggarticks Working Group 2014).
Mountain sneezeweed (*Helenium autumnale var. grandiflorum*)	Special Concern (BC provincial)	
Western painted turtle* (*Chrysemys picta*)	Endangered	Collect information on population trends, including a monitoring plan for individual sites and watersheds and studies to monitor population responses to habitat restoration, potential reintroductions or translocations and their effects (Western Painted Turtle Recovery Team 2010)
Great blue heron* (*Ardea herodias fannini*)	Special Concern	Restore foraging sites and ensure adequate recruitment of large trees for nesting; conduct surveys for colonies; monitor productivity (Heron Working Group)
Common nighthawk (*Chordeiles minor*)	Threatened	Restore and create habitat. Promote volunteer participation in surveys and monitoring (Environment Canada 2015)
Short-eared owl (*Asio flammeus*)	Special Concern	Recovery/management plan pending
Western screech owl* (*Megascops kennicottii kennicottii*)	Threatened	Recovery/management plan pending
Barn swallow (*Hirundo rustica*)	Threatened (COSEWIC)	Recovery/management plan pending
Townsend's big eared bat (*Corynorhinus townsendii*)	Special Concern (BC provincial)	Recovery/management plan pending
Little brown myotis (*Myotis lucifugus*)	Endangered	Recovery/management plan pending

Pacific water shrew* (*Sorex bendirii*)	Endangered	Restore historical and important potential habitats to rehabilitate/retain recovery sites (Pacific Water Shrew Recovery Team 2009)
Keystone species		
Northern flicker (*Colaptes auratus*)	Creates cavities used by many other species including birds, bats, and insects for reproduction and over-wintering.	
American beaver (*Castor canadensis*)	Creates key habitat resources for other species, such as over-wintering sites for painted turtles. However, can also be detrimental to some restoration efforts so requires special consideration.	

*Priority species for the Alouette watershed FWCP.

Table 2. List of restoration actions to benefit priority species

Restoration Action	Priority Species
Long-term planting of riparian cottonwood groves, to ensure continual recruitment of large cottonwood trees at the landscape scale.	Nesting habitat for great blue heron and woodpeckers; Excavated and natural cavities for secondary cavity users, including the western screech owl, little brown myotis, and Townsend's big-eared bat.
Anchoring of large wood in aquatic zones	Basking and foraging sites for re-introduced painted turtles
Creation of sand-gravel berms	Painted turtle nesting habitat
Addition of large wood in riparian areas	Refuge sites to enhance habitat for small mammals – prey species of western screech owl and short-eared owl
Ephemerally wet sites	Experimental planting of VI beggarticks; planting of mountain sneezeweed and wapato; habitat for native amphibians and not for bull frogs
Planting of diverse native species to create structural complexity	Enhances habitat diversity and forage resources for all species; limits bull frog and reed canary grass invasion; enhance populations of culturally valued species to create opportunities for traditional harvest and sustainable use
Placement of bird nest boxes and bat houses	Cavity-nesting bird species with focus on barn swallow and western screech owl, bat species with focus on Townsend's big eared bat and little myotis
Scraping soil at low bench sites to lower elevation to create marsh habitat	Foraging habitat for all priority vertebrates, especially great blue heron and sandhill crane

STUDY AREA

The study area is comprised of all riparian areas within the dike system along the South and North Alouette Rivers, between Harris Road and 224th Street, Pitt Meadows, BC (Figure 1a and b). In 2016, we implemented wetland restoration by creating tidal marsh and enhancing habitat for priority species at two sites adjacent to Harris Road (1 ha). In 2017, we will implement wetland restoration at a site (11 ha) near Neaves Road.

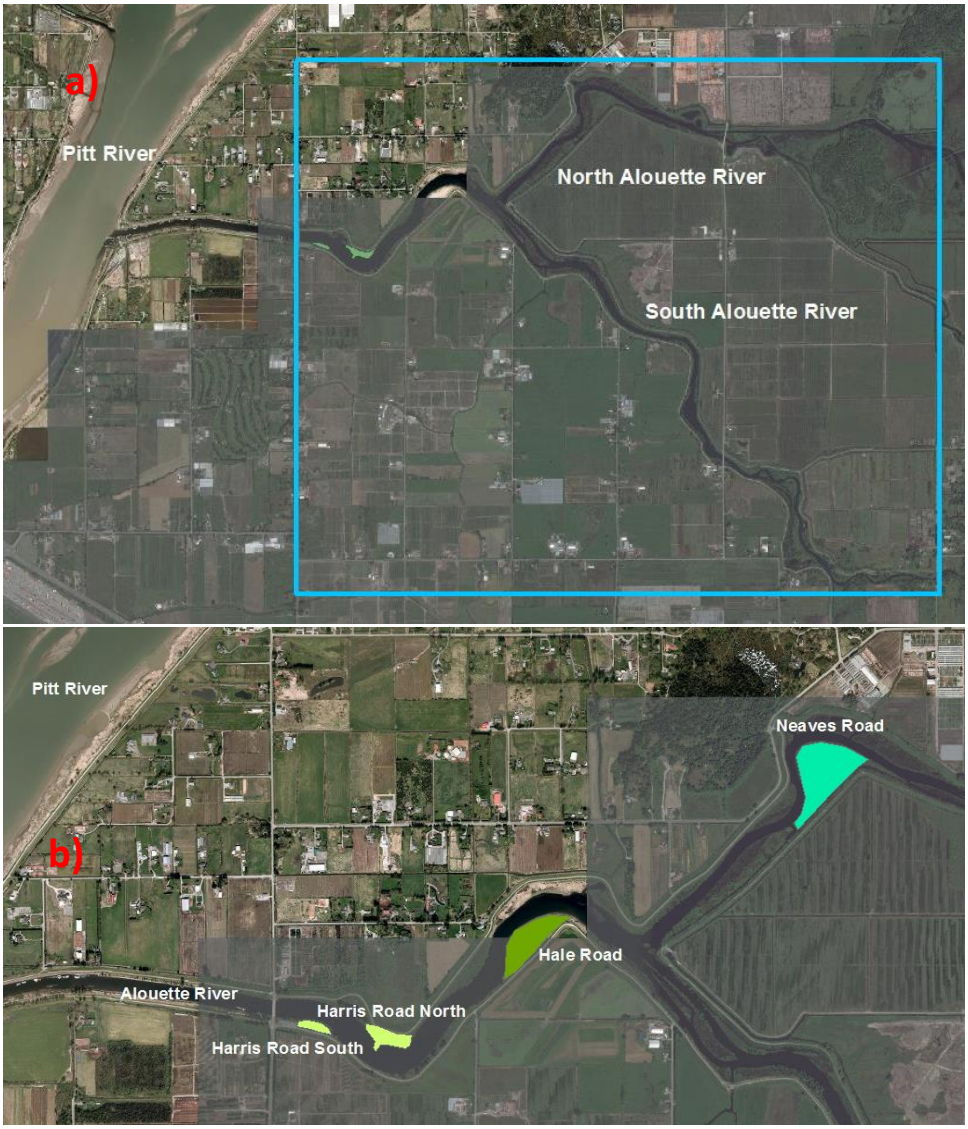

Figure 1. Location of the a). the study area (blue outline) and b) the Harris Road South and North restoration sites adjacent to the Harris Road bridge across the lower Alouette River in Pitt Meadows. The Hale Road site was completed in 2014 under a different FWCP project (Mitchell 2016); wetland restoration is planned for the Neaves Road site in 2017.

METHODS

Outreach

We planned for our outreach program to consist of outreach materials (posters for community events, a pamphlet, signage at restoration sites), a website, and a volunteer program for planting and monitoring of restoration sites.

Capacity Building

Capacity building was met via knowledge transfer and skills training from qualified professionals to Katzie staff at each stage of the implementation of wetland restoration, and of our effectiveness monitoring program. Capacity building also included training in data collection and management, data summary using Excel, and field skills including GPS navigation, survey design, and mapping of field data.

Wetland Restoration

The following methods detail actions we took to restore habitat and enhance habitat for priority species at two low bench sites along the lower Alouette River. Based on restoration site designs (Appendix 2) and using groundwater elevation data collected from monitoring wells, two tidal marshes were excavated on lateral banks of the Alouette River adjacent to Harris Road within dikes that protect surrounding farmland from freshet floods (Figure 1). Wetland restoration focused on creating a tidal marsh in which to plant wapato and tule, clearing a beach of vegetation to create nesting habitat for the painted turtle, and planting of a diverse shrub community including beaked hazelnut in place of reed canary grass. Site inventory was conducted and elevations were mapped on August 17 2016 to identify target excavation depths relative to the tidal fluctuation (Appendix 2). Mineral soils beneath the accumulated organic soils and reed canary grass roots were exposed via excavation to elevations that correlated with desirable native plant growth in nearby vegetated tidal marsh. Excavation was completed with a JD200 excavator on swamp pads 7-15 September 2016. Soils are a silty clay loam, with strong binding capacity and low erodability below the high water mark. Topsoil and excavated materials were placed in a berm between the exposed area and the existing dikes, being careful to remain a minimum of 3 m from the toe of the slope of the dikes. Berms were seeded with coastal re-vegetation seed mix and straw was spread on seeded areas to protect seeds from erosion caused by rain and wind.

Large red cedar stumps were anchored with stainless steel 3/8 aircraft cable to concrete roadside barriers (2.1 x 0.81 x 0.60 m) buried ~60 cm below ground surface. The wood was placed on the banks and in the center of excavated areas. Bird and bat shelter boxes have been constructed and will be erected in April 2017. Both sites were planted with native species on October 28-30, 2016 (Table 3). Planting prescriptions focused on culturally valued shrubs (e.g. beaked hazelnut) and aquatic species (wapato, tule), in addition to fruit-bearing shrubs, and species that typically grow well in wetland restoration sites.

Table 3. Quantities of native plant species planted at the Harris South and North restoration sites

Common Name	Scientific Name	Harris South		Harris North	
Trees and shrubs					
Black Cottonwood	*Populus balsamifera*	6		12	
Sitka Spruce	*Picea sitchensis*	6		6	
Cascara	*Rhamnus purshiana*	6		6	
Black Hawthorn	*Crataegus douglasii*	12		12	
Pacific Crab Apple	*Malus fusca*	6		12	
Red Elderberry	*Sambucus racemosa*	18		24	
Red-osier dogwood	*Cornus stolonifera*	12		24	
Nootka Rose	*Rosa nutkana*	48		48	
Black Twinberry	*Lonicera involucrata*	36		48	
Pacific Ninebark	*Physocarpos capitatus*	36		48	
Sweet Gale	*Myrica gale*	36		48	
Snowberry	*Symphoricarpos albus*	40		48	
Beaked Hazelnut	Corylus cornuta	6		18	
Saskatoon Berry	*Amelanchier alnifolia*	24		48	
Aquatic species					
		Plugs	**Pots**	**Plugs**	**Pots**
Wapato tubers*		150		150	
Tule (hard-stemmed bulrush)	*Schoenoplectus acutus*	150	30	150	30
Tule (soft-stemmed bulrush)	*S. tabernaemontani*	150	30	150	30
Beaked Sedge	*Carex rostrata*	150	40	150	40
Slough Sedge	*Carex obnupta*	150		150	
Sitka Sedge	*Carex aquatilis (sitchensis)*	150		150	
Common Spike-rush	*Eleocharis palustris*	150		150	
Narrow-leaved Bur-reed	*Sparganium emersum*	100		100	

* Cultivated by the Katzie First Nation in tanks

Effectiveness Monitoring

We initiated an effectiveness monitoring program in 2016, designed to describe and quantify vegetation, amphibian, and bird responses to our restoration efforts. We intend to continue monitoring each restoration site and the bird and amphibian community along the lower Alouette River for a minimum of five years post-restoration. We surveyed plants, amphibians, and birds at the Harris South and Harris North restoration sites prior to implementing restoration actions, and at control sites along the lower Alouette River. To evaluate restoration success at the Hale Road site (completed under another FWCP-funded project in 2014), we conducted bird surveys, which included auditory inventory of bullfrogs and bronze frogs, and monitored use of the barn swallow shelter.

