Aberfeldie Redevelopment Project Water Use Plan

Riparian Vegetation Monitoring

Reference: ABFMON-5 Task 2C
Q9-9576 Aberfeldie Dam Station Fisheries Habitat Compensation Monitoring Project

Implementation Year: 4

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Executive Summary

The Aberfeldie Generating Station, a run-of-river hydroelectric facility, was upgraded in 2006. The potential loss of productive capacity associated with the increased diversion of flows, particularly during summer months, was identified as a concern (BC Hydro, 2006). Compensatory habitat was designed and constructed in 2008 and a five-year monitoring program - ABFMON #5 - was instituted to assess whether the compensatory habitat fulfills the goal of no net loss of productive capacity after the Aberfeldie Dam redevelopment. A compensatory stream channel was designed and constructed in 2008. This newly created habitat required vegetation to restore disturbed areas and to provide shade for the channel to keep water temperatures cool and provide cover for fish. In addition to creating an ecologically stable native plant community, the re-vegetation work was to enhance slope stability thereby minimising sediment sources to the spawning channel. The study area was stratified into two treatment units (TU) based on ecological differences: the berm (TU A) and the side channel area (TU B).

The Aberfeldie Generating Station is a run-of-river hydroelectric facility located on the Bull River in southeast British Columbia, Canada. In 2009, the facility was upgraded to replace outdated equipment and to create additional energy and capacity. The Water Use Plan for the redevelopment required a reduction in the amount of spill over the dam and annual flows through the canyon (diversion reach) to the powerhouse, resulting in annual dewatering of instream glide, riffle, pool and channel margin habitat (BC Hydro 2006, Cope 2006). The mean annual flow reductions in diversion reach were anticipated to result in the loss of 2991 m^2 of primary and secondary productivity habitat (DFO 2006). An additional 170 m^2 of habitat associated with the temporary installation of the tailrace cofferdam was also to be impacted.

The grass and legume plant community seeded on the berm side exceeded 60% mean cover after the 4th growing season. Cover on the northern portion of the berm top will require supplemental seeding and fertilization for it to meet the target cover level of 60%. The vegetation on the berm has become competitive with planted seedlings for moisture and through mechanical damage (snow press) which has contributed to decreased seedling survival.

Seeded grass and legume plant communities did not perform as well on the side channel. This is due to the large proportion of the TU that consists of steep, coarse textured materials that are dry ravelling. The side channel will not meet target revegetation objectives without additional intervention.

Fourth growing season seedling survival ranged from unacceptable to good; ponderosa pine suffered 100% mortality in 2009. Cottonwood, paper birch, western larch and Saskatoon survival do not meet the target of 75% survival set by Keefer Ecological Services (2006). Native chokecherry, cottonwood, birch, and aspen disturbed during construction activities continue to sprout from rhizomes, roots, and stems which will contribute to the diversity of the riparian plant community in the study area. Survival is expected to decrease for most species as indicated by the increase in seedlings in the poor condition class. The continued development of the seeded grass and legume plant community at TU A (berm) is having a negative impact on seedling condition and seedling survival.

Brush layers were constructed to improve side channel bank stability and to provide streamside vegetation to enhance the fisheries habitat. Only one of the modified brush layers investigated met the recommended 70% effective length criteria recommened by Przeczek and Isaac (2011). It is clear that the majority of the

brush layers have failed. The most significant issues include: poor selection of species for sill logs, inadequate staking of sill logs, use of stakes and cuttings that were too small in diameter, and stakes/cuttings planted too shallow.

Sedges are establishing along the side channel. Approximately 30% of the side channel had at least one plant per meter and one of the 22 sedge assessment sections met the suggested success criterion. Sedges are rhizomatous (Hauser 2006) and the numbers of plants are expected to increase over time.

The berm treatment unit (TU A) currently satisfies some of the structural integrity criteria. The berm is geologically stable. In addition, it is physically separated from the side channel and the Bull River and therefore should not contribute sediments to either water course. The seeded vegetation is developing well on the sides of the berm; the top of the berm will require additional treatments to promote target conditions. Survival of most of the planted species will not meet target conditions. Volunteers (i.e., plants that were not planted) that are developing in response to project disturbances continue to grow and they will provide some of the long term habitat functions (nesting, perching, foraging) that may be considered components of structural integrity. A small “island” of native shrubs and trees could be planted to reduce the line of sight along the berm, increase species diversity, and provide a small patch of valuable wildlife habitat.

The side channel treatment unit (TU B) does not satisfy any of the structural integrity criteria and is unlikely to do so unless resloping treatments are applied. The sand and gravel substrate should be reasonably stable at approximately 30 degrees. Resloping would allow for the establishment of seeded grasses and legumes, planting of appropriate shrub species and use of live staking to establish willow, cottonwood and red-osier dogwood. Controlling cattle access to the side channel area may also be required to ensure that project objectives are achieved. A detailed resloping, revegetation and cattle management plan should be prepared to provide direction for the implementation of any additional work.

Invasive plants have increased throughout the project monitoring period (2009 – 2012) in both number of species and vegetative cover. The Canada thistle and bull thistle populations have expanded such that repetitive mowing and/or herbicide treatment would be the best control method at this time. Aggressive treatments are required to have an impact on these species. As spotted knapweed, blueweed and sulphur cinquefoil are able to form monocultures over a few years, it is important to attempt to eradicate these species as soon as possible. Hand-pulling or digging during the spring and throughout the year when the soils are moist is recommended while species populations are low. Implementing these mechanical treatments multiple times throughout the year and from year to year will be required to control the spread and prevent seed dispersal. To prevent dispersal of common burdock burrs it is recommended that the plants be cut, bagged and disposed of properly. Due to its aggressive nature and without treatment, the cover of yellow hawkweed is expected to increase and to out-compete the preferred plant species. If controlling yellow hawkweed is desirable early spring treatment with Milestone (aminopyralid) will provide the best results. Treatment of invasive plant infestations located on BC Hydro land adjacent to the project area is also recommended to reduce the seed source and protecting the reclamation investment.

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Introduction

The Aberfeldie Generating Station is a run-of-river hydroelectric facility located on the Bull River in southeast British Columbia, Canada. In 2009, the facility was upgraded to replace outdated equipment and to create additional energy and capacity. The Water Use Plan for the redevelopment required a reduction in the amount of spill over the dam and annual flows through the canyon (diversion reach) to the powerhouse, resulting in annual dewatering of instream glide, riffle, pool and channel margin habitat (BC Hydro 2006, Cope 2006). This resulted in an annual dewatering of 2991 m2 of primary and secondary productivity habitat (DFO 2006). An additional 170 m2 of habitat associated with the temporary installation of the tailrace cofferdam was also to be impacted.

Following consultation and review, a compensatory stream channel was designed and constructed in 2008 and located downstream of the Aberfeldie Generating Station on the north bank of the Bull River. In order to ensure the overall effectiveness of this habitat compensation project, a five-year monitoring program - ABFMON #5 - was instituted. The habitat compensation project constructed a protection berm, a series of four ponds linked by a small channel complemented with rock riffles, fish weirs, and coarse woody debris located throughout. This newly created habitat required vegetation not only to restore disturbed areas (e.g., berm) but also to provide shade for the channel to keep water temperatures cool and provide cover for fish. Following the physical construction, the area was re-vegetated with grasses, sedges, shrubs & trees, and various live staking and modified brush layers were added to complement the in-stream fish habitat work. In addition to creating an ecologically stable native plant community, the re-vegetation work was to enhance slope stability, thereby minimising sediment sources to the spawning channel.

The main goal of the monitoring program is to assess whether the compensatory habitat fulfills the goal of no net loss of productive capacity after the Aberfeldie Dam redevelopment. The monitoring program described here - ABFMON #5 - will contribute to two larger management objectives, outlined in the Aberfeldie Effectiveness Monitoring Fish Habitat Works Terms of Reference (BC Hydro, 2008a), which include:

1. Does the ecological productive capacity (e.g. plant survival, plant cover) realized in the constructed habitat, in combination with the productive capacity of the diversion reach at the 2 m^3/s summer minimum flow, achieve the Aberfeldie Redevelopment Project compensation goal of no-net-loss of productive capacity?
2. Is there a lower summer minimum instream flow discharge that, in combination with the productive capacity of the compensation habitat, could achieve the Aberfeldie Redevelopment project compensation goal of no-net-loss of productive capacity (BC Hydro 2008a, p. 6)?

An additional goal for this monitoring program, although not one of the main objectives, is to provide information on fish usage and habitat quality in the constructed fish and aquatic habitat. The ABFMON #5 monitoring program includes the following tasks: primary and secondary productivity monitoring (TASK 2A), fish and fish habitat monitoring (TASK 2B), and riparian vegetation monitoring (TASK 2C). This report addresses TASK 2C, riparian vegetation monitoring, associated with the habitat compensation project. The results of the TASK 2C monitoring program will inform the following specific objectives:

1. To monitor survival of riparian vegetation planted at the compensation habitat site; and,
2. To monitor the structural integrity of the compensation habitat (BC Hydro 2008a, p. 8).

The approach for the riparian vegetation monitoring component of ABFMON#5, TASK 2C consists of field surveys to evaluate survival and performance of riparian vegetation planted or seeded as part of the habitat compensation works. The vegetation surveys began in year 1 (2009) and continued in years 2 (2010), 3 (2011) and 4 (2012). This document reports the final year (Year 4) of ordered vegetation monitoring work as well as summarizes the Yr. 1-4 work that has taken place over the duration of this project.

Methods:

Study Area

The Aberfeldie Side Channel is located 500 m downstream of the Aberfeldie Generating Station, on the north side of the Bull River, approximately 35 kilometers east of Cranbrook in southeast British Columbia (Figure 1). The study area includes a low gradient channel and a berm constructed of soil and parent materials that were removed during channel construction. The study area also includes a small area that was cleared to provide access to the site and that was reclaimed after construction activities were complete (BC Hydro 2008b).

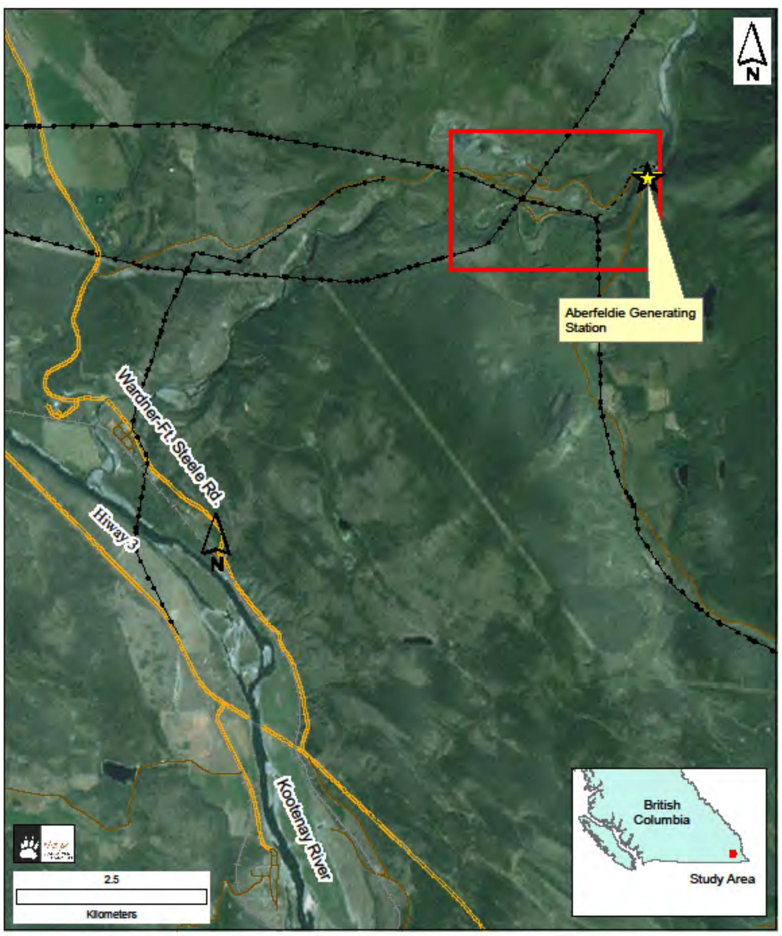


Figure 1. Overview of the study area location in south-eastern British Columbia.

Methodology

Study Site

The study area was stratified into two treatment units (TU; Figure 2): the berm (TU A) and the sides of the side channel (TU B). These treatment units were stratified to reflect ecological differences that included variation in slope, aspect, and proximity to a stream channel. These two TUs also received different restoration combinations (Table 1). TU A was further stratified for the purpose of monitoring the development of seeded agronomic grasses and legumes into Berm Side (BS; west-facing slope of the constructed berm) and Berm Top (BT; flat top of the constructed berm) and all other disturbances were combined. TU B was further stratified for the purpose of monitoring the development of seeded agronomic grasses and legumes into River Side (RS; westerly side of the channel) and Plant Side (PS; easterly side of the channel) to capture potential differences in seeding success.

Table 1. Revegetation treatments applied to the berm and side channel treatment units, Aberfeldie side channel study area.

Treatment Unit	Revegetation treatment type					
	Seeding and Fertilization	Tree and Shrub Planting		Bioengineering		Sedge Planting
		Scattered Individuals	Groups	Modified Brush Layers	Live Staking	
A- Berm	✓	✓	✓			
B - Side Channel	✓	✓		✓	✓	✓

Sampling Methodology

Permanent plots and transects were established both in TU A and TU B and marked during the first field season (2009). Please refer to the 2009 riparian vegetation monitoring report for details (Isaac & Przeczek 2010). Assessment of vegetation assessment transects, survival plots and lines, sedge planting, and bioengineering treatments occurred from September 6 to September 10, 2012. This was two weeks later than the timing of sampling in previous years and did not affect the quality of the data.

Sampling methodologies were designed to determine if four specific treatments were successful:

1. Seeding agronomic grasses and legumes (Table 1, seeding and fertilization);
2. Planting native trees and shrubs (Table 1, tree and shrub planting);
3. Planting sedges (Table 1, sedge planting); and,
4. Bioengineering (Table 1, bioengineering).

The study also includes monitoring of invasive plants that may have been introduced to the habitat compensation site during the construction activity period. Invasive plant assessments were completed concurrent with other sampling activities.

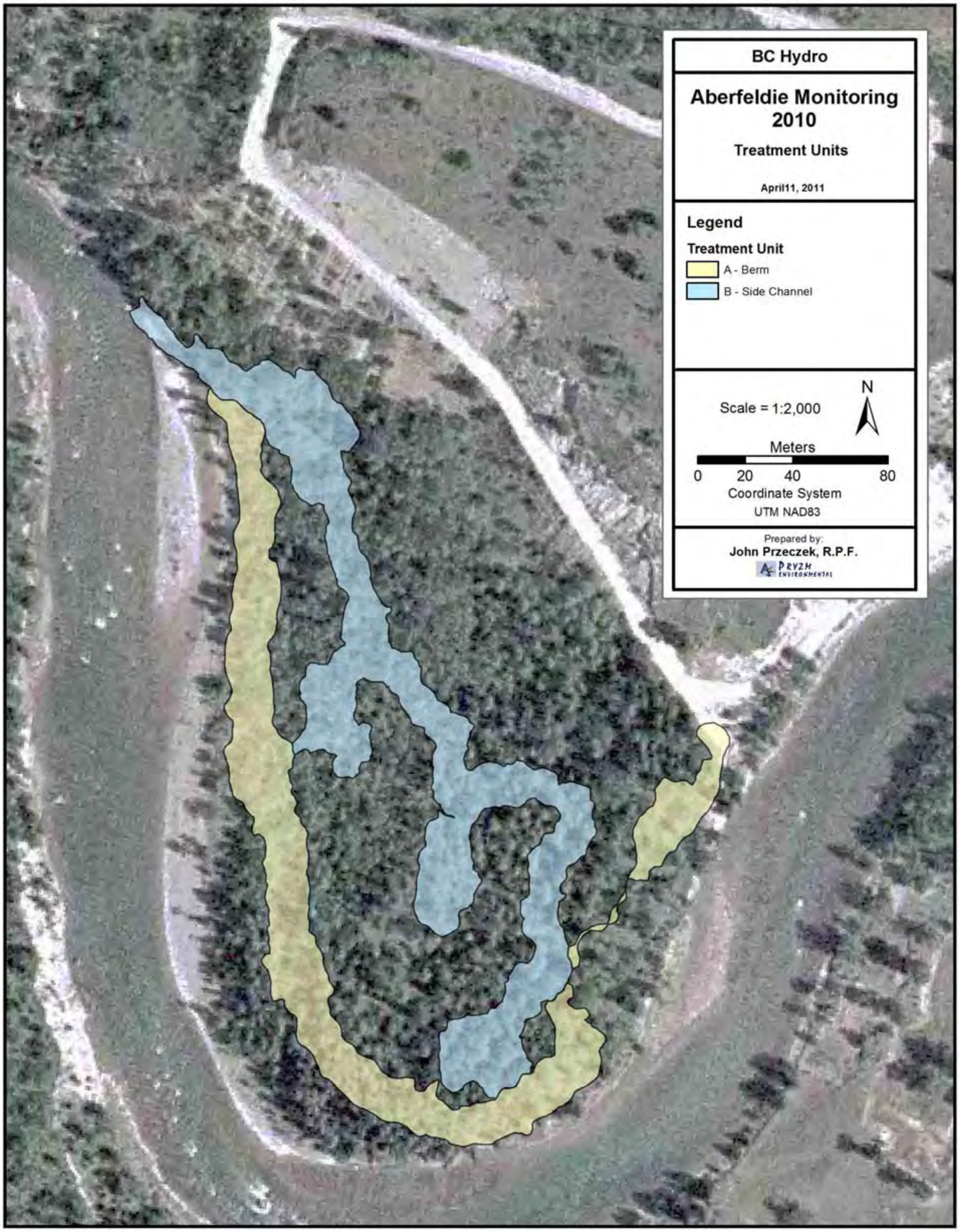


Figure 2. Treatment units identified at the Aberfeldie side channel study area (yellow=berm, TU A; blue=side channel, TU B).

Grass and Legume Seeding Success

Vegetative cover was assessed in TU A and TU B by placing six transects in each TU spaced every 3 m. Five plots were located along each transect. In these plots, herbaceous plants were assessed using a 20 x 50 cm Daubenmire frame and woody species were assessed using a 1 x 2 m frame (Daubenmire 1959, Habitat Monitoring Committee, 1996). Data collected included species percent cover and distribution, percent cover of litter, bryophytes, and surface substrate (rocks, soil, wood and organic matter). Percent cover and distribution of shrubs and tree species were collected within the larger plots. Species identification was confirmed using reference materials by Douglas et al. (1998a, 1998b, 1998c, 1999, 2000, 2001a, 2001b, 2002) and Hitchcock and Cronquist (1973). Plants found in the general area of a transect, but not within plots, were recorded as additional species to provide a more complete picture of the plant community that is developing over time.

Three photos were taken of each transect: one vertical at 0 m, one overview from Start of Transect (SOT) and one overview from End of Transect (EOT); a meter pole was placed at 3 m. An additional photo was taken directly across the side channel from the EOT of each random side channel transect.

The target for plant cover is 60% of desirable species (Keefer, 2006). Transect locations are provided in Appendix 5.

Analyses

The purpose of the following analysis was to assess differences in mean percent vegetative cover by area and between years. The four main areas – berm (Berm Top, Berm Side) and side channel (Plant Side, River Side) - were analysed separately due to ecological differences identified at the beginning of the study. Data analyses were conducted for the following groups: grass cover, forb cover, and total cover (grass + forb + shrub).

Descriptive statistics were calculated for grass, forb, and total cover values for all TUs and years. Mean percent vegetative cover was calculated for each transect in all areas by year. That is, mean percent cover of grasses, forbs, and total cover (grass + forb + shrub) was calculated for each of the 12 transects from 2009-2012. Two-factor ANOVAs were constructed to test for differences in mean percent cover between years and location (Berm Top, etc.).

Tree and Shrub Seedling Survival

Eight shrub species were selected to be monitored over the length of the monitoring project (Isaac & Przeczek 2010). These species were chosen because they represented the largest proportion of the seedlings planted in the area and a minimum of five individuals for each species were located. Species sample locations are provided in Appendix 5.

Plant survival was evaluated based on the ratio of live versus dead plants in the various plots relative to the original number of seedlings planted. The target seedling survival rate is 75% (Keefer 2006) and the target for seedling condition for successful planting was 60% (Keefer 2006) of the individual seedlings in each plot or line in condition class 2 or 3 (Table 2). Seedling condition class criteria were developed in the field prior to the 2009 assessment.

Table 2. Seedling survival success classes, Aberfeldie side channel study area.

Seedling Condition Class Criteria			
Good (3)	**Fair (2)**	**Poor (1)**	**Dead (0)**
• good colour • good needle length • good leader extension • many, large buds • browsing light-none	• not good or poor	• chlorotic • etiolated • little or no leader growth • few or small buds • heavy browsing	• dead

Seedling Plots

Spruce (*Picea engelmannii* Parry ex Engelm.) and rose (*Rosa acicularis* Lindl.) were planted in clumps or groups on the top of the berm in sufficient numbers to allow for staked plots to be located to monitor survival. Circular 3.99 m radius plots (50 m^2) were systematically surveyed until a minimum of 20 seedlings from each species was included within the plots. In 2010 each seedling location was mapped from the plot center (bearing and distance in meters) and seedlings were re-tagged and re-flagged. Four spruce plots and three rose plots were established on the top of the berm in 2009 (Isaac & Przeczek 2010).

Seedling Lines

Trees and shrubs were also planted on the berm in a random pattern, similar to seedlings along the side channel. Seedling survival was monitored using groups of 10 seedlings (where available) called survival lines due to the linear nature of the groups. Survival lines were established by tagging, numbering and flagging each seedling and georeferencing each seedling location in 2009 (Isaac & Przeczek 2010).

Analyses

Analysis of tree and shrub survivorship in previous reports used the nonparametric Wilcoxon’s matched pairs test. It was difficult to detect statistically significant shifts in survivorship between years due to small and unequal sample sizes; therefore analysis was limited to descriptive statistics and graphing survivorship over time for this report.

Sedge Planting Success

In 2009, sedge (*Carex spp*.) planting success was assessed by stratifying the banks of the side channel into sections with similar numbers of living sedge plants per linear meter of bank length. Each section was reassessed in 2012 to maintain consistency over the monitoring project. Sedge survival success for the side channel was calculated for each sedge survival success class (Isaac & Przeczek 2010). There was no attempt to differentiate sedge condition classes because all living sedge plants had good colour and were growing vigorously. Sedge planting was considered successful if at least 60% of the bank length had at least one sedge plant and at least 40% of the bank had 2 sedge plants per linear meter (Przeczek and Isaac 2010).

Bioengineering Success

Live Staking

Live staking assessments in 2009 concluded that the treatment was not successful and that the lack of success would not compromise project objectives. Live staking was not assessed after 2009.

Modified Brush Layers

Six modified brush layers were examined in detail to determine their potential to become established and contribute to side channel bank stability. Specific criteria evaluated included:

- sill log species
- sill log staking (includes presence/absence, size, and whether the stakes were still in place)
- brush layer length (start of sill log to end of sill log or first stake to last stake where sill logs were absent)
- number of cuttings in brush layer
- number of cuttings with leaves
- effective length (length in meters of a brush layer with live cuttings)

Modified brush layers were considered successful if the effective length[1] represents a minimum of 70% of the total length (Przeczek and Isaac 2011). Brush layer sample locations are provided in Appendix 5.

Structural Integrity

One of the objectives of the project is to monitor the structural integrity of the compensation habitat. Structural integrity is a measure of the reliability of the structure to function as required (Pearson *et al.*, 2005). Furthermore, structural integrity refers to the ability of a structure to perform as it was intended to perform and function for as long as it is supposed to function. Structural elements are linked to the other objectives of this study, which include the development of an acceptable cover of seeded grasses and legumes, adequate survival of planted native trees and shrubs, successful establishment of planted sedge seedlings, successful establishment of bioengineering treatments, and the overall geological stability of constructed channel banks. Assessing structural integrity requires professional judgement based on the integration of the preceding components.

Invasive Plant Assessments

In addition to the 0% noxious weed target set by Keefer (2006), the Weed Control Act states: "Every occupier shall control, in accordance with the regulations, noxious weeds growing or located on land and premises, and on any other property located on land and premises, occupied by him." This means that private landowners, private companies, utility companies, regional districts and municipalities, and provincial government agencies or anyone in physical possession of land all have a responsibility to

[1] Effective length is defined as the total length occupied by living stakes with gaps that do not exceed 1.0 m.

manage weeds in the Province[2]. An inventory of invasive plants was conducted by walking through the reclaimed portions study area on September 10, 2012. Species, distribution, density and number of plants were recorded. The inventory was conducted by counting the number of plants or patches (> 5plants within 1 m radius) occurring in each of the two reclaimed areas (berm and side channel) and recording distribution (Table 3) and density codes (Table 4) according to protocols set out in the Invasive Alien Plant Program[3]. Options for the removal/eradication of the invasive species are discussed in Invasive Plant Assessments section of the Discussion. Locations of the primary invasive plants of concern are provided in Appendix 5.