Vegetation

Intertidal Transects

Vegetation in the intertidal zone was surveyed along five 75 m transects on the south and north side of the lower South Alouette River on September 12-14, 2016, between Neaves and Harris Road (Figure 2(a)). No attempt was made along transects to ensure that every species present was reported. Instead, species observed while walking transects at a normal pace were categorized as 'dominant', 'frequent', or 'rare'. Each transect contained five sampling plots spaced 15 m apart, in which relative abundance of all plant species present in the plots was estimated by visual assessment of percent cover.

Site Surveys

Prior to restoration works, vegetation was surveyed on September 2, 2016 within six randomly positioned 1 x 1 m plots within the Harris South and Harris North restoration sites (Figure 2). Relative abundance of all plant species present in the plots was estimated by visual assessment of percent cover. Using the same methods as the intertidal transects conducted upriver along the Alouette River, the intertidal zone at each restoration site was surveyed by walking at a normal pace; species observed were categorized as 'dominant', 'frequent', or 'rare'.

Figure 2. Location of a) transects for surveying intertidal vegetation and b) 1x1 m vegetation plots surveyed in September, 2016 at the Harris South and North restoration sites.

Amphibians

Surveys for amphibian egg masses were conducted according to established protocols (Pearson 2015) on March 24 2016 (pre-restoration) and March 17 2017 (post-restoration) along all water edges at the Harris South and North sites. Egg mass surveys were also conducted on March 30 2017 at the Neaves Road site (pre-restoration).

Birds

Point Counts

Birds were surveyed between 06:00-09:30 from June 15th to 20th 2016 during five minute point counts stationed (n = 37) at least 300 m apart along the dike on both sides of the lower south and north Alouette rivers (Figure 3). 'Control' stations were positioned more than 300 m from restoration sites, while 'site' stations were positioned on the dike at the centre of the long axis of restoration sites. Birds were surveyed by foot or from a canoe. The estimated location of all birds seen or heard was recorded on print outs of Google Earth satellite imagery within ~ 300 m radius around point count stations. Bird species was recorded using American Ornithologist's Union alpha-numerical codes, along with counts per species, detection cue (V=visual, C=call, S=song, D=drum, FA=fly around, FO=fly over), breeding status (Pair or Nest). Females and juveniles were noted when observed. Surveys were only conducted on mornings with low wind and when there was no precipitation.

Site Surveys

To more accurately determine breeding status, birds at the Harris South, Harris North, and Hale Road restoration sites were also surveyed during 20 minute point counts. These longer point counts were conducted on different days than five minute point counts, and were conducted on three mornings separated by at least three days. Only birds seen or heard within the restoration sites were recorded. Repeated observations of the same species at sites across all three visits, observations of females associated with males, and observations of adult birds carrying food were used to assess whether restoration sites comprised a portion of breeding territories and whether restoration sites likely contained nests.

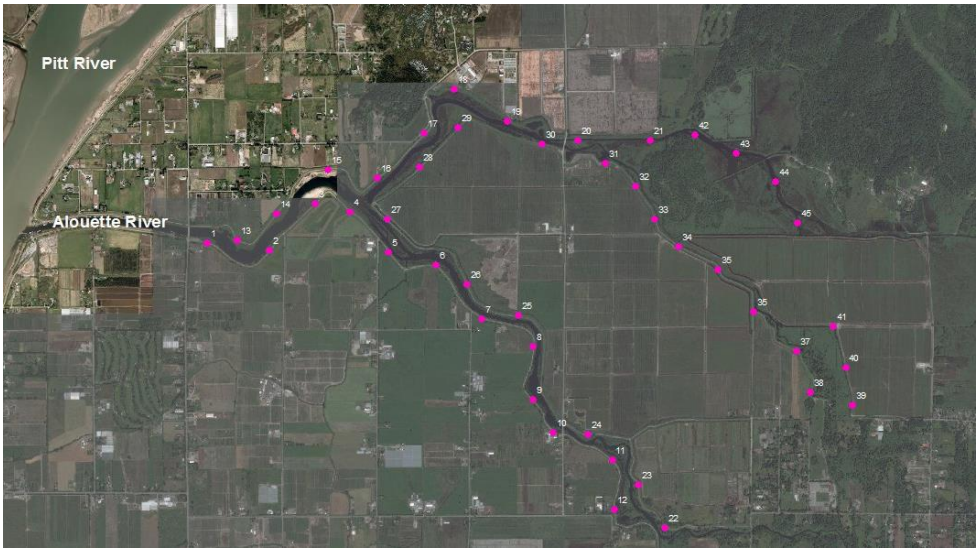

Figure 3. Locations of five minute point counts conducted in June 2016 along the lower Alouette River.

RESULTS

Outreach

The results of our outreach program are detailed in Appendix 1. Our website (www.katzienaturalresources.ca) is in the final stages of production and we plan to publish it by April 30 2017. The website will host our Eco-Cultural Restoration Plan, and details on our efforts in wetland and wapato restoration. Our focus for 2017 is to recruit volunteers to help us with site planting and monitoring. We anticipate that volunteer recruitment will be more successful in 2017 as a result of signage erected at the restoration sites, which refer members of the general public to our website, which will detail how community members can get involved.

Capacity Building

The following table is non-exhaustive list of the skills and knowledge transfer to Katzie staff during this project. Three Katzie staff participated in the Wetlands Institute week-long training in wetland restoration techniques in August-September 2016.

Skill and Knowledge	Number of staff trained	Training time (~days)
Data management in excel	3	0.5
Data summary using basic statistics in excel	3	1
Survey design and effectiveness monitoring	3	0.5
Use of GPS	2	1
GIS mapping and geospatial analysis using ArcGIS	1	3
GIS mapping using GoogleEarth	2	0.5
Vegetation cover mapping	1	0.5
Vegetation surveying	1	0.5
Identification of species at risk	2	1
Amphibian monitoring – egg mass surveys	2	6
Ground water elevation monitoring	2	1.5
Ground elevation surveying	1	0.5
All aspects of implementation of wetland restoration	3	12
Owl surveying using call playback	2	0.5

Wetland Restoration

We restored 1.0 ha of wetlands at two sites along the lower Alouette River by excavating the low bench to a lower elevation, anchoring large wood, and planting native species (Figures 4-6). The exposed areas were protected from potential high-energy flows associated with freshet and water releases from the upstream Alouette dam by retaining a 3-5 m wide berm of existing stable soils and grasses between the river and the excavated areas. Exposed soils were exposed to tidal waters by a wide, shallow-sloped channel at the downstream end of the project to allow backwater flow that would not scour exposed banks.

The base of the exposed marshes undulates to create varied topography that will support a variety of native tidal marsh species. Our primary target elevation was based on a narrow band of wapato in the adjacent river, and additional ledges and ‘shelves’ at elevations targeting sedge and bulrush. Low ‘lips’ in the marsh bottom promote shallow ponding (< 20 cm) within the constructed marshes to encourage

wapato and other forb and herb colonization. Elevations based on nearby wapato at Harris South were from 0.50 – 0.55 m above sea level (ASL), with additional target species from 0.40 – 0.9 m ASL. Elevations at Harris North were 0.55 – 0.60 m ASL, with additional target species from 0.45 – 0.9 m ASL.

Figure 4. Harris South restoration site pre-restoration (left) showing low bench 95% covered with reed canary grass, and post-restoration (right, view west) showing excavation to create tidal marsh and anchored large wood.

Figure 5. Harris North restoration site pre-restoration (left, view east) and post-restoration (right, view west) showing anchored large wood within excavation to create tidal marsh.

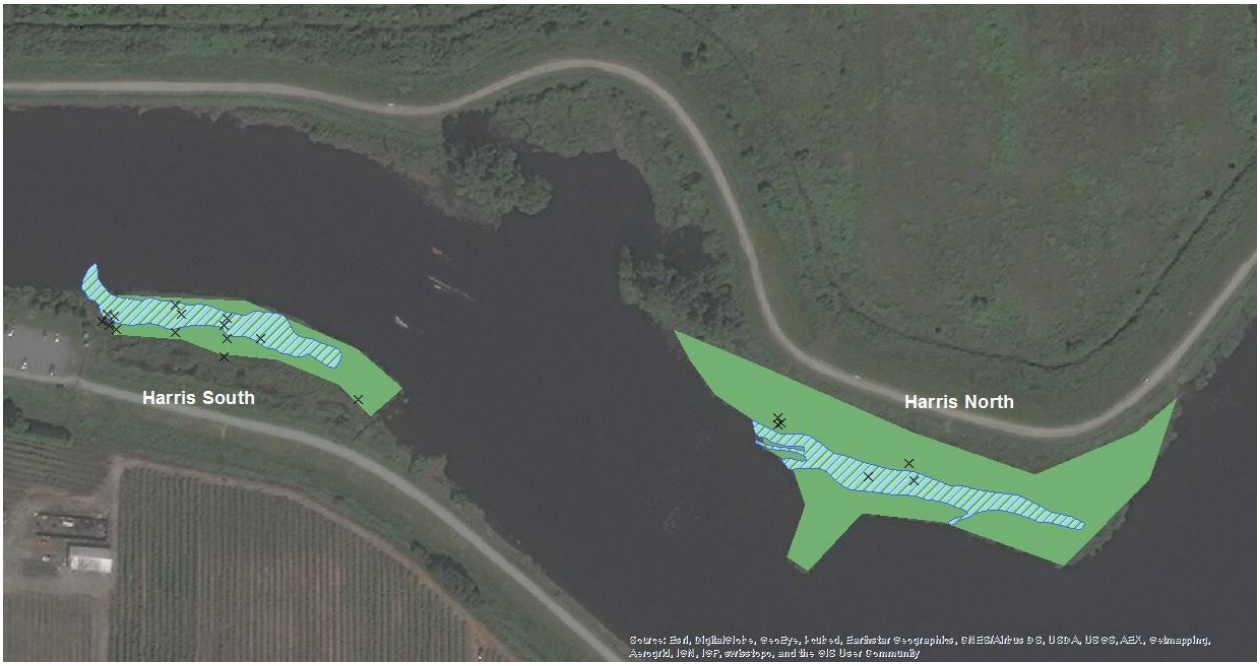

Figure 6. Final shape of excavations to create marsh habitat and locations of anchored wood at the Harris South and Harris North restoration sites.

Effectiveness Monitoring

Occurrences of Species at Risk

Vegetation and bird surveys conducted as part of our effectiveness monitoring program resulted in new occurrence records of species of conservation concern for the Alouette watershed (Table 4). Of particular significance is an occurrence of four clumps of well-established American sweet-flag within a 45 m length of the lower Alouette River, which was found while conducting intertidal vegetation surveys, and one occurrence of an adult western toad at the Harris North restoration site.

Table 4. Locations of species of conservation concern observed incidentally and during vegetation and bird surveys conducted in 2016

Common name	Scientific name	Status	Easting	Northing	Month	Day
American sweet-flag	*Acorus americanus*	Red	523231	5456706	October	12
Mountain sneezeweed	*Helenium autumnale var grandiflorum*	Blue	523122	5456754	September	2
Small spike-rush	*Eleocharis parvula*	Blue	523023	5456745	September	2
Flowering quillwort	*Lillaea scilloides*	Blue	523023	5456745	September	2
Pointed rush	*Juncus oxymeris*	Blue	524057	5457112	September	12
Western toad	*Anaxyrus boreas*	Special Concern	523027	5456789	June	10
Olive-sided flycatcher	*Contopus cooperi*	Threatened	527817	5457551	June	20
Band-tailed pigeon	*Patagioenas fasciata*	Special Concern	526777	5457021	June	15

Vegetation

Prior to restoration works, the Harris South and North restoration sites are estimated to have been almost 100% covered by reed canary grass (Table 5). However, the intertidal zone is dominated by native species, and reed canary grass though present is much less dominant (Appendix 3). These results will be compared across years to vegetation cover across the restoration sites in the years post restoration, while the intertidal zones of restoration sites will be compared to control sites along the Alouette River which show similar dominance by native species at most sites (Appendix 4). Future work will focus on determining whether there are any site conditions that correlate with dominance by native species, which will be used to guide priorities for choosing future restoration sites.

Table 5. Percent cover of plant species in 1 x 1 m survey plots randomly placed within the Harris South and Harris North restoration sites

Plot	Scientific name	Common name	Percent cover
Harris South			
1	*Phalaris arundinacea*	reed canarygrass	100.0
2	*Phalaris arundinacea*	reed canarygrass	100.0
3	*Phalaris arundinacea*	reed canarygrass	100.0
4	*Phalaris arundinacea*	reed canarygrass	100.0
5	*Phalaris arundinacea*	reed canarygrass	100.0
6	*Phalaris arundinacea*	reed canarygrass	100.0
Harris North			
1	*Carex sitchensis*	Sitka sedge	0.5
1	*Galium trifidum*	small bedstraw	0.5
1	*Phalaris arundinacea*	reed canarygrass	100.0
2	*Phalaris arundinacea*	reed canarygrass	100.0
3	*Lathyrus palustris*	marsh pea	1.0
3	*Phalaris arundinacea*	reed canarygrass	100.0
4	*Phalaris arundinacea*	reed canarygrass	100.0
5	*Phalaris arundinacea*	reed canarygrass	100.0
6	*Carex obnupta*	slough sedge	7.0
6	*Equisetum fluviatile*	swamp horsetail	5.0
6	*Galium trifidum*	small bedstraw	0.5
6	*Juncus balticus*	Baltic rush	2.0
6	*Lathyrus palustris*	marsh pea	3.0
6	*Phalaris arundinacea*	reed canarygrass	85.0

Amphibians

Surveys for egg masses at the Harris South and North restoration sites did not result in any observations of egg masses. Egg masses (n=18) of the northwestern salamander were observed at the Neaves Road site within the channel adjacent to the dike. No other native amphibians were observed in 2016, with the exception of one adult western toad observed incidentally at the Harris North site on June 10, 2016, and one northwestern garter snake observed incidentally at the Harris South site on June 7, 2016.

Birds

Point Counts

Point count surveys resulted in a geo-referenced database of bird detections around point counts (Figure 7, Appendix 5). The database will be used in the future to relate birds to vegetation cover to support wetland restoration planning and effectiveness monitoring. Of the 520 birds seen or heard during five survey mornings in June, 60% of detections were of 10 frequently-detected species. The common yellowthroat, willow flycatcher, and marsh wren were the most frequently detected species along the low bench riparian zone within the dike (Appendix 5). Common yellowthroat males and females were frequently observed on low shrubs, and willow flycatchers were more often detected as males singing from tall shrubs. Marsh wrens were the only species observed almost exclusively within the reed canary grass. Combined these three species comprised 25% of all detections. The spotted towhee, American robin, and song sparrow were frequently observed within low and tall shrubs, and the savannah sparrow was only observed in hayfields adjacent to the dike. Bird species richness was higher in areas where reed canary grass low benches contained shrubs (Katzie First Nation, unpublished mapping). The remaining 3 of the 10 frequently-detected species were swallows – at least 20 individuals each of the barn, tree, and cliff swallow were recorded. Cliff swallows were only observed in the upriver portion of the surveyed area. Multiple and frequent observations of the barn swallow and great blue heron were made throughout the study area, and sandhill crane pairs were seen or heard on several occasions foraging in adjacent agricultural fields.

Site Surveys

We determined that the marsh wren and common yellowthroat likely held all or a portion of their breeding territories both at pre-restoration sites (Harris South and North), and at the post-restoration Hale Road site (Table 6) during three visits to each site in June 2016. A marsh wren pair likely nested in the reed canary grass ~1.5 m from the water edge at the Harris South site. In addition, we observed no species using the shelter in the centre of the Hale Road site. During each visit, small flocks of barn swallows (3-5) were observed flying over the created wetland, and one great blue heron was observed at the edge of the center pond or within the created marsh on each of three visits. A female mallard and belted kingfisher pair were observed on one survey foraging in the central pond.

Table 6. Evaluation of use of three restoration sites along the lower Alouette River as breeding habitat by birds, June 2016

Site	Species	Nest		Territory	
		Likely	Possible	Likely	Possible
Harris South	Marsh wren	1			
	Common yellowthroat			1	
Harris North	Marsh wren			2	
	Common yellowthroat			1	
Hale Road	Marsh wren			2	
	Common yellowthroat			2	
	Song sparrow			1	
	Rufous hummingbird			1	
	Northern flicker			1	

Figure 7. Geo-referenced bird detections during five minute point counts around point count #5 along the lower Alouette River, June 2016

DISCUSSION

Wetland Restoration

One main benefit of this project was the creation of 1 ha of tidal marsh habitat within a region with extensive loss of wetland habitat due to a hydro-electric dam and water diversion, as well as the dike system. Equally of benefit, this project resulted in significant capacity building within the Katzie First Nation in wetland restoration planning and implementation. We intend to apply and extend these new skills to a larger site (~10 ha) near Neaves Road along the lower Alouette River in 2017.

Creation of marsh habitat will result in long-term benefits to the biodiversity of the region, and at least medium term benefits for a wide range of species, including as foraging habitat for the great blue heron, sandhill crane, pacific water shrew, short-eared owl, and western screech owl. We derived specific priority restoration actions for species of conservation concern from management documents (Table 2). Overall, sites were designed to be structurally complex, to create conditions that promote species diversity and thus ecosystem resilience, especially to invasive species. We also designed sites for accessible use of culturally-valued plants, particularly wapato and tule, to create opportunities for members of the Katzie and wider community to learn about and participate in traditional practices. We are currently assessing planting success at the restoration sites, and will be completing more planting at each site in April 2017.

Effectiveness Monitoring

Pre-restoration inventory shows that the low bench floodplain between the dikes was more than 95% covered by reed canary grass, whereas native species dominated in the intertidal zone. Bird surveys show that three species primarily characterize the reed canary grass low bench riparian – marsh wren, common yellowthroat, and willow flycatcher. Surveys suggest that replacement of the reed canary grass with shrubs will benefit a wide range of species, since most species were observed using shrubs while only the marsh wren was observed primarily in the reed canary grass. We will compare pre-restoration use of the sites for breeding, which was limited to just the marsh wren and common yellowthroat, with use in the years post-restoration.

Egg mass surveys conducted in March suggest that native amphibians did not breed at the sites, but an adult western toad was found incidentally on wood within the reed canary grass bench at the Harris North site. It is unlikely that the western toad bred at the site, and instead may have migrated from the Pitt River, given the long distance movements known for this species (COSEWIC 2002).

Completed in 2014, the Hale Road restoration site was observed to provide habitat for great blue herons and barn swallows. During each visit, small flocks of barn swallows (3-5) were observed flying over the created wetland, and one great blue heron was observed at the edge of the center pond or within the created marsh on each of three visits. A female mallard and belted kingfisher pair were observed on one survey foraging in the central pond. Pre-restoration observations of bird use of the Hale Road noted that great blue herons were observed foraging in the intertidal zone (Mitchell 2016). Given that the site itself was a low bench covered almost exclusively with reed canary grass, it likely did not provide suitable habitat for these species prior to creation of the marsh and ponds. However, a bull frog was heard calling from the ponds on each visit, which confirms the importance of creating ponds that dry in the summer as a strategy to control bull frog invasion at restoration sites.

We are currently conducting surveys for owls along the lower Alouette River. Combined with data on vegetation, amphibian, and birds collected as part of our effectiveness monitoring, the results of our monitoring program will allow us to measure success in wetland restoration, prioritize future sites for restoration, while also collecting useful data on the distribution of priority species.

RECOMMENDATIONS

We were unable to initiate a cottonwood planting program in 2016 due to expressions of concern by members of the community that cottonwoods planted along the lower Alouette River could block the 'view'. It is possible that great blue herons no longer nest along the lower Alouette River (last nesting occurred prior to 2011 at Coniagas Channel) because they lack a suitable platform provided by large diameter trees. To nest in larger colonies successfully, great blue herons may require large diameter trees on which they can form a circular colony. Cottonwoods are planted linearly along the lower Alouette River, those currently growing are susceptible to blowdown, and there is almost no recruitment. We recommend a watershed-scale cottonwood planting program for the lower Alouette River involving BC Hydro, private landowners, local government, and community groups for the benefit of nesting great blue heron and a wide range of cavity-using species, and to improve biodiversity in the region overall.

ACKNOWLEDGEMENTS

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APPENDIX 1. Summary of Outreach Program

Outreach Format	Details
Website (draft)	http://www.katzienaturalresources.ca
Signage at restoration sites (see below)	To be erected in April 2017
Posters and information booth	Pitt Meadows Day, June 2016
	Opening ceremony, Katzie Elementary School
	Rivers Day, Alouette River Management Society, September 2016
	Katzie Culture Day, Katzie Health Center, October 2016
Presentations	Wetlands Institute, August 2016
	Katzie Education Awards, January 2017
	Canadian Wildlife Service, Seminar series, November 2016
	K.E.E.P.S., Board of Directors meeting, November 2016
Media	Full page (3) cover story in 'The News' Maple Ridge and Pitt Meadows

Mike Leon, Katzie First Nation, "Build a Wetland" workshop, Rivers Day September 2016

Eco-Cultural Restoration Poster

Wapato Restoration Poster

Eco-Cultural Restoration in Katzie Traditional Territory

Using science and traditional knowledge to support cultural revitalization and ecosystem restoration

Since the late 1800's, about 80% of wetlands in the Alouette River watershed have been lost or degraded due to diking, land conversion, the spread of invasive species, and changes in the river's flow. These changes resulted in localized scarcity of wetland plants that were important for thousands of years to the livelihood of Katzie people for technology, food and medicine. At this site in 2016, we created a wetland and planted culturally-valued plants, so that people can once again harvest from the land and reconnect to ancient cultural traditions that promote healthy lives and ecosystems. We also created and enhanced habitat for species of conservation concern, like the great blue heron.

Restoring Culturally Valued Plants

wapato in bloom

Wapato (x̌ʷəq̓ʷáwɬs) is an aquatic plant that produces starchy, potato-like tubers. Prior to the arrival of Europeans, wapato tubers were extensively cultivated and harvested by the Katzie (q̓íc̓əy̓) people as a diet staple for thousands of years. The loss and degradation of over 80% of wetlands in Katzie traditional territory has meant that Katzie people no longer have access to wapato as a traditional food. We are working to restore wapato by planting and harvesting wapato in the wild, and in tanks in our backyards.

In addition to planting wapato here, we have also planted tule (wí·lʼ), Pacific crabapple (qʷəʔáp), beaked hazelnut (tᵊíc̓əmətp), and black hawthorn (méc̓ənətp). Tule was once used by Katzie women to make baskets (sítən) and mats (sɬéwən). The fruit of Pacific crabapple and beaked hazelnut were stored for winter food. The hard wood of black hawthorn was valued for making tools, for example, the thorns were used to make rakes (ɬə́t̓əmən̓) to harvest spawning eulachon .

thorns of black hawthorn

wapato tubers

tule

Photos by R. Leon

Words in brackets are translations in Halkomelem, the traditional language of the Katzie people.

www.katzienaturalresources.ca

With support from FWCP Fish & Wildlife Compensation Program; This project was undertaken with the financial support of: Ce projet a été réalisé avec l'appui financier de : Environment and Climate Change Canada / Environnement et Changement climatique Canada; vancouver foundation; City of Pitt Meadows The Natural Place

Signage at Harris South restoration site (to be erected in April 2017)

Eco-Cultural Restoration in Katzie Traditional Territory

Using science and traditional knowledge to support cultural revitalization and ecosystem restoration

Since the late 1800's, about 80% of wetlands in the Alouette River watershed have been lost or degraded due to diking, dams, land conversion, and the spread of invasive species. These changes resulted in localized scarcity of wetland plants were important for thousands of years to the livelihood of Katzie people for technology, food and medicine. At this site and another just across the river, we created a wetland and planted culturally-valued plants, so that people can once again harvest from the land and reconnect to ancient cultural traditions that promote healthy lives and ecosystems. We have also created habitat to support species of conservation concern, like the great blue heron and western toad, which are listed under Canada's Species at Risk Act.