Table 3. Distribution codes

Code	**Description**
1	Rare individual, a single occurrence
2	Few sporadically occurring individuals
3	Single patch or clump of a species
4	Several sporadically occurring individuals
5	A few patches or clumps of a species
6	Several well-spaced patches or clumps of a species
7	Continuous uniform occurrence of well-spaced individuals
8	Continuous occurrence of a species with a few gaps in the distribution
9	Continuous dense occurrence of a species

Table 4. Density codes.

Code	**Description**	**Reference**
1	≤ 1 plant/m2	Low
2	2-5 plants/m2	Medium
3	6-10 plants/m2	High
4	> 10 plants/m2	Dense

[2] The complete text of the Weed Control Act and Regulations can be accessed at: http://www.qp.gov.bc.ca/statreg/stat/W/96487_01.htm

[3] http://www.for.gov.bc.ca/hra/Plants/index.htm

Results

Percent Cover (Seeded Grasses and Forbs)

Grasses

The amount of grass cover varied significantly with year (Table 5). The percent coverage of grass has steadily increased since the original planting in 2009 across all sites (mean % ± SE: 4.6% ± 0.6 in 2009 vs. 27.3% ± 3.4 in 2011; Figure 3).

Table 5. Summary of changes in percent cover by year (2009-2012) and location (berm side, berm top, plant side, and river side of the side channel) for grasses, forbs, and total cover (grasses + forbs + shrubs) at the Aberfeldie side channel compensation project. Mean percent cover per transect for grasses, forbs, and grasses + forbs were used in this analysis. Interaction terms (i.e. YEAR*LOCATION) did not affect the analysis for forbs and total cover and were therefore removed for model simplification. Significant differences are indicated in bold.

Plant Type	Location	F-value	p-value
Grasses	Year	$F3_{,32} = 12.39$	**<0.0001**
	Location	$F_{3,32} = 18.74$	**<0.0001**
	Year*Location	$F_{9,32} = 2.68$	**0.0193**
Forbs	Year	$F_{3,41} = 0.13$	0.9435
	Location	$F_{3,41} = 19.04$	**<0.0001**
Total cover (grass + forb + shrub)	Year	$F_{3,41} = 4.13$	**0.0120**
	Location	$F_{3,41} = 51.05$	**<0.0001**

The significant interaction (year * location) indicates that the change in grass coverage over time was not consistent between the four sites. That is, grass coverage increased significantly across all years at the berm side (Figure 3a), whereas grass coverage on the river side of the side channel increased slowly and there was no significant change from the original planting until 2012 (Figure 3d).

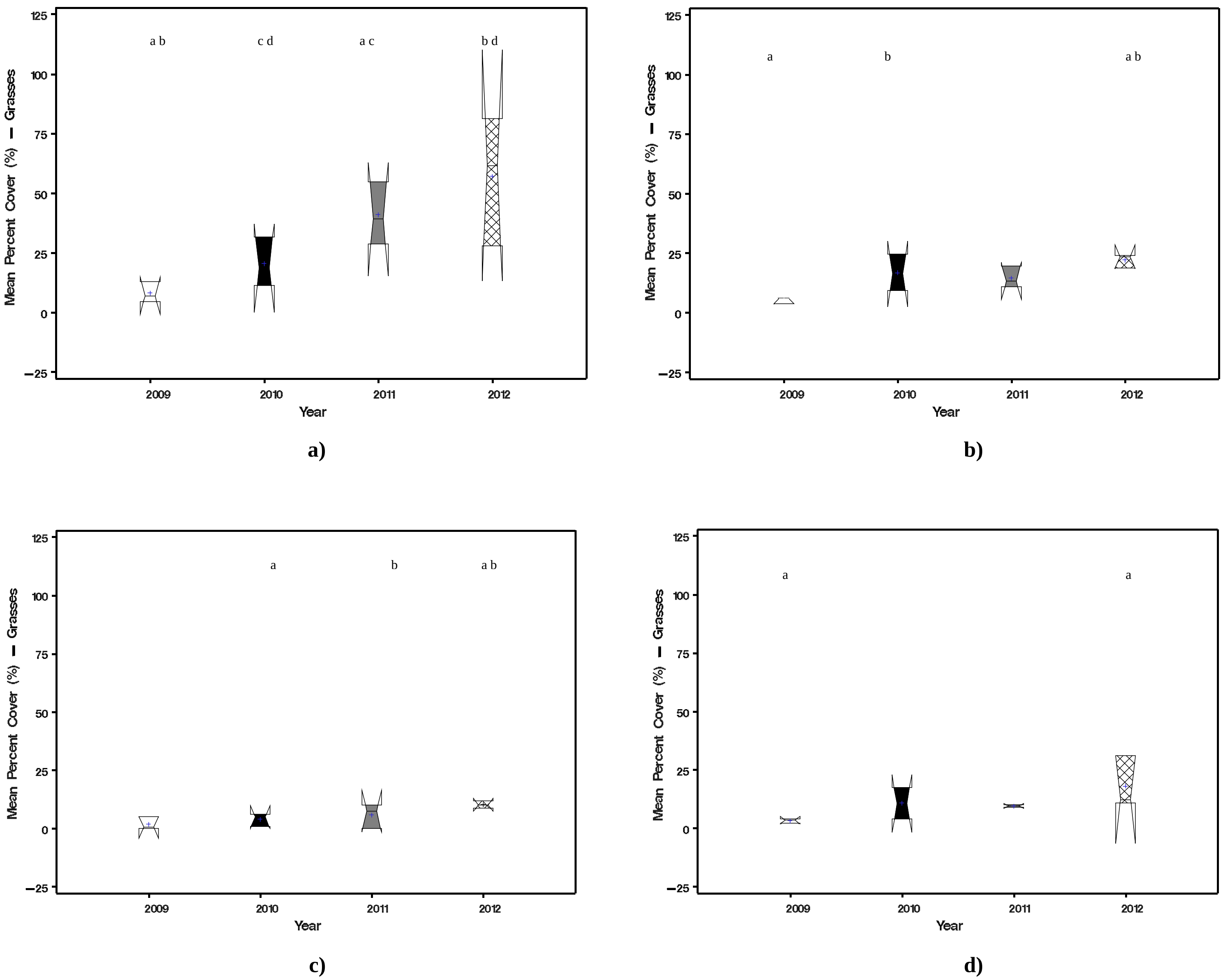
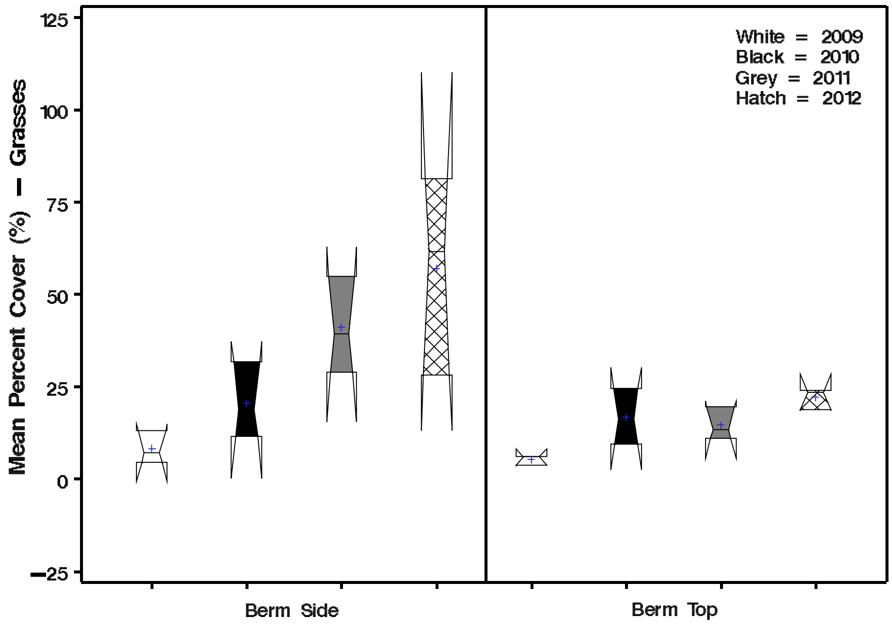
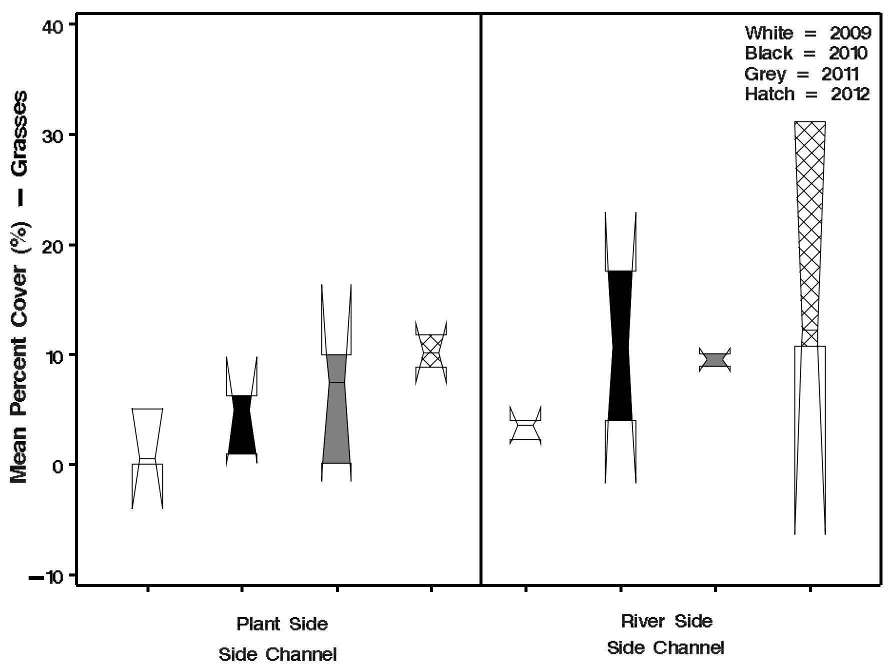


Figure 3. Box plot of mean percent cover (%) for grass from 2009 to 2012 on the a) berm side, b) berm top, c) plant side (side channel), and d) river side (side channel) at the Aberfeldie side channel study area. Boxes represent 50% of the data. Medians are indicated by notches and the mean is indicated by '+'. Tails extend to minimum and maximum values. Letters denote significant differences between years.

Grass coverage also varied significantly with the side channel areas (Table 5). Grass coverage was greatest on the berm, particularly on the berm side (31.6% ± 3.4), whereas the coverage of grass in the side channel was considerably lower (plant side: 5.3% ± 0.9; river side: 10.4% ± 1.5; Figure 4).



a)



b)

Figure 4. Box plot of mean percent cover (%) of grasses from 2009 to 2012 in the two side channel sections a) side/top of berm and b) plant /river side of the side channel at the Aberfeldie side channel compensation project. Boxes represent 50% of the data. Medians are indicated by notches and the mean is indicated by '+'. Tails extend to minimum and maximum values. Note different vertical axis labels in b).

Forbs

Overall, the amount of forb cover across the two treatment areas has remained constant across all years of the vegetation monitoring project (mean % ± SE: 15.7% ± 2.7 in 2009 vs. 14.5% ± 2.5 in 2012; Table 5, Figure 5).