Restoring Habitat for Species of Conservation Concern

We created a freshwater tidal marsh at this site by excavating the meadow covered by reed canary grass to a lower elevation. Reed canary grass is a highly invasive species – it's the grass you see growing everywhere along the dike. By replacing reed canary grass with a marsh (máqʷəm) planted with native species, we have increased habitat diversity for the benefit of many species, including amphibians, birds, and bats.

western toad (x̌áməlaɬce)

We also added large pieces of wood, which act as refuge sites for amphibians and small mammals, and we put up shelter boxes for bats and birds. Diking, damming, and urban development have resulted in fewer large old trees and thus a lot less decaying wood along the river. Of particular concern is the loss of old and decaying cottonwoods. These are preferred by woodpeckers like the northern flicker for excavating nest cavities. Once woodpeckers are finished nesting, their cavities are used by a wide range of other species, including owls and bats.

northern flicker (tᵊíqt)

great blue heron (sməq̓ʷaʔ)

Photos by R. Leon and K. Squires

By adding wood, putting up shelter boxes, and planting cottonwood trees, we are helping to compensate for the loss of big old trees and the habitat they provide along the banks of the Alouette River. www.katzienaturalresources.ca

Words in brackets are translations in Halkomelem, the traditional language of the Katzie people.

With support from FWCP Fish & Wildlife Compensation Program; This project was undertaken with the financial support of: Ce projet a été réalisé avec l'appui financier de : Environment and Climate Change Canada / Environnement et Changement climatique Canada; vancouver foundation; City of Pitt Meadows The Natural Place

Signage at Harris North restoration site (to be erected in April 2017)

Have you seen this turtle?

The western painted turtle is an endangered species. It once lived along the Alouette River, but no longer occurs here due to the loss of habitat. To encourage their return, hatchling western painted turtles were recently released into this watershed. We cleared the vegetation from this beach so that females can more easily lay their eggs.

You can help us with painted turtle conservation by please staying off the beach, and by keeping an eye out for them! You are most likely to see one basking on a log in the sun. Western painted turtles can be confused with red-eared sliders, a non-native turtle that people keep as pets. You can tell them apart by the red mark on the side of the slider's head.

If you see a western painted turtle please contact us through our website **katzienaturalresources.ca**

Signage at Harris South restoration site (to be erected in April 2017)

APPENDIX 2. Restoration Planning and Design

Elevation Mapping

The Harris Road South site is comprised of a lateral bar on the south bank of Alouette River (Figure A1 and A2 (a)). Narrow tidal mud flats are colonized by *Nuphar, Potamogeton, Saggitaria* (wapato), Carex, *Scirpus, Juncus* and *Equisetum*. Main body of the bar is colonized by *Phalaris arundinacea*, and *Rosa* dominate a longitudinal berm that parallels the Municipal dike to the south. Daily tides fluctuate approximately 0.4 - 1.1 m ASL, with annual freshets reaching 2.2 m with occasional higher elevation floods.

The Harris Road North site is comprised of a lateral bar on north bank of the Alouette River (Figure A1 and A2 (b)). Very narrow tidal flats with occasional *Saggitaria* below steep banks. Main body of the bar is colonized by *Phalaris arundinacea*, and *Spirea* dominate at the bank towards the Municipal dike to the north. Daily tides fluctuate approximately 0.4 - 1.1 m ASL, with annual freshets reaching 2.2 m with occasional higher elevation floods.

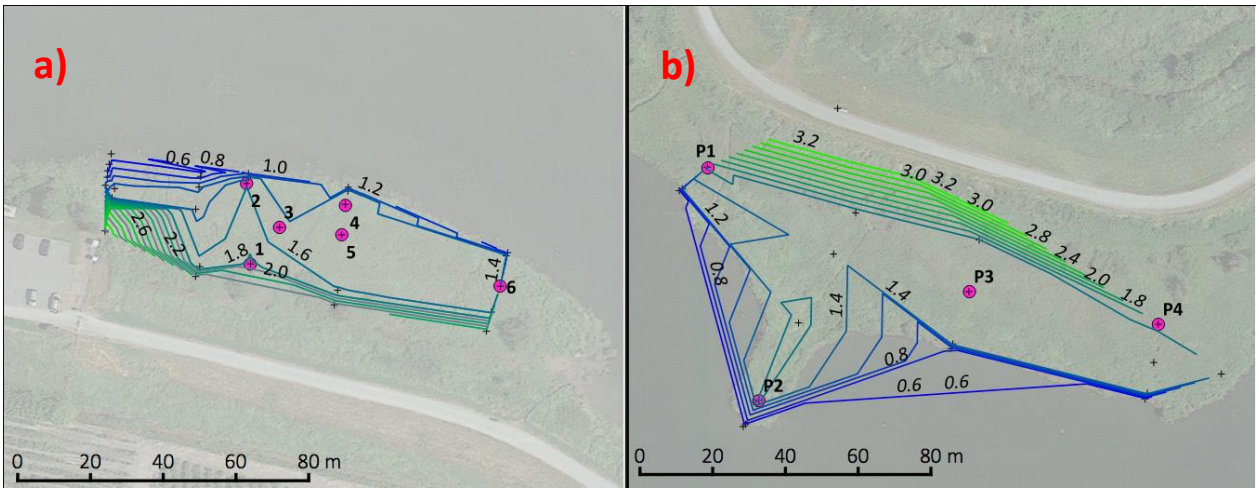

Figure A1. Map of elevations (m) at the Harris Road South (a) and North (b) sites.

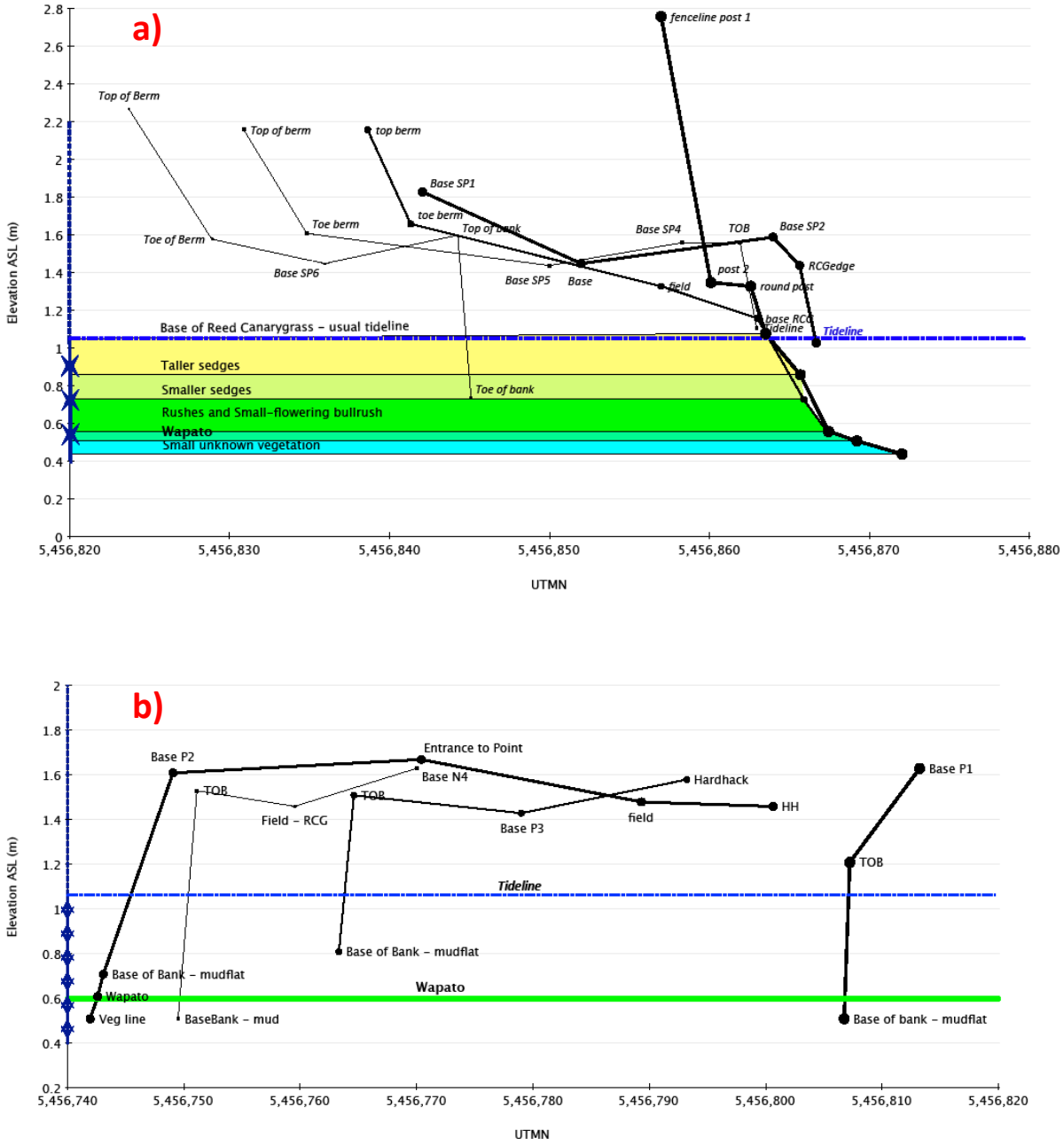

Figure A2. Cross-sectional elevation profiles of the Harris Road South (a) and North (b) restoration sites.

Harris Road South Restoration Plan - Tidal Marsh and Beach Restoration

Existing Conditions:

- 0.4 ha target area.
- Reed canary grass monoculture > 1.1 m elevation.
- Narrow tidal flats along north edge with sparse native vegetation.
- East-west berm at south edge of target area with native plants, likely planted, dominated by Rosa sp.
- Freshwater tidal influence with daily fluctuations between 0.4 and 1.1 m ASL.
- Soils dominated by silty clay loams
- Sandy beach at east end of sidebar being overgrown by grasses.

Constraints

- No works within 3 m of toe of slope of Pitt Meadows flood dike.
- Retain berm along water to maintain existing defences (rooted grasses) against erosive flow, min 5 m width.

Desired Outcomes:

- Beach improved to attract nesting of Western Painted Turtles. Increase area of freshwater marsh
- Target aquatic conditions for Wapato (*Saggitaria*) and Bullrush (*Scirpus*) growth, among a diverse native community.
- Target riparian conditions for Hazelnut, crab-apple, salmonberry, and thimbleberry.
- Provide educational boardwalk.

Actions

- Clean grasses off beach, raise with imported sands if necessary, and protect with a fence.
- Excavate marshes to target elevations for Wapato, Bulrush and Sedge species, retain protective berm between excavation and marsh (Figure A3 (a)). Provide narrow (2-3 m) opening at downstream end in Year 1 to limit tidal flows and reduce potential erosive forces; increase width of opening in Year 2 to increase tidal influence on marshes.
- Install and anchor large woody debris.
- Pile spoil along existing berm; salvage native vegetation on north edge of berm for replanting. Compact spoil then roughen surface to reduce erosive forces of spring freshet.
- Seed heavily with perennial grasses and legumes; consider narrow wattle fences if banks still friable in late October. Plant shrubs.

Harris Road North Restoration Plan - Tidal Backwater Marsh Excavation

Existing Conditions:

- 0.8 ha target area.
- Reed Canarygrass monoculture > 1.1 m elevation.
- Steep bank to very narrow mudflats on south edge.
- *Spiraea* scattered on north edge and along steep banked berm, providing protection from erosion.
- Freshwater tidal influence with daily fluctuations between 0.4 and 1.1 m ASL.
- Soils dominated by silty clay loams

Constraints

- No works within 3 m of toe of slope of Pitt Meadows flood dike.
- Retain berm along water to maintain existing defences (rooted grasses & Spiraea) against erosive flow, min 5 m width.