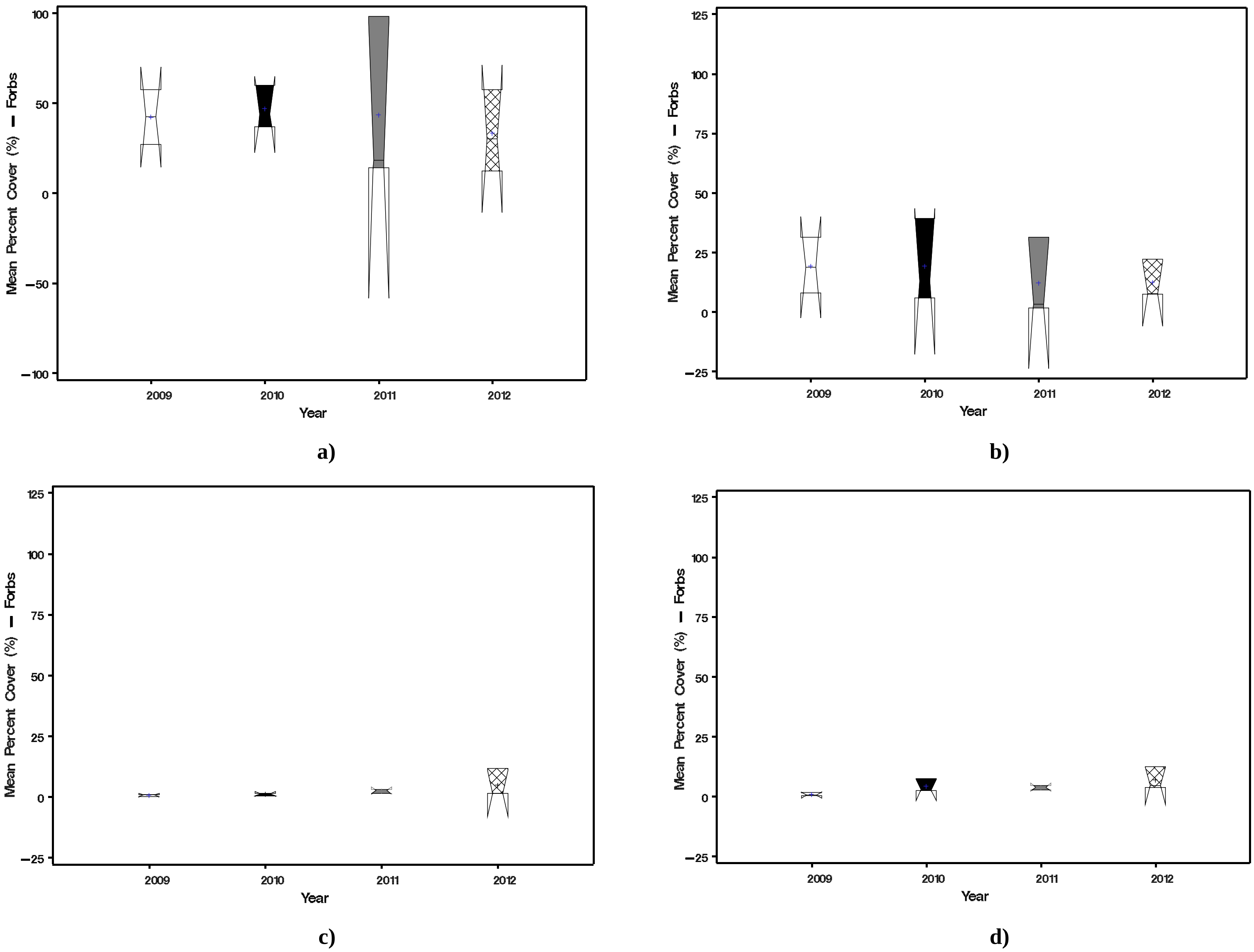
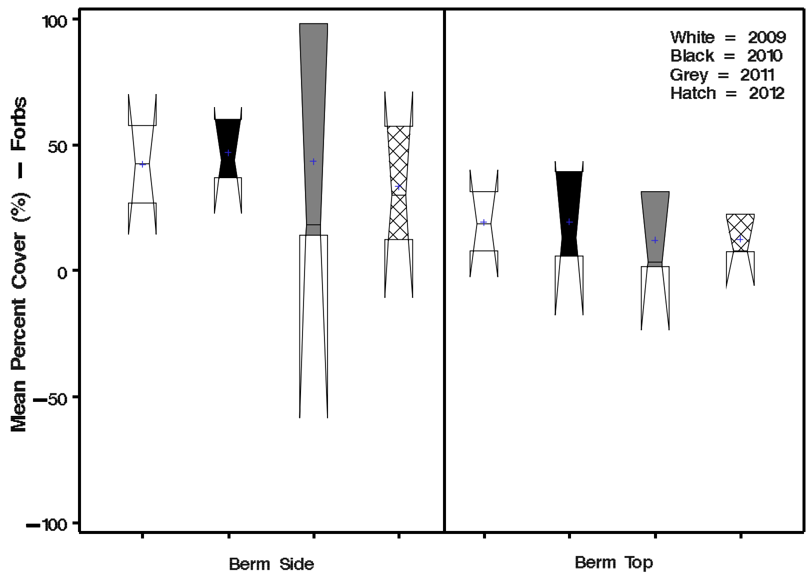
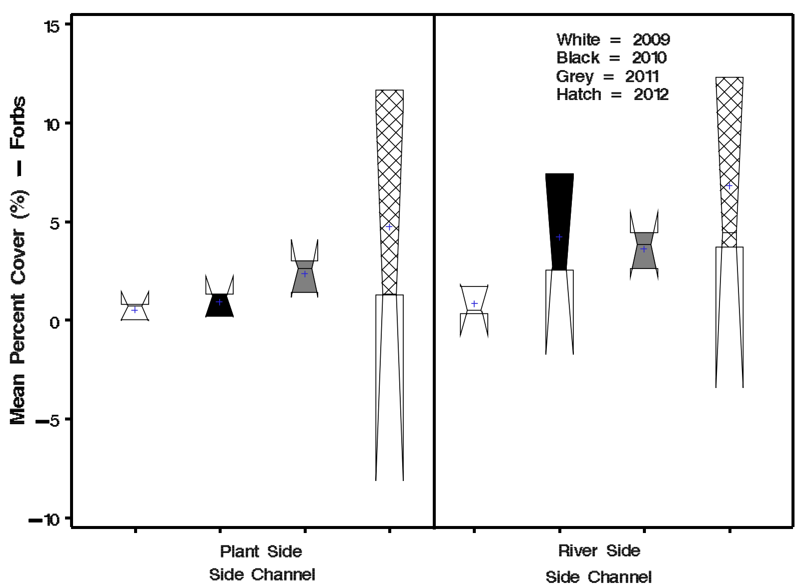


Figure 5. Box plot of mean percent cover (%) for forbs from 2009 to 2012 in the a) berm side, b) berm top, c) plant side (side channel), and d) river side (side channel) at the Aberfeldie side channel study area. Boxes represent 50% of the data. Medians are indicated by notches and the mean is indicated by '+'. Tails extend to minimum and maximum values. NOTE: Different y-axis for berm side forbs.

However, there continues to be significant differences in forb coverage depending on the section of the habitat compensation project. Forb cover was significantly greater on the berm side (41.4% ± 4.0) than on the berm top (15.7% ± 2.5; Figure 6a). Forb cover was significantly lower on both side channel locations compared to the berm locations (plant side: 2.0% ± 0.5; river side: 3.9% ± 0.6; Figure 6b).



a)



b)

Figure 6. Box plot of mean percent cover (%) of forbs from 2009 to 2012 in the two side channel sections a) side/top of berm and b) plant /river side of the side channel at the Aberfeldie side channel compensation project. Boxes represent 50% of the data. Medians are indicated by notches and the mean is indicated by '+'. Tails extend to minimum and maximum values. Note different vertical axis labels in b).

Total Cover

Overall, the amount of total vegetation cover has significantly increased over time (20.9% ± 3.1 in 2009 to 42.7% ± 4.8 in 2012; Figure 7).

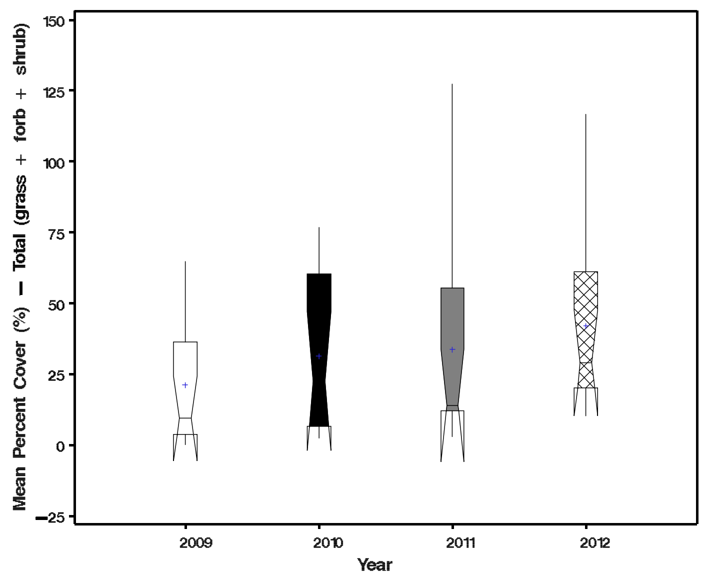


Figure 7. Box plot of mean percent total cover (%; grass, forb & shrubs) from 2009 to 2012 combined across all areas (berm and side channel) at the Aberfeldie side channel study area. Boxes represent 50% of the data. Medians are indicated by notches and the mean is indicated by '+'. Tails extend to minimum and maximum values.

Total plant cover was significantly greater on the berm-side (mean ± SE: 74.9% ± 4.1) than on the berm top (30.8% ± 3.1; Figure 8). Total percent cover was significantly lower in the side channel, both on the plant (7.3% ± 1.1) and the river side (14.3% ± 1.8).

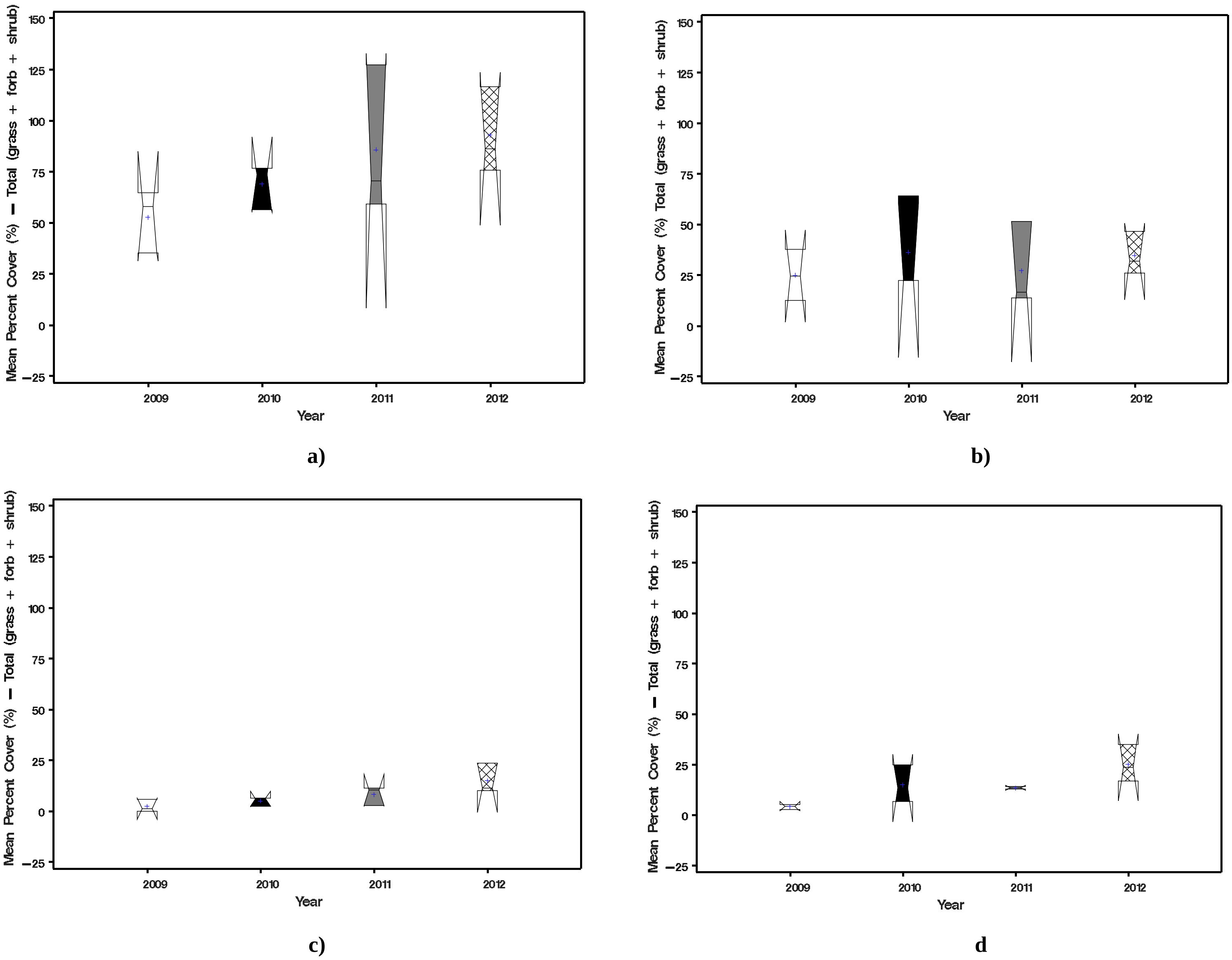


Figure 8. Box plot of mean total percent cover (%) for total grass, forb & shrubs from 2009 to 2012 in the a) berm side, b) berm top, c) plant side (side channel), and d) river side (side channel) at the Aberfeldie side channel study area. Boxes represent 50% of the data. Medians are indicated by notches and the mean is indicated by '+'. Tails extend to minimum and maximum values.

Seeded vegetation at the two berm sites (berm top and berm side) germinated consistently. Vegetation on the berm side is growing well and has considerable coverage (Figure 8). On the other hand, it is unlikely that the berm top location will meet the target of 60% cover set by Keefer (2006) (Table 6, Plate 1, Plate 2 and Plate 5). Seeded vegetation at the two side channel sites (river side and power plant side) germinated inconsistently and mean total cover for each site will not meet Keefer's (2006) target of 60% cover (Plate 3, Plate 4 and Plate 6). Vegetation cover at the two side channel sites continues to be very low and the likelihood of future plant establishment is low as long as slope instability continues to be an issue. Appendix 1 provides a summary of the vegetation data collected in 2009 - 2012.

Table 6. Mean vegetative cover (%) by location and year at the Aberfeldie side channel study area

Location	Year			
	2009	2010	2011	2012
Berm Side	52.5	68.8	100.8	85.5
Berm Top	24.9	36.2	32.4	38.7
Side Channel (River Side)	4.1	14.9	16.2	25.1
Side Channel (Plant Side)	2.3	4.9	8.2	12.7

Planted Tree and Shrub Seedling Survival

Seedling Survival

Although the most significant mortality occurred during the 2010 growing season, tree and shrub survivorship continued to decline in 2012, four growing seasons after planting (Table 7). The target survivorship (75%, Keefer, 2006)) was only met for hawthorn, prickly rose in lines and plots, and Engelmann spruce in lines. Some species (black cottonwood, western larch) suffered immediate declines in survivorship (i.e. between 2009 and 2010) whereas other species (Engelmann spruce, Saskatoon, prickly rose) began declining in survivorship later (i.e. in 2011).

Seedling Condition

There was a general decline in seedling condition in all species in 2012 (Table 8) from previous years. The condition target (60% of plants must fall in good and/or fair category, Keefer 2006) was only met for hawthorn, prickly rose in lines and plots and hawthorn and Engelmann spruce in lines. Plate 9 shows seedlings of a variety of species and condition codes.

Table 7. Summary of survivorship (live or dead) by shrub species and planting type (line vs. plot). Values represent percentage of the total number of individuals falling into each category.

Species	Code	Transect Type	Year	Live	Dead
Black Cottonwood	Ac AC	LINE	2009	90	10
			2010	50	50
			2011	50	50
			2012	30	70
Paper Birch	Ep EP	LINE	2009	100	0
			2010	100	0
			2011	60	40
			2012	40	60
Hawthorn (*Crataegus douglasii* Lidl.)	HW	LINE	2009	100	0
			2010	85	15
			2011	85	15
			2012	80	20
Western Larch (*Larix occidentalis* Nutt.)	Lw LW	LINE	2009	70	30
			2010	50	50
			2011	50	50
			2012	40	60
Ponderosa Pine (*Pinus ponderosa* C. Lawson)	PP	LINE	2009	0	100
Prickly Rose	RA	LINE	2009	100	0
			2010	90	10
			2011	88	12
			2012	82	18
Prickly Rose	RA	PLOT	2009	100	0
			2010	100	0
			2011	96	4
			2012	86	14
Saskatoon (*Amelanchier alnifolia* (Nutt.) Nutt. ex M. Roem.)	SASK	LINE	2009	90	10
			2010	80	20
			2011	70	30
			2012	60	40
Engelmann Spruce	Sx SX	LINE	2009	100	0
			2010	94	6
			2011	90	10
			2012	76	24
Engelmann Spruce	Sx SX	PLOT	2009	100	0
			2010	91	9
			2011	82	18
			2012	46	54

Table 8. Summary of condition by shrub species and planting type. Values represent percentage of the total number of individuals falling into each condition class relative to original numbers planted.

Species	Code	Transect Type	Year	Dead	Poor	Fair	Good	G+F
Black Cottonwood	Ac AC	LINE	2009	10	10	40	40	80
			2010	50	10	20	20	40
			2011	50	20	20	10	30
			2012	70	0	20	10	30
Paper Birch	Ep EP	LINE	2009	0	0	40	60	100
			2010	0	40	40	20	60
			2011	40	40	20	0	20
			2012	60	20	20	0	20
Hawthorn	HW	LINE	2009	0	0	30	70	100
			2010	15	5	60	20	80
			2011	15	10	35	40	75
			2012	20	15	30	35	65
Western Larch	Lw LW	LINE	2009	30	0	0	70	70
			2010	50	0	50	0	50
			2011	50	10	40	0	40
			2012	60	0	40	0	40
Ponderosa Pine	PP	LINE	2009	100	0	0	0	0
Prickly Rose	RA	LINE	2009	0	0	4	96	100
			2010	10	2	52	36	88
			2011	12	20	30	38	68
			2012	18	8	40	34	74
Prickly Rose	RA	PLOT	2009	0	0	0	100	100
			2010	0	4	60	36	96
			2011	4	36	32	28	60
			2012	14	21	18	47	65
Saskatoon	SASK	LINE	2009	10	10	60	20	80
			2010	20	30	35	15	50
			2011	30	25	40	5	45
			2012	40	15	10	35	45
Engelmann Spruce	Sx SX	LINE	2009	0	0	22	78	100
			2010	6	10	70	14	84
			2011	10	20	56	14	70
			2012	24	12	54	10	64
Engelmann Spruce	Sx SX	PLOT	2009	0	0	9	91	100
			2010	9	4.5	82	4.5	86.5
			2011	18	64	13.5	4.5	18
			2012	54	46	0	0	0

Sedge Planting Success

There was a slight decline in the proportion of sedge plants along the side channel (Table 9). Surviving plants were well established, had good colour and vigour, and many were producing seed heads. There was one survival class sections that met the suggested 40% good + fair and 60% good + fair + poor success criteria suggested by Przeczek and Isaac (2010) (Table 10).

Table 9. Comparison of mean sedge success class percent between 2009 and 2012 at the Aberfeldie side channel study area.

	Mean Sedge Success Class %			
Year	Good (3)	Fair (2)	Poor (1)	None (0)
2009	46.9	17.3	15.0	21.0
2010	13.4	14.5	15.9	56.3
2011	13.3	7.7	10.2	68.9
2012	8.3	7.4	14.3	70.0

Table 10. Percent of sedge section length in each sedge success class, Aberfeldie side channel study area.

Sedge Survival Section		**Success Class %**				
Start	End	Good (3)	Fair (2)	Poor (1)	None (0)	G+F
000	**001**	**32**	**27**	**16**	**25**	**59**
001	002	0	0	0	100	0
002	003	5	14	0	82	19
003	004	10	8	5	77	18
004	005	0	0	9	91	0
005	006	0	16	11	73	16
006	007	6	6	44	44	12
007	008	16	8	16	59	24
008	009	5	0	18	78	5
009	010	22	14	38	26	36
010	011	21	7	16	56	28
011	012	5	0	5	90	5
012	013	0	5	5	89	5
013	014	7	7	7	78	14
014	015	0	0	5	95	0
015	016	0	0	9	91	0
016	017	2	1	6	92	3
017	018	3	0	2	95	3
018	019	7	15	36	42	22
019	020					
020	021	23	16	19	43	39
021	000	11	11	34	45	22
Average %		***8.3***	***7.4***	***14.3***	***70.0***	***15.7***

Notes: bolded Sedge Survival Sections meet the suggested minimum success criteria.
Sedge Survival Sections 020-021 and 021-000 were not assessed in 2011.

Bioengineering Success

Modified Brush Layers

Six modified brush layers, ranging from 4.4 to 17.9 m in length (Table 11), were re-assessed to determine if they had established sufficiently to provide effective erosion control and become important components of the streamside riparian plant community. Modified brush layer 6 was the only one to meet the recommended minimum 70% effective length criterion (Przeczek and Isaac 2011). Brush layers 4 and 9 had fewer live cuttings in 2012 than in 2011 and brush layers 6, 12 and 16 had more live cuttings.

Table 11. Selected brush layer assessment data, Aberfeldie side channel study area. Layers meeting the recommended criterion are in bold.

Assessment Year	Attribute	Brush Layer Number					
		1	4	6	9	12	16
2009	Length (m):	10.2	4.8	17.4	7.9	4.4	17.9
	Total Cuttings:	38	19	100	35	19	71
	Live cuttings (with leaves):	9	8	41	14	4	29
	% Live Cuttings:	23.7	42.1	41.0	40.0	21.1	40.8
2010	Live cuttings (with leaves):	4	1	22	6	4	6
	% Live Cuttings:	10.5	5.3	22	17.1	21.1	8.5
	Effective Length (m)	3.32	1.00	14.93	5.22	2.42	5.55
	% Effective Length	32.5	20.8	**85.8**	66.1	55.0	31.0
2011	Live cuttings (with leaves):	2	1	18	4	3	6
	% Live Cuttings:	5.3	5.3	18.0	11.4	15.8	8.5
	Effective Length (m)	2.00	1.00	13.74	3.80	2.42	5.49
	% Effective Length	19.6	20.8	**79.0**	48.1	55	30.7
2012	Live cuttings (with leaves):	2	0	25	0	4	10
	% Live Cuttings:	5.3	0	25	0	21.1	14.1
	Effective Length (m)	2.00	0.00	13.52	4.12	2.45	9.13
	% Effective Length	19.6	0.0	**77.7**	52.2	55.7	51.0

Plate 11 includes views of some unsuccessful brush layers and Appendix 4 presents a summary of the modified brush layer assessments.

Invasive Plant Assessments

Keefer (2006) recommended a target of 0% cover for invasive plants. Invasive plants continue to be concentrated along the river side of both the side-channel and the berm. Overall it appears that the noxious weed population increased by 23% from 2011 to 2012. The patches of Canada thistle (*Cirsium arvense* (L.) Scop.) and bull thistle (BT, *Cirsium vulgare* (Savi) Ten.) have increased in number and size with the largest patch of CT extending 18x3m (0.005 ha, photo 1245). However the count of single plants had decreased. Distribution along the side-channel was mostly individual plants with densities ranging from 1 - 2 plants/m^2. A number of patches have formed along the berm with densities of 6 plants/m^2 and greater.

The yellow hawkweed (YH, *Hieracium spp.*) population is increasing such that often there is less than 25m between plants or patches. Hound's-tongue (HT, *Cynoglossum officinale L.)* is also increasing to form patches or scattered plants with less than 5m between individuals.

Occurrence of common burdock (CB, *Arctium minus* L.) and blueweed (BW, *Echium vulgare* L.) have remained constant and occur only along the berm.

The presence of spotted knapweed (SK, *Centaurea biebersteinii* DC) has increased significantly. One patch with a density of 4 (>10 plants/ m^2) was observed on the river side of the side channel and two plants were found on the berm. Sulphur cinquefoil plants (*Potentilla recta* L.) were found with the SK on the berm as well as distributed sporadically along the side-channel.

Three new species were found in the area. A patch of perennial sow thistle (PS, *Sonchus arvensis* L.) with a density of 6 plants/m^2 was observed on the river side of the side channel, another similar patch is growing on the berm, and there is a less dense patch on the plant side of the side channel. Two absinthe wormwood plants (WW, *Artemisia absinthium* L.) were observed; one on the riverside of the side channel and the other on the berm. One common tansy plant (TC, *Tanacetum vulgare* L.) was found along the berm.

These species all pose a threat to the success of the side channel project due to the lack of competitive vegetation, presence of exposed mineral soil, and presence of wind and wildlife that transport seed and disturb the soil. Plate 7 shows a number of invasive plant species of concern at the project site.

Discussion

The results of the TASK 2C monitoring program address the following objectives:

1. Monitor the development of seeded areas (grass & legumes) and the survival of riparian vegetation (trees & shrubs) planted at the compensation habitat site; and,
2. Monitor the structural integrity (bioengineering structures) of the compensation habitat.

In addition, the occurrence, density and distribution of invasive plants were also assessed.

Grass and Legume Seeding Success

The cover levels of the two berm sites were higher than those of the two side channel sites (Figure 6). The main gate was left open and a number of cattle were found grazing in the side channel area. Wherever they crossed the side channel there was obvious disturbance to the side channel banks (Plate 8). The loose sandy/gravelly nature of the parent materials in the study area makes them particularly susceptible to disturbance which results in increased soil exposure, damage to developing plant communities, increased surface erosion, and introduction of invasive plants.