Desired Outcomes:

- Target aquatic conditions for Wapato (*Saggitaria*) and Bullrush (*Scirpus*) growth, among a diverse native community.
- Target riparian conditions for Hazelnut, crab-apple, salmonberry, and thimbleberry.

Actions

- Excavate marshes to target elevations for Wapato, Bulrush and Sedge species, retain protective berm between excavation and marsh (Figure A3 (b) and A4). Provide narrow (2-3 m) channels to Alouette to limit tidal flows and reduce potential erosive forces; increase width of opening in Year 2 if necessary to increase tidal influence on marshes.
- Install and anchor large woody debris in and around marsh.
- Pile spoil north of excavation; salvage native vegetation for replanting. Compact spoil then roughen surface to reduce erosive forces of spring freshet. Seed heavily with perennial grasses and legumes. Plant native shrubs. Consider narrow wattle fences if spoil still friable in late October.

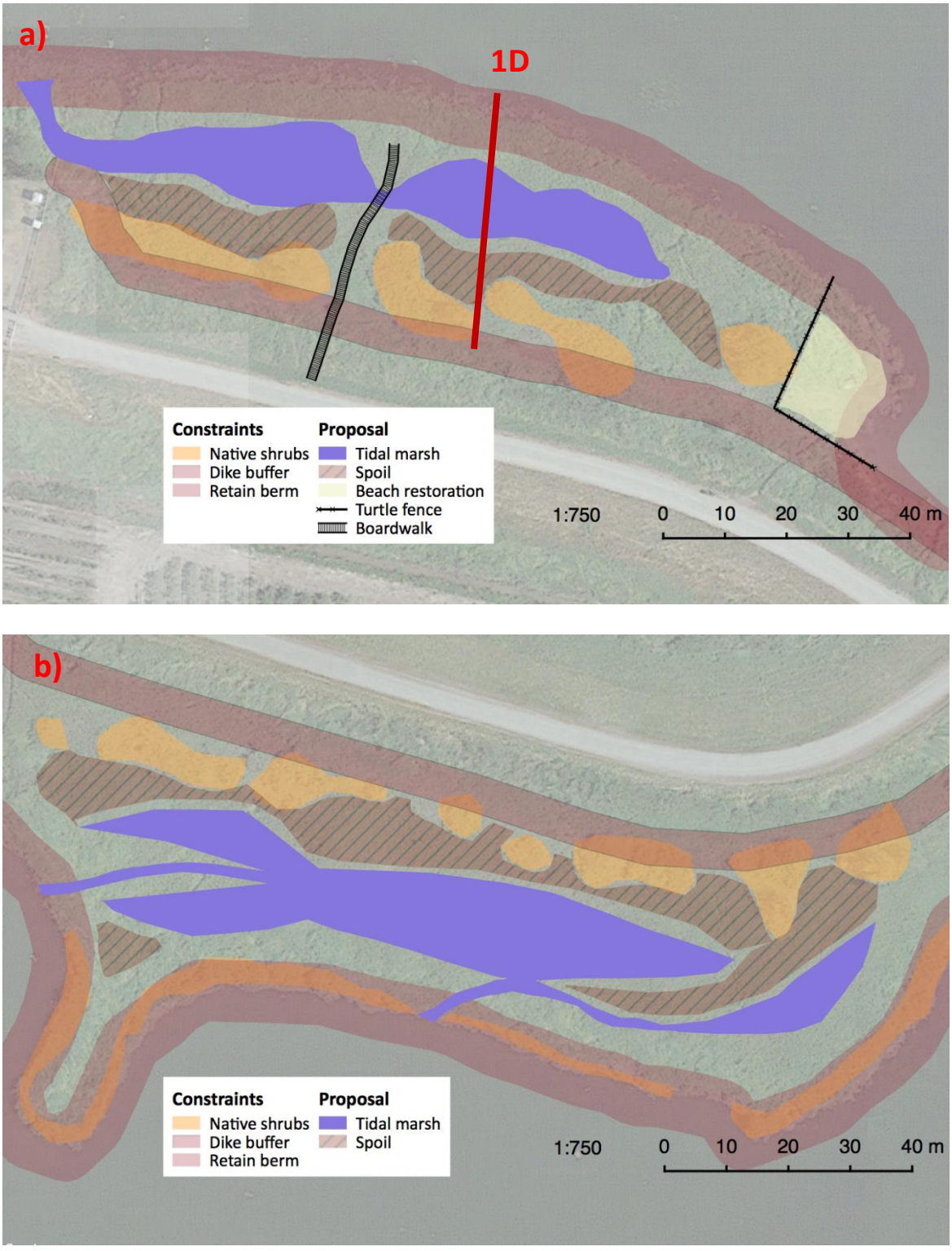

Figure A3. Proposed site design for (a) Harris Road South and (b) Harris Road North.

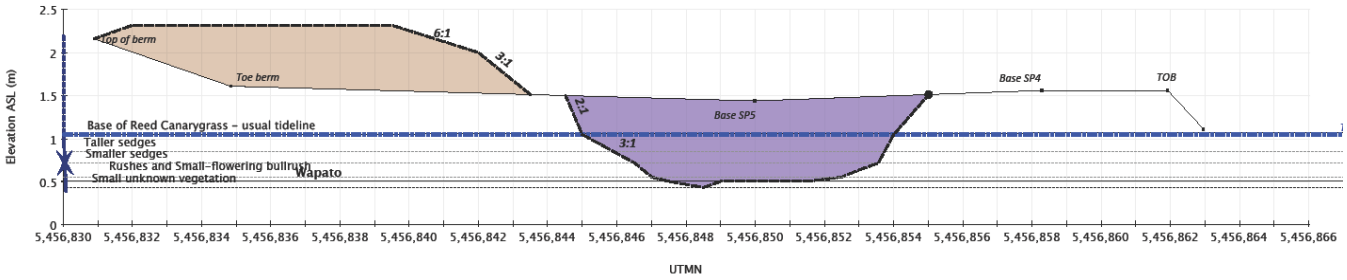

Figure A4. Sample profile at 1D (Figure A3(a)) at the Harris Road South restoration site.

Erosion Control Strategies

Erosive forces will impact exposed slopes, with separate strategies were required for the excavation zone and spoil piles. Exposed soils are silty clay loams with a high clay content, and appear relatively stable. Other restoration projects in the area that have been exposed to tidal fluctuation and freshets appear to have kept their as-built shape with little sloughing or significant change.

Excavation Zone

Excavated banks will be exposed to daily tidal fluctuations in an 0.7 m band from approximately 0.4 - 1.1 m ASL. No wave action is present. Existing banks are protected by Phalaris and Spiraea roots at the daily tide-line, but not below. Erosion control strategies will include:
1)Retain protective berm between excavated areas and Alouette River (min 5 m width).
2) Cut steep slopes (1:1 to 2:1) to reduce area exposed and encourage self-sealing by *Phalaris* root mats above tide line.
3) Shallow slopes in tidal flats (>7:1) to encourage vegetation growth.
4) Open connecting channel to Alouette at end of project (work upstream - downstream). Minimize connecting channel width in Year 1 to allow tidal flows at reduced rates; open channel to final width in Year 2 or 3 after cut banks have stabilized.

Spoil Piles

Exposed soils of excavated spoil piles will be subject to erosive forces from precipitation, with fall rains providing the initial assault, as well as by daily tidal fluctuations during the Spring freshet at an anticipated elevation of 2.2 m. Erosion control strategies will include:
1) Place spoil away from river, and protect upstream edges with existing vegetation.
2) Shallow slopes (>3:1) to reduce erosive forces from rainfall.
3) Compact spoil piles using excavator during extraction, followed by roughing of the surface with thumbs (top 30-50 cm) and immediate heavy seeding with perennial and legume mix such as Coastal Revegetation Mix. Protect seed with hay mulch. Successful heavy seeding will be critical to protect spoil piles against the freshet in May following construction.
4) Plant salvaged shrubs immediately. Install additional plants in early fall, following start of fall rains.
5) Install wattle fencing if significant erosion (indicated by rilling or sheet erosion) is occurring following the first fall rains despite above measures.

APPENDIX 3. Survey Data for Intertidal Vegetation – Restoration Sites

Species recorded in the intertidal zone of Harris South restoration site			Species abundances at elevation**		
Scientific	**Common**	**Status***	**Low**	**Mid**	**High**
Alisma triviale	American water-plantain	Y	1	3	-
Bidens tripartita	three-parted beggarticks	**E**	1	1	-
Callitriche stagnalis	pond water-starwort	**E**	-	2	-
Carex obnupta	slough sedge	Y	-	-	1
Carex sitchensis	Sitka sedge	Y	-	-	2
Ceratophyllum demersum	common hornwort	Y	1	-	-
Eleocharis obtusa	blunt spike-rush	Y	1	2	-
Eleocharis palustris	common spike-rush	Y	1	3	-
Eleocharis parvula	small spike-rush	B	-	1	-
Equisetum fluviatile	swamp horsetail	Y	-	1	-
Galium trifidum ssp. *trifidum*	small bedstraw	Y	-	-	1
Glycera borealis	northern mannagrass	Y	-	-	1
Gratiola ebracteata	bractless hedge-hyssop	Y	1	2	-
Hypericum boreale	northern bog St. John's-wort	**E**	-	-	1
Iris pseudacorus	yellow iris	**E**	-	-	1
Juncus acuminatus	tapered rush	Y	-	-	1
Juncus tenuis	slender rush	Y	-	-	2
Lilaeopsis occidentalis	western lilaeopsis	Y	1	1	-
Limosella aquatica	water mudwort	Y	1	-	-
Ludwigia palustris	water-purslane	Y	2	2	-
Lycopus americanus	cut-leaved water horehound	Y	-	-	1
Lysimachia terrestris	bog loosestrife	**E**	-	-	1
Lythrum salicaria	purple loosestrife	**E**	-	-	1
Myosotis scorpiodes	European forget-me-not	**E**	-	1	-
Myriophyllum hippuroides	western water-milfoil	Y	2	3	-
Nymphaea sp.	water lily	**E**	1	2	-
Persicaria hydropiperoides	water-pepper	Y	2	3	-
Phalaris arundinacea	reed canarygrass	**E**	-	-	2
Potamogeton sp.	pondweed	Y	3	2	-
Ranunculus flammula	lesser spearwort	Y	-	-	1
Sagittaria latifolia var. latifolia	wapato	Y	-	2	-
Sium suave	hemlock water-parsnip	Y	-	-	1
Sparganium sp.	bur-reed	Y	2	3	-
Persiaria minor	asian knotweed	**E**	-	1	-