Berm TU (TU A)

Seeded vegetation on the side of the berm was distributed relatively evenly and after the fourth growing season the target objective of 60% cover is being met or exceeded. Vegetation on the top of the berm is growing adequately and the south end supports a larger forb component than the central and northern sections (Appendix 1). The top of the berm does not meet the target cover objective and supplemental seeding and fertilization treatments will be required to meet project targets. The relatively aggressive plant community that is developing has resulted in moisture competition and mechanical damage (snow press) issues for planted seedlings which has contributed to decreased seedling survival.

It is important to recognize that the revegetation success of the berm treatment unit does not have any direct impact on the productive capacity of the side channel treatment unit. In the event of a flooding event on the Bull River the berm may divert the water and reduce potential damage and siltation in the constructed side channel.

Side Channel TU (TU B)

Side channel vegetation development is characterized by poor and patchy establishment and mean vegetative cover below 15%. The side channel has large areas with steep dry ravelling banks that are introducing sediment into the side channel and will not support vegetation that meets target cover levels until the banks stabilize. The current unsatisfactory performance of the seeded grasses and legumes is expected to continue until slopes are modified to a profile that will support plant growth (Plate 6, Plate 11)[4]. In addition, the benefits of streamside shrubs (shading, litter fall, insect drop) cannot be realized unless the banks are stabilized.

Resloping treatments may improve access for cattle that use the area and result in damage to streamside plant communities and introduction of soil into the side channel. Controlling cattle access may be the only way to prevent potential negative impacts from cattle grazing in the area and to ensure that project objectives are achieved. A detailed resloping, revegetation and cattle management plan should be prepared to provide direction for the implementation of any additional work.

Planted Tree and Shrub Seedling Survival

The fourth growing season seedling survival ranged from unacceptable to excellent. Ponderosa pine suffered 100% mortality in 2009. Cottonwood, paper birch, western larch, Saskatoon and Engelmann spruce in plots do not meet the target of 75% survival. Native chokecherry, cottonwood, birch, and aspen disturbed during construction activities continue to sprout from rhizomes, roots, and stems which will contribute to the diversity of the riparian plant community in the study area (Plate 10).

Survival is expected to decrease for most species as indicated by the increase in seedlings in the poor condition class. The continued development of the seeded grass and legume plant community at TU A (berm) is having a negative impact on seedling condition and seedling survival. Reduced moisture availability for trees and shrubs, due to the well-established grass/legume plant community, is probably the most important constraint on planting success. Planting operations need to consider the potential competing plant community and site preparation treatments should focus on minimizing expected limiting factors.

If the extended line of sight along the berm is a concern, a small planting project focussed on creating a mixed native shrub and tree species "island" could be considered. Site preparation would be required to reduce moisture competition from the established grasses and forbs. A section of the berm top where grass and legume establishment is not meeting target conditions would be the best location for this project. Planting an island on the berm would reduce the line of sight along the berm and create a unique habitat that would be functional for shrub nesting bird species and it would provide hiding cover for ungulates. Fencing should be considered to minimize grazing damage from ungulates and cattle for first the 10 years following planting.

[4] In coarse sandy materials a slope of approximately 30 degrees would be stable.

Sedge Planting Success

Sedges are establishing along the side channel. Approximately 30% of the side channel had at least one plant per meter and one of the sedge assessment sections met the suggested success criteria. Sedges are rhizomatous (Hauser 2006) and the numbers of plants are expected to increase over time. It is unlikely that the sedge plantings will meet target objectives over the length of the side channel. However, the presence of the sedge plants, while good for species diversity, is not a significant consideration for determining project success.

Bioengineering Success

Modified Brush Layers

Only one of the assessed brush layers met the recommended criteria of at least 70% effective length. The poor performance of the modified brush layers was probably due to improper installation in 2009. Installation problems included poor choice of sill log species, inadequate staking of sill logs and shallow planting of cuttings for brush layers. Three of the brush layers (no. 6, 12, 16) had increased numbers of cuttings with leaves due to new sprouts forming since the last growing season. We do not expect the sprouting to be sufficient to significantly increase the effective length of any of the modified brush layers.

Structural Integrity

Berm Treatment Unit (TU A)

This treatment unit currently satisfies some of the criteria associated with assessing its structural integrity. The berm is geologically stable. It is physically separate from the side channel and the Bull River and therefore should not contribute sediments to either water course. The seeded vegetation is developing well (particularly on the sides of the berm). Survival of most of the planted seedlings is below target levels and moisture competition from seeded grasses and legumes has had a negative effect on seedling survival and quality. Desirable native species volunteers are developing in response to project disturbances and as they continue to grow they will provide some of the long term habitat functions (nesting, perching, foraging) that may be considered components of structural integrity. It is unlikely that poor survival of planted species will impact the long term structural integrity of this treatment unit.

Side Channel Treatment Unit (TU B)

This treatment does not satisfy any of the criteria associated with assessing its structural integrity and it is unlikely to do so unless resloping treatments are applied. The sand and gravel substrate should be reasonably geologically stable at approximately 30 degrees[5] but a simple slope will not be adequate for creating a diverse, stable riparian plant community. Resloping would allow establishment of sedges, rushes, grasses and legumes, planting of appropriate shrub species and use of live staking to establish willow, cottonwood and red-osier dogwood. However, resloping treatments may introduce unacceptable amounts of sediment into the side channel with negative effects on the establishing invertebrate and fish

[5] Arthon Construction Ltd. “Aggregates : ANGLE of REPOSE”. April 11 2009. <http://www.arthon.com/library/angleofrepose.html>.

populations. Resloping may also improve access to the side channel for cattle and wildlife which may have negative impacts on riparian plant communities and introduce sediment to the channel.

Invasive Plant Assessments[6]

The target level for invasive plant species is 0% cover (Keefer 2006). However, invasive plant populations continued to increase throughout the project area over the past year with three new species being introduced which is in addition to the two new species introduced in 2011. In 2009 bull thistle was the only noxious weed found along the vegetation transects with a mean cover of 3% cover on the berm side which increased to 8% in 2012. Invasive hawkweeds were not present at any of sample locations but have increased to over 9% at the berm top and range from 0.5% to 3.0% mean cover at the other three sites. This trend will continue if invasive plant control treatments are not implemented.

The B.C. Weed Control Act[8] imposes a duty on all land occupiers to control designated noxious plants with the purpose of protecting natural resources and industry from the negative impacts of these species. Under the act weed species are classified as noxious on either a Provincial or Regional level or generally as a nuisance plant.

The East Kootenay Invasive Plant Council (EKIPC) coordinates the management of invasive plants, provides invasive plant education and is responsible to prevent the further introduction and spread of invasive plants in the area and to maintain a comprehensive inventory of invasive plants[7]. EKIPC has also created lists of species that they consider a threat to the district within specified invasive plant management units (IPMA). The Aberfeldie study area is located within IPMA 3.

Table 12 lists the 12 weed species found in the study area showing the designation defined under the weed act and by EKIPC. EKIPC also assigns a treatment priority to every species and these are provided in Table 13.

[6] Information for this section was taken from: Government of British Columbia, <http://www.for.gov.bc.ca/hra/Plants/index.htm>; Montana Weed Control Association, , March 7, 2013, <http://www.mtweed.org>, and The Colorado Weed Management Association, Noxious Weed Information, March 7, 2013, <http://www.cwma.org/>.

[7] East Kootenay Invasive Plant Council, <http://www.ekipc.com/>, accessed March, 7, 2013.

Table 12 Summary of designation of noxious weed species found in the Aberfeldie side channel study area**.**

Common Name	EKIPC Priority[7]	BC Weed Control Act[8]
bull thistle		nuisance
blueweed	2	regional
Canada thistle	3	provincial
common burdock		nuisance
common tansy	2	regional
curled dock		nuisance
hound's-tongue	Bio-control	provincial
perennial sow-thistle	3	provincial
sulphur cinquefoil	3	
spotted knapweed	2	provincial
absinthe wormwood	1	
yellow hawkweed		nuisance

Table 13. EKIPC Invasive Site Priorities[7]

PRIORITY	PURPOSE OR INTENT
1 Extremely High	To stop the spread of invasive plants threatening currently non-infested, highly susceptible areas. These sites are less than or equal to 0.25 ha and there is a good expectation of control. This priority also includes sites that are threatening a large neighbouring economic base for example, seed and other high value crops. The management strategy is to eliminate these populations.
2 High	To stop the enlargement of sites in highly susceptible areas. These sites are less than or equal to 0.5 ha in size and are located in highly susceptible areas with a high potential for spread within the area or threatened adjacent non-infested areas. The management strategy is to control or contain the spread of these populations (usually satellite populations).
3 Moderate	To stop the enlargement of sites when: 1) The sites are greater than 0.5 ha in size in highly susceptible areas, **or** 2) The sites are less than 0.5 ha in size in moderately susceptible areas. The management strategy is to contain the spread of these populations.
4 Low	To stop the enlargement/contain sites greater than 0.5 ha in size in moderately susceptible areas with the low potential to spread within the area.

There are several strategies that can be implemented to control the spread of invasive plants. The control method or combination of methods selected is dependent upon the goals and objectives and the weed species targeted[9] therefore it is helpful to be familiar with each plant's characteristics. Appendix 5 provides summary information on the reproductive characteristics of invasive plant species present and weed control strategies suitable to the Aberfeldie side channel project area. Table 14 and Table 15 summarize the treatment options available for each of the invasive species present on the Aberfeldie site.

[8] Ministry of Agriculture, <http://www.agf.gov.bc.ca/cropprot/noxious.htm>, accessed March 7, 2013.

[9] Information for this section was taken from: Government of British Columbia, <http://www.for.gov.bc.ca/hra/Plants/index.htm>.

Absinth wormwood is a semi-woody, clump-forming long-lived perennial. Once established in a pasture or range area, it is very difficult to remove and can have significant impacts on the quality of forage for wildlife and livestock as it is poisonous and aromatic. It is also allelopathic and able to out-compete desirable grasses and other plants. The plant invades disturbed dry and moist soils thriving where moisture is abundant (King County Noxious Weed Control Program Best Management Practices).

Control of small individuals can be maintained by, hand pulling or digging up the roots when the soil is moist. Use of the herbicides aminopyralid, clopyralid, dicamba, glyphosate or 2,4-D is effective when applied from late June to mid-August.

Blueweed is an annual to short-lived perennial. It thrives in sunny, arid areas and does not tolerate shade thus invades rangelands and pastures. It is unpalatable and can be toxic to some grazing animals and its stiff hairs can cause skin irritation in humans (Montana Weed Control Association).

Small infestations may be controlled by hand-pulling or digging however protective clothing is necessary to avoid contact with the prickly hairs. Larger infestations can be treated with spring or early autumn applications of 2,4-D or metsulfuron.

Canada thistle is a colony-forming perennial that develops from deep and extensive roots. It invades both disturbed and native plant communities and has adapted to a wide range of soil types and environmental conditions. Herbicides should be applied either when plants are in the bud stage or to re-growth in the fall. At the bud stage, leaf area for herbicide coverage and absorption is maximized, and root reserves are at their lowest. In the fall, translocation of the herbicide to the roots is the greatest. Aminopyralid (Milestone®), clopyralid (Transline®), and picloram (Tordon 22K®) provide similar suppression of Canada thistle. For light infestations, pulling or hand-cutting can be effective if done several times each season to starve underground roots and stems. Mowing in late June when root reserves are lowest may result in the greatest reduction of the weed.

Common tansy spreads mainly by seeds, and less commonly from creeping rhizomes, to form dense clumps. It grows best in full sun and prefers sites with moist well-drained soils infesting stream banks, rangeland, roadsides and other disturbed habitats. The plants are unpalatable and contain alkaloids that are toxic to both humans and livestock if consumed in large quantities (King County Noxious Weed Control Program Best Management Practices).

Herbicide treatment with picloram/2,4 D, metsulfuron methyl, or aminopyralid provides the most effective control. Hand-pulling of small infestations should be repeated over successive springs as plants will sprout from remaining roots. Protective clothing should be worn to prevent possible absorption of toxins through skin.

Perennial sow-thistle is a prickly perennial that has serious impacts to agricultural lands but its aggressive colony-forming habit means that it also threatens all habitat types wherever it establishes. It poses a serious problem in marsh lands and other riparian areas.

Due to their extensive root systems and resistance to herbicides sow thistles are difficult to control and require intensive cultivation or high rates of herbicides. Chemical control can be achieved by applying 2,4-D, clopyralid, dicamba, glyphosate, or picloram at the pre-bud or bud stage.

Spotted knapweed is a short-lived perennial (3-9 years) that invades and rapidly colonizes disturbed areas in low- to mid-elevation grasslands and open forests. It may spread into adjacent undisturbed sites.

Spotted knapweed reproduces by seed that germinate in spring or fall. Dormant seeds remain viable for over 8 years.

Hand-pulling can be effective in controlling small infestation of spotted knapweed however follow-up treatments will be required to deplete the seed bank. Clopyralid and aminopyralid are the most effective herbicides for spotted knapweed control, having soil residual activity that provides extended control of germination.

Sulphur cinquefoil is a very competitive perennial that invades disturbed and undisturbed habitats and can dominate sites displacing established vegetation. It reproduces by seed and vegetatively from roots.

Herbicides that reduce sulphur cinquefoil populations include 2,4-D, aminopyralid, and picloram. Applications in the rosette or pre-bloom stages of growth are most effective. Small infestations can be managed by digging. Once a colony is established early spring or fall treatment (after green-up) with Picloram, clopyralid, or 2,4-D is effective in controlling or eradication this noxious weed.

Table 14. Treatment options for invasive plant species on the Aberfeldie side channel study area.

Invasive Plant	Treatment Options*	Preferred Treatment Option and Rationale	Preferred Treatment Timing
Absinth wormwood	Herb HP Mow	Apply late spring and summer Individual plants or small infestations To prevent seed production	Late June, Mid-August
Blueweed	Herb Mow	Apply spring or fall If herbicide window missed, to prevent seed production	April or September
Canada thistle	Herb Mech	Integrate a combination of management tools to deplete the aggressive creeping root system	Herb - September Mow - June
Common tansy	Herb HP	Reproduction by rhizomes To prevent seed production	May-June
Perennial sow thistle	Herb	Ensure control	June
Spotted knapweed	Herb HP Mow	Cost-effective Small sites in remote areas To prevent seed production	May and September
Sulphur cinquefoil	Herb HP	Ensure control To prevent seed production	May-June

* Herb – herbicide, Mech – mechanical, Bio – biological control, IPM – Integrated Pest Management

Table 15. Recommended biocontrol agents.

Biocontrol Agent	Invasive Plant Species	Mode of Action	Release Timing
Mogulones cruciger Herbst.	Hound's-tongue	Reduces plant vigour through damage to the root and stem.	May-June

Additional Species of Concern

There are four species that have invaded the study that are considered nuisance weeds on a provincial level and not on the EKIPC lists. Their ability to aggressively out-compete desirable species could result in project objectives being compromised over time.

Bull thistle is a biennial and tends to invade over-grazed or otherwise disturbed pastures, rangeland, roadsides, and waste areas. Biennial thistles reproduce only from seed, so the key to a successful management program is to control the plants before flowering. Small infestations can be effectively hand-pulled or dug up.

Chemical control on exotic thistles is most effective when plants are in the rosette stage and least effective when thistles are flowering. On severely disturbed sites, 2,4-D ester is most effective when applied 10-14 days before bolting of the flowering stems. Dicamba can be used earlier in the spring than 2,4-D. Picloram, alone or in combination with the other herbicides mentioned, gives the best late-season control, but is more expensive, cannot be used near groundwater or during certain seasons of the year, and presents a greater risk of damaging non-target species. Digging up small infestations is effective though labour-intensive. Mowing or cutting top-growth before seed-set will eliminate annual seed production and nuisance burrs.

Common burdock is a biennial found in disturbed areas in grasslands and forests, along roadsides and riparian areas. The burrs produced by common burdock can cause eye, nose or mouth injuries to grazing animals.

Infestations can be controlled by mowing or cutting after the plant has bolted to eliminate seed production. Application of a herbicide (2,4-D, picloram, dicamba, or glyphosate) is most effective when carried out on first-year rosettes.

Curled dock is a robust perennial plant with a deep taproot and produces an abundance of seed with a long dormancy period. Young plants are not very competitive but once established, the root system is extensive and very difficult to control. Curled dock favors heavy wet soils, but can adapt to dry areas with poor soils. Its seeds and foliage can be toxic to animals (Washington State University Whitman County Extension).

Control is best attained using herbicide treatment of metsulfuron, chlorsulfuron, glyphosate, clopyralid, aminopyralid, triclopyr or 2,4-D. Herbicides should be applied to actively growing plants in the spring and early summer; however, once curly dock becomes established, fall applications work best. Digging of new infestations is only effective if all of the rootstock is removed.

Hound’s-tongue tends to be a nuisance weed rather than a noxious plant unless infestations grow to become large patches. The burrs often become imbedded in the hair, eye or eyelids of animals. They can be problematic for hikers, hunters and fishermen, and also to their pets. Hound’s-tongue contains alkaloids that are especially toxic to cattle and horses. Within the study area hound’s-tongue has not reached the noxious stage.

In general, spring application of herbicide provides consistently better control of hound’s-tongue than fall treatments. First-year hound’s-tongue rosettes are controlled easily with 2,4-D. Picloram, dicamba, and metsulfuron. Herbicide treatment should be restricted to rosettes and bolting plants should be pulled and disposed of. Mowing before flowering will prevent seed production. Hand-pulling of small infestations is very effective but in harder soils the root will break off, resulting in re-sprouting. A better approach is to sever the root below ground level by tilling which should inhibit re-sprouting. Biocontrol using the root weevil, Mogulones cruciger is very effective on large infestations (Table 15).

Yellow hawkweed is a creeping perennial that spreads by stolons and rhizomes creating colonies. Yellow hawkweed is not on the BC weed list, however in the United States it is a classified weed and control is mandatory. The invasiveness of the introduced species of hawkweed (14 in BC) is evident along road sides and on pasture lands in BC

Spring treatment with Picloram, combinations of Picloram plus 2,4-D or aminopyralid can be effective in controlling the hawkweed; 2,4-D alone is inadequate. Cultural and mechanical methods are usually ineffective as the smallest segment of remaining root can develop into a new plant.

Recommendations

1. Seedlings were planted without regard for location, total numbers available for assessment, or potential for replication in an experimental design. Consider designing and laying out survival assessment plots that would allow for more effective statistical analysis of seedling survival for each species.
2. Consider planting a small native tree and shrub island on a section of the berm top (TU A) that is not currently meeting target revegetation conditions. This will improve species diversity, provide additional wildlife habitat, and reduce the line of sight along the berm. The island should be fenced to minimize potential browsing impacts.
3. Consider supplemental seeding and fertilizing of the portion of the berm top TU that is not achieving 60% cover. This may provide the boost required to meet the target vegetation cover of 60%. The additional nutrients are not expected to affect either the side channel or the Bull River. Additional site preparation may be required to provide sufficient acceptable seedbed for improving the cover of seeded grasses and forbs. This recommendation needs to be considered in combination with recommendation 2.
4. The current physical configuration of the side channel treatment unit (TU B) will not promote achieving revegetation and structural integrity objectives for the project. Consider resloping and revegetating the side channel to a species mix that will promote project objectives. Controlling cattle access to the side channel area may also be required to ensure that project objectives are achieved. A detailed resloping, revegetation and cattle management plan should be prepared to provide direction for the implementation of any additional work.
5. Ensure that gates remain closed to reduce access by cattle and additional damage to sensitive banks at the side channel TU.
6. Hand-pulling and digging spotted knapweed, blueweed, sulphur cinquefoil and common burdock plants during the spring and throughout the year when the soil is moist is highly recommended to eradicate these species.
7. Repetitive mowing and/or herbicide treatment is recommended to control further spread of Canada thistle and bull thistle.

8. Herbicide treatment of perennial sow thistle, common tansy and curled dock is strongly recommended. If controlling yellow hawkweed is desirable, early spring treatment with Milestone (aminopyralid) will provide the best results.
9. Treatment of invasive plant infestations located on BC Hydro land adjacent to the project area is also recommended to reduce the seed source and protect the side channel investments. Treatments would be the adjacent land owner's responsibility and dialogue between them and BC Hydro would be required

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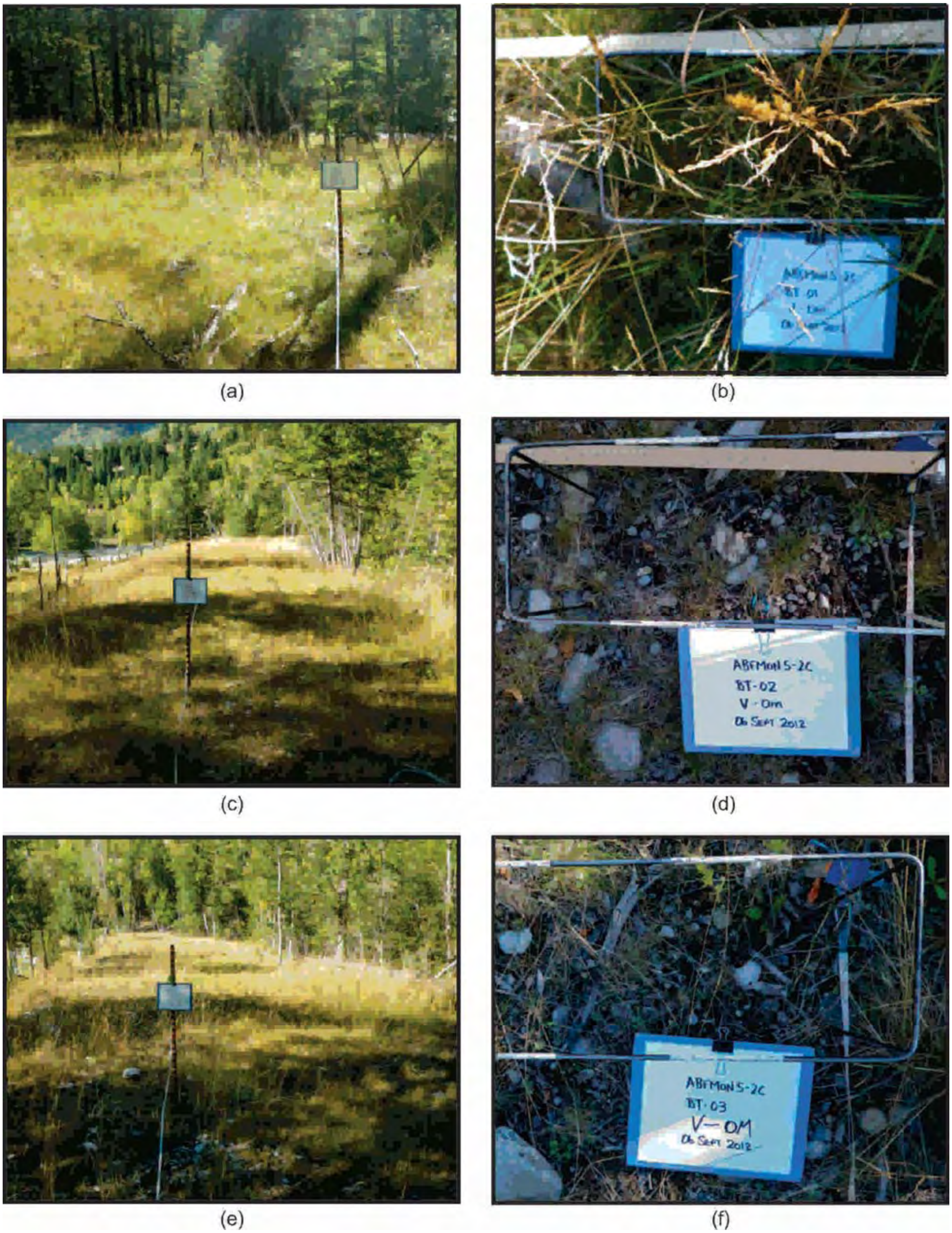


Plate 1. Various views of the three permanent vegetation monitoring transects on top of the berm: (a) BT01 from EOT to MOT, (b) BT01 at 0 meters, (c) BT02 from SOT to MOT, (d) BT02 at 0 meters, and (e) BT03 from SOT to EOT, (f) BT03 at 0 meters.

Plate 2. Various views of three permanent vegetation monitoring transects on the side of the berm: (a) BS01 from SOT to EOT, (b) BS01 at 0 meters, (c) BS02 from SOT to EOT, (d) BS02 at 0 meters, (e) BS03 from SOT to EOT, and (f) BS03 at 0 meters.

Plate 3. Various views of three temporary vegetation monitoring transects on the river side of the side channel: (a) RS01 from EOT to SOT, (b) RS01 at 0 meters, (c) RS02 from EOT to SOT, (d) RS02 at 0 meters, (e) RS03 from EOT to SOT, and (f) RS03 at 0 meters.