Species recorded in the intertidal zone of Harris North restoration site			Species abundances at elevation**		
Scientific	**Common**	**Status***	**Low**	**Mid**	**High**
Alisma triviale	American water-plantain	Y	-	2	-
Athyrium filix-femina	lady fern	Y	-	-	1
Callitriche stagnalis	pond water-starwort	E	1	1	-
Carex sitchensis	Sitka sedge	Y	-	-	1
Ceratophyllum demersum	common hornwort	Y	2	-	-
Eleocharis obtusa	blunt spike-rush	Y	-	1	-
Eleocharis parvula	small spike-rush	B	-	1	-
Galium trifidum ssp. *trifidum*	small bedstraw	Y	-	-	2
Glycera borealis	northern mannagrass	Y	-	1	-
Gratiola ebracteata	bractless hedge-hyssop	Y	2	1	-
Helenium autumnale var *grandiflorum*	mountain sneezeweed	B	-	-	1
Impatiens capensis	spotted touch-me-not	E	-	-	1
Iris pseudacorus	yellow iris	E	-	-	1
Juncus articulatus ssp. *articulatus*	jointed rush	Y	-	1	-
Lillaea scilloides	flowering quillwort	B	-	1	-
Limosella aquatica	water mudwort	Y	1	2	-
Lotus corniculatus	bird's-foot trefoil	E	-	-	1
Ludwigia palustris	water-purslane	Y	-	2	-
Lycopus americanus	cut-leaved water horehound	Y	-	-	1
Lysimachia terrestris	bog loosestrife	E	-	-	1
Lythrum salicaria	purple loosestrife	E	-	-	1
Mentha arvensis	field mint	Y	-	-	1
Myosotis scorpiodes	European forget-me-not	E	-	-	1
Myrica gale	sweet gale	Y	-	-	2
Myriophyllum hippuroides	western water-milfoil	Y	2	3	-
Nymphaea sp.	water lily	E	2	-	-
Persiaria minor	asian knotweed	E	-	1	-
Persicaria hydropiperoides	water-pepper	Y	1	2	-
Phalaris arundinacea	reed canarygrass	E	-	1	3
Potamogeton sp.	pondweed	Y	1	-	-
Potentilla norvegica	Norweigian cinquiefoil	Y	-	-	1
Prunella vulgaris spp. *vulgaris*	self-heal	E	-	-	1
Sagittaria latifolia var. latifolia	wapato	Y	-	-	1
Sium suave	hemlock water-parsnip	Y	-	-	1
Sparganium sp.	bur-reed	Y	2	1	-
Spiraea douglasii	hardhack	Y	-	-	2
Veronica anagallis-aquatica	blue water speedwell	E	-	-	1

*E = exotic (non-native); Y, B, R = CDC status of native species (Yellow, Blue, Red) ** 3= dominant, 2= frequent, 1= rare

APPENDIX 4. Survey Data for Intertidal Vegetation along the Lower Alouette River

Transect South 1			
Scientific	**Common**	**Status**	**Abundance**
Eleocharis palustris	common spike-rush	Y	Dominant
Ludwigia palustris	water-purslane	Y	Dominant
Myriophyllum ussuriense	Ussurian water-milfoil	Y	Dominant
Persicaria hydropiper	marshpepper smartweed	E	Dominant
Callitriche stagnalis	pond-water starwort	E	Frequent
Carex sitchensis	Sitka sedge	Y	Frequent
Juncus oxymeris	pointed rush	B	Frequent
Phalaris arundinacea	reed canarygrass	E	Frequent
Sparganium emersum	emersed bur-reed	Y	Frequent
Alisma triviale	American water-plantain	Y	Rare
Bidens tripartita	three-parted beggarticks	E	Rare
Eleocharis parvula	small spike-rush	B	Rare
Gratiola neglecta	American hedge-hyssop	Y	Rare
Impatiens capensis	jewelweed	E	Rare
Iris pseudacorus	yellow iris	E	Rare
Lilaea scilloides	flowering quillwort	B	Rare
Limosella aquatica	water mudwort	Y	Rare
Lysimachia terrestris	bog loosestrife	E	Rare
Lythrum salicaria	purple loosestrife	E	Rare
Mentha arvensis	field mint	Y	Rare
Nymphaea sp.	unidentified water-lily	E	Rare
Potomegaton sp.	water shield	Y	Rare
Sagittaria latifolia	wapato	Y	Rare
Schoenoplectus tabernaemontani	soft-stemmed bulrush	Y	Rare
Sium suave	hemlock water-parsnip	Y	Rare

Transect South 2			
Scientific	**Common**	**Status**	**Abundance**
Ludwigia palustris	water-purslane	Y	Dominant
Nymphaea sp.	unidentified pond-lily	E	Dominant
Bidens tripartita	three-parted beggarticks	E	Frequent
Carex sitchensis	Sitka sedge	Y	Frequent
Eleocharis palustris	common spike-rush	Y	Frequent
Juncus oxymeris	pointed rush	B	Frequent
Lysimachia terrestris	bog loosestrife	E	Frequent
Mentha arvensis	field mint	Y	Frequent
Myriophyllum ussuriense	Ussurian water-milfoil	Y	Frequent
Phalaris arundinacea	reed canarygrass	E	Frequent
Schoenoplectus tabernaemontani	soft-stemmed bulrush	Y	Frequent
Scirpus cyperinus	wool grass	Y	Frequent
Alisma triviale	American water-plantain	Y	Rare
Callitriche stagnalis	pond water-starwort	E	Rare
Carex utriculata	beaked sedge	Y	Rare
Eleocharis obtusa	blunt spike-rush	Y	Rare
Equisetum fluviatile	swamp horsetail	Y	Rare
Gratiola neglecta	American hedge-hyssop	Y	Rare
Iris pseudacorus	yellow iris	E	Rare
Lilaea scilloides	flowering quillwort	B	Rare
Lilaeopsis occidentalis	western lilaeopsis	Y	Rare
Limosella aquatica	water mudwort	Y	Rare
Lythrum salicaria	purple loosestrife	E	Rare
Myosotis scorpiodes	European forget-me-not	E	Rare
Najas flexilis	wavy water nymph	Y	Rare
Persicaria hydropiper	marshpepper smartweed	E	Rare
Persicaria minor	Asian knotweed	E	Rare
Sagittaria latifolia	wapato	Y	Rare
Sium suave	hemlock water-parsnip	E	Rare
Sparganium emersum	emersed bur-reed	Y	Rare

Transect South 3			
Scientific	**Common**	**Status**	**Abundance**
Persicaria hydropiper	marshpepper smartweed	E	Dominant
Phalaris arundinacea	reed canarygrass	E	Dominant
Callitriche stagnalis	pond water-starwort	E	Frequent
Ceratophyllum demersum	common hornwort	Y	Frequent
Ludwigia palustris	water-purslane	Y	Frequent
Myosotis scorpiodes	European forget-me-not	E	Frequent
Sparganium emersum	emersed bur-reed	Y	Frequent
Alisma triviale	American water-plantain	Y	Rare
Eleocharis obtusa	blunt spike-rush	Y	Rare
Glyceria elata	tall mannagrass	Y	Rare
Gratiola neglecta	American hedge-hyssop	Y	Rare
Iris pseudacorus	yellow iris	E	Rare
Limosella aquatica	water mudfowrt	Y	Rare
Lythrum salicaria	purple loosestrife	E	Rare
Myriophyllum ussuriense	Ussurian water-milfoil	Y	Rare
Najas flexilis	wavy water nymph	Y	Rare
Nymphaea sp.	unidentified pond-lily	E	Rare
Potamogeton sp.	unidentified pond weed	Y	Rare
Sagittaria latifolia	wapato	Y	Rare
Scirpus cyperinus	wool grass	Y	Rare
Typha latifolia	broad-leaved cattail	Y	Rare

Transect South 4			
Scientific	**Common**	**Status**	**Abundance**
Callitriche stagnalis	pond-water starwort	E	Dominant
Myriophyllum ussuriense	Ussurian water-milfoil	Y	Dominant
Phalaris arundinacea	reed canarygrass	E	Dominant
Carex sitchensis	Sitka sedge	Y	Frequent
Ceratophyllum demersum	common hornwort	Y	Frequent
Limosella aquatica	water mudwort	Y	Frequent
Eleocharis obtusa	blunt spike-rush	Y	Rare
Epilobium ciliatum	purple willowherb	Y	Rare
Gratiola neglecta	American hedge-hyssop	Y	Rare
Impatiens capensis	jewelweed	E	Rare
Lythrum salicaria	purple loosestrife	E	Rare
Myosotis scorpiodes	European forget-me-not	Y	Rare
Sparganium emersum	emersed bur-reed	Y	Rare

Transect South 5			
Scientific	**Common**	**Status**	**Abundance**
Callitriche stagnalis	pond-water starwort	E	Dominant
Phalaris arundinacea	reed canarygrass	E	Dominant
Alisma triviale	American water-plantain	Y	Frequent
Ceratophyllum demersum	common hornwort	Y	Frequent
Persicaria hydropiper	marshpepper smartweed	Y	Frequent
Sparganium emersum	emersed bur-reed	Y	Frequent
Eleocharis obtusa	blunt spike-rush	Y	Rare
Equisetum fluviatile	swamp horsetail	Y	Rare
Gratiola neglecta	American hedge-hyssop	Y	Rare
Impatiens capensis	jewelweed	E	Rare
Iris pseudacorus	yellow iris	E	Rare
Juncus articulatus	jointed rush	Y	Rare
Lilaea scilloides	flowering quillwort	B	Rare
Limosella aquatica	water mudwort	Y	Rare
Lythrum salicaria	purple loosestrife	E	Rare
Myriophyllum ussuriense	Ussurian water-milfoil	Y	Rare
Najas flexilis	wavy water nymph	Y	Rare
Persicaria lapathifolia	willow weed	Y	Rare
Persicaria minor	Asian knotweed	E	Rare
Potamogeton sp.	unidentified pondweed	Y	Rare
Schoenoplectus tabernaemontani	soft-stemmed bulrush	Y	Rare
Scirpus cyperinus	wool grass	Y	Rare

Transect North 1			
Scientific	**Common**	**Status**	**Abundance**
Carex sitchensis	Sitka sedge	Y	Dominant
Phalaris arundinacea	reed canarygrass	E	Dominant
Carex obnupta	slough sedge	Y	Frequent
Galium trifidum	small bestraw	Y	Frequent
Myosotis scorpiodes	European forget-me-not	E	Frequent
Myriophyllum ussuriense	Usssurian water-milfoil	Y	Frequent
Persicaria hydropiper	marshpepper smartweed	E	Frequent
Sagittaria latifolia	wapato	Y	Frequent
Alisma triviale	American water-plantain	Y	Rare
Bidens tripartita	three-parted beggarticks	E	Rare
Callitriche stagnalis	pond-water starwort	E	Rare
Equisetum fluviatile	swamp horsetail	Y	Rare
Gratiola neglecta	American hedge-hyssop	Y	Rare

Iris pseudacorus	yellow iris	E	Rare
*Isoetes*sp.	unidientified quillwort	Y?	Rare
Juncus effusus	common rush	Y	Rare
Limosella aquatica	water mudwort	Y	Rare
Ludwigia palustris	water-purslane	Y	Rare
Lysimachia terrestris	bog loosestrife	E	Rare
Lythrum salicaria	purple loosestrife	E	Rare
Mentha arvensis	field mint	Y	Rare
Potamogeton sp.	unidentified pondweed	Y?	Rare
Juncus oxymeris	pointed rush	B	Rare
Epilobium ciliatum	purple-leaved willowherb	Y	Rare

Transect North 2			
Scientific	**Common**	**Status**	**Abundance**
Callitriche stagnalis	pond-water starwort	E	Rare
Carex obnupta	slough sedge	Y	Rare
Galium trifidum	small bestraw	Y	Rare
Hypericum scouleri ssp. *scouleri*	western St. John's-wort	Y	Rare
*Isoetes*sp.	unidientified quillwort	Y?	Rare
Juncus articulatus	jointed rush	Y	Rare
Juncus effusus	common rush	Y	Rare
Limosella aquatica	water mudwort	Y	Rare
Ludwigia palustris	water-purslane	Y	Rare
Lysimachia terrestris	bog loosestrife	E	Rare
Lythrum salicaria	purple loosestrife	E	Rare
Myriophyllum ussuriense	Usssurian water-milfoil	Y	Rare
Phalaris arundinacea	reed canarygrass	E	Rare
Potentilla norvegica	Norweigan cinquefoil	Y	Rare
Rorippa palustris	marsh yellow cress	Y	Rare
Sagittaria latifolia	wapato	Y	Rare

Transect North 3			
Scientific	**Common**	**Status**	**Abundance**
Carex sitchensis	Sitka sedge	Y	Dominant
Phalaris arundinacea	reed canarygrass	E	Dominant
Myosotis scorpiodes	European forget-me-not	E	Frequent
Persicaria hydropiper	marshpepper smartweed	E	Frequent
Bidens tripartita	three-parted beggarticks	E	Rare
Callitriche heterophylla subsp. *bolanderi*	diverse-leaved water-starwort	Y	Rare
Callitriche stagnalis	pond-water starwort	E	Rare
Carex obnupta	slough sedge	Y	Rare
Eleocharis obtusa	blunt spike-rush	Y	Rare
Hypericum scouleri ssp. *scouleri*	western St. John's-wort	Y	Rare
Limosella aquatica	water mudwort	Y	Rare
Ludwigia palustris	water-purslane	Y	Rare
Lythrum salicaria	purple loosestrife	E	Rare
Myrica gale	sweet gale	Y	Rare
Myriophyllum ussuriense	Ussurian water-milfoil	Y	Rare
Nymphaea sp.	unidentified water lily	E	Rare
Sagittaria latifolia	wapato	Y	Rare
Scirpus cyperinus	wool grass	Y	Rare

Transect North 4			
Scientific	**Common**	**Status**	**Abundance**
Carex sitchensis	Sitka sedge	Y	Dominant
Phalaris arundinacea	reed canarygrass	E	Dominant
Persicaria hydropiper	marshpepper smartweed	E	Frequent
Alisma triviale	American water-plantain	Y	Rare
Bidens tripartita	three-parted beggarticks	E	Rare
Callitriche heterophylla subsp. *bolanderi*	diverse-leaved water-starwort	Y	Rare
Callitriche stagnalis	pond-water starwort	E	Rare
Carex utriculata	beaked sedge	Y	Rare
Ceratophyllum demersum	common hornwort	Y	Rare
Equisetum fluviatile	swamp horsetail	Y	Rare
Gratiola neglecta	American hedge-hyssop	Y	Rare
Juncus articulatus	jointed rush	Y	Rare
Limosella aquatica	water mudwort	Y	Rare
Ludwigia palustris	water-purslane	Y	Rare
Lythrum salicaria	purple loosestrife	Y	Rare
Myriophyllum ussuriense	Ussurian water-milfoil	Y	Rare
Persicaria minor	Asian knotweed	E	Rare

Sagittaria latifolia	wapato	Y	Rare

Transect North 5			
Scientific	**Common**	**Status**	**Abundance**
Sparganium emersum	emersed bur-reed	Y	Dominant
Sagittaria latifolia	wapato	Y	Frequent
Potamogeton sp.	unidentified pondweed	Y	Frequent
Phalaris arundinacea	reed canarygrass	E	Rare
Callitriche stagnalis	pond-water starwort	E	Frequent
Lythrum salicaria	purple loosestrife	E	Rare
Myriophyllum ussuriense	Ussurian water-milfoil	Y	Dominant
Alisma triviale	American water-plantain	Y	Rare
Lilaea scilloides	flowering quillwort	B	Rare
Callitriche heterophylla subsp. *bolanderi*	diverse-leaved water-starwort	Y	Rare
Persicaria hydropiper	marshpepper smartweed	E	Rare
Eleocharis obtusa	blunt spike-rush	Y	Rare
Epilobium ciliatum	purple-leaved willowherb	Y	Rare

Percent cover of plants within vegetation plots surveyed along transect South 1								
Scientific	**Common Name**	**Status**	**S1-1**	**S1-2**	**S1-3**	**S1-4**	**S1-5**	**Average**
Juncus oxymeris	pointed rush	B	1	0	0	0	0	0.2
Eleocharis parvula	small spike-rush	B	1	0	0	0	0	0.2
Phalaris arundinacea	reed canarygrass	E	2	0	3	0	5	2
Callitriche stagnalis	pond-water starwort	E	0		0	3	0	0.75
Bidens tripartita	three-parted beggarticks	E	0		0	0	1	0.25
Persicaria hydropiper	marshpepper smartweed	E	5		2	1	5	3.25
Eleocharis palustris	common spike-rush	Y	10	12	20	0	40	16.4
Ludwigia palustris	water-purslane	Y	4	4	10	7	13	7.6
Limosella aquatica	water mudwort	Y	1	0	0	0.5	0	0.3
Sagittaria latifolia	wapato	Y	1	0	0	0	0	0.2
Gratiola neglecta	American hedge-hyssop	Y	1	0	1	0	0	0.4
Myriophyllum ussuriense	Ussurian water-milfoil	Y	30	2	10	3	15	12
Carex sitchensis	Sitka sedge	Y	0	18	0	0	0	3.6
Potomegaton sp.	water shield	Y	0	1	0	0	0	0.2
Sparganium emersum	emersed bur-reed	Y	0	0	0	5	2	1.4
Bare Ground			44	63	54	80.5	19	52.1
Native			49	37	41	15.5	70	42.5
Exotic			7	0	5	4	11	5.4

Percent cover of plants within vegetation plots surveyed along transect South 2								
Scientific	**Common Name**	**Status**	**S2-1**	**S2-2**	**S2-3**	**S2-4**	**S2-5**	**Average**
Myosotis scorpiodes	European forget-me-not	E	20.0	0.0	12.0	0.0	0.0	6.4
Bidens tripartita	three-parted beggarticks	E	1.0	0.0	0.0	0.0	1.0	0.4
Persicaria hydropiper	marshpepper smartweed	E	0.0	0.5	1.0	0.0	0.0	0.3
Phalaris arundinacea	reed canarygrass	E	0.0	0.0	5.0	0.0	3.0	1.6
Callitriche stagnalis	pond water-starwort	E	0.0	0.0	5.0	0.0	0.0	1.0
Lythrum salicaria	purple loosestrife	E	0.0	0.0	0.0	3.0	0.0	0.6
Persicaria minor	Asian knotweed	E	0.0	0.0	0.0	0.0	1.0	0.2
Najas flexilis	wavy water nymph	Y	15.0	35.0	0.0	0.0	6.0	11.2
Carex utriculata	beaked sedge	Y	15.0	0.0	0.0	0.0	0.0	3.0
Ludwigia palustris	water-purslane	Y	20.0	5.0	45.0	0.0	30.0	20.0
Myriophyllum ussuriense	Ussurian water-milfoil	Y	5.0	3.0	5.0	0.0	15.0	5.6
Schoenoplectus tabernaemontani	soft-stemmed bulrush	Y	3.0	0.5	3.0	8.0	5.0	3.9
Eleocharis obtusa	blunt spike-rush	Y	1.0	0.0	0.0	0.0	0.0	0.2
Limosella aquatica	water mudwort	Y	1.0	0.5	0.0	0.0	1.0	0.5
Gratiola neglecta	American hedge-hyssop	Y	1.0	0.0	0.0	0.0	1.0	0.4
Sagittaria latifolia	wapato	Y	0.0	2.0	0.0	0.0	0.0	0.4
Carex sitchensis	Sitka sedge	Y	0.0	0.0	10.0	65.0	0.0	15.0
Mentha arvensis	field mint	Y	0.0	0.0	3.0	0.0	10.0	2.6
Alisma triviale	American water-plantain	Y	0.0	0.0	1.0	0.0	1.0	0.4
Equisetum fluviatile	swamp horsetail	Y	0.0	0.0	0.5	2.0	0.0	0.5
Lilaeopsis occidentalis	western lilaeopsis	Y	0.0	0.0	0.0	0.0	15.0	3.0
Juncus oxymeris	pointed rush	B	0.0	0.0	0.0	0.0	10.0	2.0
Eleocharis palustris	common spike-rush	Y	0.0	0.0	0.0	0.0	5.0	1.0
Bare Ground			18.0	53.5	9.5	22.0	0.0	20.6
Native			61.0	46.0	67.5	75.0	99.0	69.7
Exotic			36.0	35.5	23.0	3.0	11.0	21.7

Percent cover of plants within vegetation plots surveyed along transect South 3								
Scientific	**Common Name**	**Status**	**S3-1**	**S3-2**	**S3-3**	**S3-4**	**S3-5**	**Average**
Phalaris arundinacea	reed canarygrass	E	60.0	20.0	15.0	20.0	10.0	25.0
Persicaria hydropiper	marshpepper smartweed	E	5.0	8.0	25.0	35.0	30.0	20.6
Callitriche stagnalis	pond water-starwort	E	5.0	5.0	15.0	5.0	1.0	6.2
Lythrum salicaria	purple loosestrife	E	0.0	2.0	0.0	0.0	0.0	0.4
Iris pseudacorus	yellow iris	E	0.0	0.0	0.0	2.0	0.0	0.4
Myosotis scorpiodes	European forget-me-not	E	0.0	0.0	0.0	0.0	45.0	9.0
Ceratophyllum demersum	common hornwort	Y	3.0	2.0	2.0	2.0	0.0	1.8
Najas flexilis	wavy water nymph	Y	5.0	0.0	0.0	0.0	0.0	1.0
Myriophyllum ussuriense	Ussurian water-milfoil	Y	0.5	0.0	0.0	0.0	0.5	0.2
Sparganium emersum	emersed bur-reed	Y	0.0	35.0	3.0	0.0	0.0	7.6
Limosella aquatica	water mudfowrt	Y	0.0	3.0	0.0	0.0	0.5	0.7
Ludwigia palustris	water-purslane	Y	0.0	5.0	0.0	2.0	0.0	1.4
Sagittaria latifolia	wapato	Y	0.0	0.0	2.0	3.0	0.0	1.0
Gratiola neglecta	American hedge-hyssop	Y	0.0	0.0	0.0	2.0	1.0	0.6
Bare Ground			21.5	20.0	38.0	29.0	12.0	24.1
Native			8.5	45.0	7.0	9.0	2.0	14.3
Exotic			70.0	35.0	55.0	62.0	86.0	61.6

Percent cover of plants within vegetation plots surveyed along transect South 4								
Scientific	**Common Name**	**Status**	**S4-1**	**S4-2**	**S4-3**	**S4-4**	**S4-5**	**Average**
Phalaris arundinacea	reed canarygrass	E	10.0	60.0	35.0	0.0	80.0	37.0
Callitriche stagnalis	pond-water starwort	E	0.0	2.0	9.0	0.0	0.0	2.2
Impatiens capensis	jewelweed	E	0.0	0.0	0.0	1.0	0.0	0.2
Carex sitchensis	Sitka sedge	Y	90.0	0.0	0.0	25.0	0.0	23.0
Myriophyllum ussuriense	Ussurian water-milfoil	Y	0.0	3.0	1.0	3.0	0.0	1.4
Ceratophyllum demersum	common hornwort	Y	0.0	0.0	4.0	10.0	7.0	4.2
Eleocharis obtusa	blunt spike-rush	Y	0.0	0.0	0.0	10.0	0.0	2.0
Gratiola neglecta	American hedge-hyssop	Y	0.0	0.0	0.0	1.0	0.0	0.2
Epilobium ciliatum	purple willowherb	Y	0.0	0.0	0.0	1.0	0.0	0.2
Limosella aquatica	water mudwort	Y	0.0	0.0	0.0	1.0	0.0	0.2
Bare Ground			0.0	35.0	51.0	48.0	13.0	29.4
Native			90.0	3.0	5.0	51.0	7.0	31.2
Exotic			10.0	62.0	44.0	1.0	80.0	39.4

Percent cover of plants within vegetation plots surveyed along transect South 5								
Scientific	**Common Name**	**Status**	**S5-1**	**S5-2**	**S5-3**	**S5-4**	**S5-5**	**Average**
Phalaris arundinacea	reed canarygrass	E	20.0	8.0	90.0	35.0	40.0	38.6
Callitriche stagnalis	pond-water starwort	E	10.0	5.0	0.0	0.5	5.0	4.1
Lythrum salicaria	purple loosestrife	E	0.0	0.0	0.0	0	7	1.4
Gratiola neglecta	American hedge-hyssop	Y	1.0	0.0	0.0	0.5	0.5	0.4
Juncus articulatus	jointed rush	Y	1.0	0.0	0.0	0.0	0.0	0.2
Eleocharis obtusa	blunt spike-rush	Y	1.0	0.0	0.0	0.0	0.0	0.2
Ceratophyllum demersum	common hornwort	Y	5.0	0.0	2.0	8.0	0.0	3.0
Limosella aquatica	water mudwort	Y	1.0	0.0	0.0	0.0	0.0	0.2
Persicaria lapathifolia	willow weed	Y	5.0	0.0	0.0	0.0	0.0	1.0
Sparganium emersum	emersed bur-reed	Y	0.0	45.0	0.0	0.0	0.0	9.0
Najas flexilis	wavy water nymph	Y	0.0	0.0	0.0	2.0	0.0	0.4
Myriophyllum ussuriense	Ussurian water-milfoil	Y	0.0	0.0	0.0	0	3	0.6
Bare Ground			56.0	42.0	8.0	54.0	44.5	40.9
Native			14.0	45.0	2.0	10.5	3.5	15.0
Exotic			30.0	13.0	90.0	35.5	52.0	44.1

Percent cover of plants within vegetation plots surveyed along transect North 1								
Scientific	**Common Name**	**Status**	**N1-1**	**N1-2**	**N1-3**	**N1-4**	**N1-5**	**Average**
Myosotis scorpiodes	European forget-me-not	E	45.0	0.0	0.0	0.0	0.0	9.0
Phalaris arundinacea	reed canarygrass	E	12.0	70.0	20.0	12.0	10.0	24.8
Persicaria hydropiper	marshpepper smartweed	E	1.0	0.0	0.0	0.0	0.0	0.2
Lythrum salicaria	purple loosestrife	E	0.0	0.0	0.0	2.0	0.0	0.4
Juncus oxymeris	pointed rush	B	2.0	0.0	0.0	0	0	0.4
Mentha arvensis	field mint	Y	0.0	10.0	0.0	0.0	0.0	2.0
Carex sitchensis	Sitka sedge	Y	0.0	0.0	70.0	0.0	40.0	22.0
Carex obnupta	slough sedge	Y	0.0	0.0	0.0	70.0	0.0	14.0
Epilobium ciliatum	purple-leaved willowherb	Y	0.0	0.0	0.0	1.0	0.0	0.2
Galium trifidum	small bedstraw	Y	0.0	0.0	0.0	1.0	1.0	0.4
Ludwigia palustris	water-purslane	Y	0.0	0.0	0.0	0.5	0.0	0.1
Sagittaria latifolia	wapato	Y	0.0	0.0	0.0	0	3	0.6
Myriophyllum ussuriense	Ussurian water-milfoil	Y	0.0	0.0	0.0	0	1	0.2
Bare Ground			40.0	20.0	10.0	13.5	45.0	25.7
Native			2.0	10.0	70.0	72.5	45.0	39.9
Exotic			58.0	70.0	20.0	14.0	10.0	34.4

Percent cover of plants within vegetation plots surveyed along transect North 2								
Scientific	**Common Name**	**Status**	**N2-1**	**N2-2**	**N2-3**	**N2-4**	**N2-5**	**Average**
Phalaris arundinacea	reed canarygrass	E	3.0	0.0	0.0	0.0	0.0	0.6
Lythrum salicaria	purple loosestrife	E	1.0	0.0	0.0	0.0	0.0	0.2
Lysimachia terrestris	bog loosestrife	E	0.0	0.5	0.0	0.0	0.0	0.1
Callitriche stagnalis	pond-water starwort	E	0.0	0.5	0.0	0.0	0.0	0.1
Juncus articulatus	jointed rush	Y	1.0	0.0	0.0	0.0	0.0	0.2
Ludwigia palustris	water-purslane	Y	15.0	0.5	0.0	0.0	0.0	3.1
Carex obnupta	slough sedge	Y	2.0	0.0	0.0	0.0	0.0	0.4
Rorippa palustris	marsh yellow cress	Y	8.0	0.0	0.0	0.0	0.0	1.6
Juncus effusus	common rush	Y	0.5	0.0	0.0	0.0	0.0	0.1
Galium trifidum	small bedstraw	Y	2.0	0.0	0.0	0.0	0.0	0.4
Hypericum scouleri ssp. *scouleri*	western St. John's-wort	Y	1.0	1.0	0.0	0.0	0.0	0.4
Myriophyllum ussuriense	Ussurian water-milfoil	Y	0.5	0.0	0.0	0.0	0.0	0.1
Isoetes sp.	unknown quillwort	Y?	0.0	0.5	0.0	0.0	0.0	0.1
Bare Ground			66.0	97.0	100.0	100.0	100.0	92.6
Native			30.0	2.0	0.0	0.0	0.0	6.4
Exotic			4.0	1.0	0.0	0.0	0.0	1.0

Percent cover of plants within vegetation plots surveyed along transect North 3								
Scientific	**Common Name**	**Status**	**N3-1**	**N3-2**	**N3-3**	**N3-4**	**N3-5**	**Average**
Phalaris arundinacea	reed canarygrass	E	40.0	30.0	25.0	35.0	10.0	28.0
Callitriche stagnalis	pond-water starwort	E	5.0	2.0	0.0	2.0	0.0	1.8
Bidens tripartita	three-parted beggarticks	E	3.0	0.0	0.0	0.0	0.0	0.6
Lythrum salicaria	purple loosestrife	E	2.0	0.0	0.0	0.0	0.0	0.4
Persicaria hydropiper	marshpepper smartweed	E	5.0	1.0	0.0	0.0	10.0	3.2
Myosotis scorpiodes	European forget-me-not	E	0.0	0.0	0.0	0	15	3
Carex obnupta	slough sedge	Y	2.0	1.0	0.0	0.0	0.0	0.6
Limosella aquatica	water mudwort	Y	1.0	1.0	0.0	0.0	0.0	0.4
Ludwigia palustris	water-purslane	Y	0.0	18.0	0.0	0.0	7.0	5.0
Myriophyllum ussuriense	Ussurian water-milfoil	Y	0.0	3.0	0.0	0.0	3.0	1.2
Callitriche heterophylla subsp. *bolanderi*	diverse-leaved water-starwort	Y	0.0	2.0	0.0	0.0	0.0	0.4
Hypericum scouleri ssp. *scouleri*	western St. John's-wort	Y	0.0	1.0	0.0	0.0	0.0	0.2
Carex sitchensis	Sitka sedge	Y	0.0	0.0	15.0	30.0	25.0	14.0
Sagittaria latifolia	wapato	Y	0.0	0.0	2.0	0.0	0.0	0.4
Myrica gale	sweet gale	Y	0.0	0.0	0.0	2	0	0.4
Bare Ground			42.0	41.0	58.0	31.0	30.0	40.4
Native			3.0	26.0	17.0	32.0	35.0	22.6
Exotic			55.0	33.0	25.0	37.0	35.0	37.0

Percent cover of plants within vegetation plots surveyed along transect North 4								
Scientific	**Common Name**	**Status**	**N4-1**	**N4-2**	**N4-3**	**N4-4**	**N4-5**	**Average**
Phalaris arundinacea	reed canarygrass	E	20.0	5.0	45.0	0.0	8.0	15.6
Persicaria hydropiper	marshpepper smartweed	E	1.0	1.0	2.0	15.0	1.0	4.0
Persicaria minor	Asian knotweed	E	0.0	5.0	2.0	8.0	0.0	3.0
Lythrum salicaria	purple loosestrife	E	0.0	0.0	3.0	0.0	0.0	0.6
Callitriche stagnalis	pond-water starwort	E	0.0	0.0	0.0	3.0	0.0	0.6
Bidens tripartita	three-parted beggarticks	E	0.0	0.0	0.0	1.0	0.0	0.2
Carex sitchensis	Sitka sedge	Y	50.0	0.0	0.0	0.0	60.0	22.0
Ludwigia palustris	water-purslane	Y	0.0	5.0	0.0	0.0	0.0	1.0
Callitriche heterophylla subsp. *bolanderi*	diverse-leaved water-starwort	Y	0.0	3.0	0.0	0	0	0.6
Juncus articulatus	jointed rush	Y	0.0	0.5	0.0	0.0	0.0	0.1
Ceratophyllum demersum	common hornwort	Y	0.0	0.0	2.0	0.0	0.0	0.4
Limosella aquatica	water mudwort	Y	0.0	0.0	0.0	5.0	0.0	1.0
Gratiola neglecta	American hedge-hyssop	Y	0.0	0.0	0.0	2.0	0.0	0.4
Myriophyllum ussuriense	Ussurian water-milfoil	Y	0.0	0.0	0.0	1.0	0.0	0.2
Alisma triviale	American water-plantain	Y	0.0	0.0	0.0	1	0	0.2
Bare Ground			29.0	80.5	46.0	64.0	31.0	50.1
Native			50.0	8.5	2.0	9.0	60.0	25.9
Exotic			21.0	11.0	52.0	27.0	9.0	24.0

Percent cover of plants within vegetation plots surveyed along transect North 5								
Scientific	**Common Name**	**Status**	**N5-1**	**N5-2**	**N5-3**	**N5-4**	**N5-5**	**Average**
Callitriche stagnalis	pond-water starwort	E	1.0	0.0	1.0	0.0	0.0	0.4
Phalaris arundinacea	reed canarygrass	E	0.0	3.0	0.0	0.0	0.0	0.6
Persicaria hydropiper	marshpepper smartweed	E	0.0	1.0	0.0	0.0	0.0	0.2
Lythrum salicaria	purple loosestrife	E	0.0	0.0	0.0	1	0.5	0.3
Sparganium emersum	emersed bur-reed	Y	20.0	18.0	15.0	5.0	20.0	15.6
Myriophyllum ussuriense	Ussurian water-milfoil	Y	55.0	12.0	5.0	15.0	3.0	18.0
Potomogeton sp.	unidentified pondweed	Y	3.0	5.0	2.0	0.0	0.0	2.0
Lilaea scilloides	flowering quillwort	B	1.0	0.0	0.0	0.0	0.0	0.2
Eleocharis obtusa	blunt spike-rush	Y	0.0	0.0	1.0	0.0	0.0	0.2
Epilobium ciliatum	purple-leaved willowherb	Y	0.0	0.0	0.0	0.5	0.0	0.1
Callitriche heterophylla subsp. *bolanderi*	diverse-leaved water-starwort	Y	0.0	0.0	0.0	0.0	1.0	0.2
Bare Ground			20.0	61.0	76.0	78.5	75.5	62.2
Native			79.0	35.0	23.0	20.5	24.0	36.3
Exotic			1.0	4.0	1.0	1.0	0.5	1.5

APPENDIX 5. Summary of Point Count Surveys for Birds along the Lower Alouette River

Species	Average count	Standard Error	Species	Average count	Standard Error
COYE	1.41	0.14	BUOR	0.05	0.05
WIFL	1.32	0.17	EUCD	0.05	0.04
MAWR	0.97	0.13	KILL	0.05	0.05
BASW	0.86	0.30	OCWA	0.05	0.04
SOSP	0.78	0.13	GRCA	0.03	0.03
AMRO	0.65	0.12	LABU	0.03	0.03
TRSW	0.62	0.21	OSFL	0.03	0.03
CLSW	0.57	0.26	PAWR	0.03	0.03
SAVS	0.57	0.12	REVI	0.03	0.03
SPTO	0.54	0.11	RTHA	0.03	0.03
RWBL	0.51	0.46	WAVI	0.03	0.03
CEWA	0.43	0.18	YRWA	0.03	0.03
NOFL	0.43	0.10			
EUST	0.41	0.17			
BHCO	0.38	0.10			
BHGR	0.35	0.08			
SWTH	0.27	0.08			
EAKI	0.24	0.10			
MALL	0.22	0.10			
AMCR	0.19	0.10			
WCSP	0.19	0.09			
GBHE	0.16	0.07			
WODU	0.16	0.09			
NRWS	0.14	0.08			
BAEA	0.11	0.05			
CAGO	0.11	0.08			
COME	0.11	0.11			
RUHU	0.11	0.06			
SACR	0.11	0.08			
VGSW	0.11	0.08			
BLSW	0.08	0.08			
CORA	0.08	0.08			
OSPR	0.08	0.05			
WWPE	0.08	0.05			
YEWA	0.08	0.05			
AMGO	0.05	0.04			
BCCH	0.05	0.04			
BEKI	0.05	0.04			