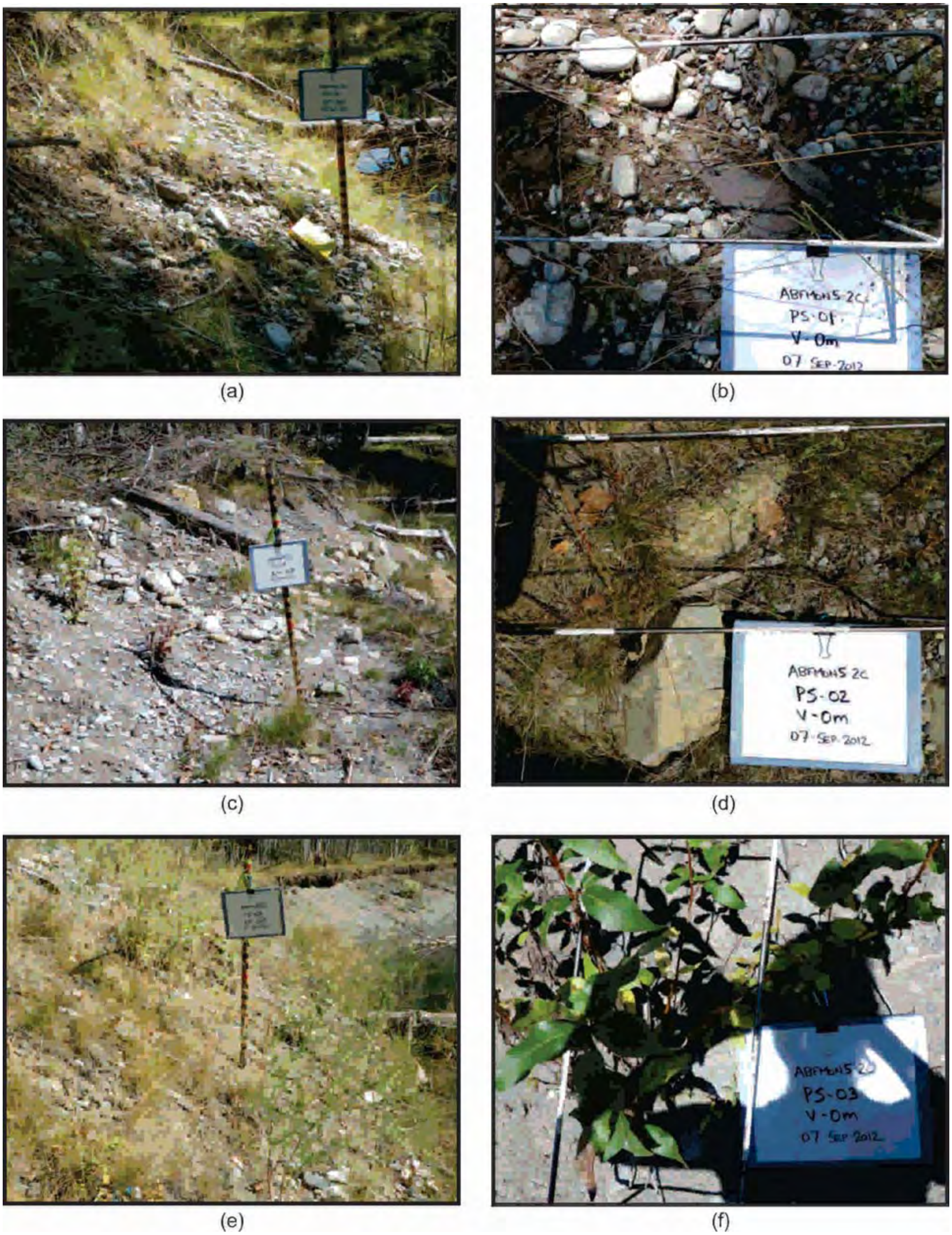


Plate 4. Various views of three temporary vegetation monitoring transects on the power plant side of the side channel: (a) PS01 from EOT to SOT, (b) PS01 at 0 meters, (c) PS02 from EOT to SOT, (d) PS02 at 0 meters, (e) PS03 from EOT to SOT, and (f) PS03 at 0 meters.

(a)

(b)

(c)

(d)

Plate 5. Selected photographs showing: (a) the berm looking south, (b) overview of the berm looking north west, (c) the berm looking west just below the parking area, and (d) the berm looking north.

(b)

(a)

(c)

(d)

Plate 6. Selected photographs showing: (a) unsuccessful revegetation efforts on a steep dry ravelling slope in TU B (side channel), (b) overview of a portion of the side channel, (c), a section of the side channel at the weir, and (d) unacceptable patchy vegetation development at the northern end of the side channel.

Plate 7. Selected photographs showing invasive species : (a) and (b) bull thistle, (c) Canada thistle(d) spotted knapweed, and (e) absinth wormwood.

Plate 8. Selected photographs showing: (a) cattle crossing damage at the side channel, (b) + (c) +(d) cattle grazing at various locations along the side channel.

Plate 9. Selected photographs showing surviving seedlings: (a) good quality hawthorn, (b) poor quality hawthorn, (c) fair quality western larch, (d) good quality Engelmann spruce, (e) fair quality Engelmann spruce, (f) good quality Saskatoon, (g) + (h) good quality prickly rose, and (i) good quality cottonwood with browsing damage.

Plate 10. Selected photographs showing native species volunteers: (a) cottonwood at the side channel showing extensive root system, (b) chokecherry, (c) birch copse, and sprouted cuttings from modified brush layers (d) willow, and (e) red-osier dogwood.

Plate 11. Selected photographs showing: (a) unsuccessful brush layer showing how the modified slope allows for the establishment of grasses and forbs, (b) improperly staked sill log with a few sprouted cuttings, (c) unsuccessful modified brush layers (d) a section of successful modified brush layer, and (e) unsuccessful modified brush layers.

Appendix 1. Vegetation Data

Summary transect information by year and species group

	Berm Side			
2009	**BS-01**	**BS-02**	**BS-03**	**Mean**
Forb	57.4	42.2	26.8	42.1
Grass	4.5	13.0	7.0	8.2
Shrub	2.6	2.7	1.3	2.2
Total	**64.5**	**57.9**	**35.1**	**52.5**
2010				
Forb	60.0	43.6	36.9	46.8
Grass	11.4	31.7	18.6	20.6
Shrub	2.1	1.3	0.9	1.4
Total	**73.5**	**76.6**	**56.4**	**68.8**
2011				
Forb	98.1	14.0	18.0	43.4
Grass	28.8	54.8	39.1	40.9
Shrub	0.3	47.5	1.9	16.6
Total	**127.2**	**116.3**	**59.0**	**100.8**
2012				
Forb	57.3	30.0	12.3	33.2
Grass	4.5	81.2	61.6	49.1
Shrub	2.6	5.3	1.7	3.2
Total	**64.4**	**116.5**	**75.6**	**85.5**

	Berm Top			
2009	**BT-01**	**BT-02**	**BT-03**	**Mean**
Forb	31.2	7.9	18.6	19.2
Grass	6.1	3.7	5.9	5.2
Shrub	0.2	1.0	0.0	0.4
Total	**37.5**	**12.6**	**24.5**	**24.9**
2010				
Forb	39.3	5.7	12.8	19.3
Grass	24.5	16.2	9.3	16.7
Shrub	0.2	0.4	0.3	0.3
Total	**64.0**	**22.3**	**22.4**	**36.2**
2011				
Forb	31.2	1.0	3.7	12.0
Grass	27.6	18.3	13.2	19.7
Shrub	0.8	0.5	0.2	0.5
Total	**59.6**	**20.4**	**17.1**	**32.4**
2012				
Forb	22.2	4.5	7.3	11.3
Grass	36.5	26.5	18.6	27.2
Shrub	0.3	0.1	0.1	0.2
Total	**59**	**31.1**	**26**	**38.7**

	Side Channel Plant Side			
2009	**PS-01**	**PS-02**	**PS-03**	**Mean**
Forb	0.7	0.8	0.0	0.5
Grass	0.5	5.0	0.0	1.8
Shrub	0.0	0.0	0.0	0.0
Total	**1.2**	**5.8**	**0.0**	**2.3**
2010				
Forb	1.3	0.2	1.2	0.9
Grass	0.9	6.2	4.9	4
Shrub	0.1	0.0	0.0	0.0
Total	**2.3**	**6.4**	**6.1**	**4.9**
2011				
Forb	3.0	2.6	1.4	2.3
Grass	7.4	0.1	9.9	5.8
Shrub	0.0	0.2	0.0	0.1
Total	**10.4**	**2.9**	**11.3**	**8.2**
2012				
Forb	1.3	1.0	9.3	3.9
Grass	8.8	8.1	9.4	8.8
Shrub	0.0	0.1	0.0	0.0
Total	**10.1**	**9.2**	**18.7**	**12.7**

	Side Channel River Side			
2009	**RS-01**	**RS-02**	**RS-03**	**Mean**
Forb	0.5	0.3	1.7	0.8
Grass	2.2	4	3.5	3.2
Shrub	0.0	0.0	0.0	0.0
Total	**2.7**	**4.3**	**5.2**	**4.1**
2010				
Forb	2.7	7.4	2.5	4.2
Grass	10.6	17.5	4.0	10.7
Shrub	0.0	0.0	0.1	0.0
Total	**13.3**	**24.9**	**6.6**	**14.9**
2011				
Forb	4.4	2.6	3.8	3.6
Grass	8.9	18.5	9.5	12.3
Shrub	0.6	0.1	0.1	0.3
Total	**13.9**	**21.2**	**13.4**	**16.2**
2012				
Forb	12.3	3.7	4.4	6.8
Grass	10.7	31.1	12.2	18
Shrub	0.6	0.0	0.2	0.3
Total	**23.6**	**34.8**	**16.8**	**25.1**

Appendix 2. Seedling Survival Data

2012 seedling count by condition class

Species	Transect Type	Year	Live	Dead	Poor	Fair	Good	Total
Black Cottonwood	LINE	2012	3	7		2	1	10
Paper Birch	LINE	2012	2	3	1	1		5
Hawthorn	LINE	2012	16	4	3	6	7	20
Western Larch	LINE	2012	4	6		4		10
Ponderosa Pine	LINE	2009	0	10				10
Prickly Rose	LINE	2012	41	9	4	20	17	50
Prickly Rose	PLOT	2012	24	4	6	5	13	28
Saskatoon	LINE	2012	12	8	3	2	7	20
Engelmann Spruce	LINE	2012	38	12	6	27	5	50
Engelmann Spruce	PLOT	2012	10	12	10			22

Note: shaded rows show species that are below the target minimum of 75% survival.

Appendix 3. Sedge Data

Sedge Survival Section		Success Class (est. meters)			
Start	End	Good (3)	Fair (2)	Poor (1)	None (0)
000	001	18	15	9	14
001	002	0	0	0	12
002	003	1	3	0	18
003	004	4	3	2	30
004	005	0	0	2	21
005	006	0	7	5	33
006	007	1	1	7	7
007	008	6	3	6	22
008	009	2	0	7	31
009	010	24	15	41	28
010	011	18	6	14	49
011	012	2	0	2	36
012	013	0	1	1	17
013	014	2	2	2	21
014	015	0	0	1	18
015	016	0	0	1	10
016	017	2	1	7	115
017	018	2	0	1	59
018	019	5	11	26	31
019	020				
020	021	17	12	14	32
021	000	6	6	19	25

Appendix 4. Bioengineering Data

2009

Brush Layer Number:	**1**	**4**	**6**
Sill Log Species:	Lw	Ac (old, decaying)	Ac (old, dead), Ep
Sill Log Staked:	no	yes (undersized stakes)	partially
Length (m):	10.2	4.8	17.4
Total Layer Cuttings:	38	19	100
Cuttings with Leaves:	9	8	41
% Live Cuttings:	23.7	42.1	41.0
Comments:	cuttings too shallow many small diameter cuttings poor sill log choice	sill logs stakes too small cuttings too small too far up the bank poor sill log choice	some stakes too shallow right on river, good location poor sill log choice

Brush Layer Number:	**9**	**12**	**16**
Sill Log Species:	Ac (old, dead), Sx	Ep	Ac (sprouting)
Sill Log Staked:	partially (inadequately)	yes (50%), no (50%)	no (failed or failing)
Length (m):	7.9	4.4	17.9
Total Layer Cuttings:	35	19	71
Cuttings with Leaves:	14	4	29
% Live Cuttings:	40.0	21.1	40.8
Comments:	sill logs stakes too small cuttings too small poor sill log choice	some stakes too shallow cuttings too small poor sill log choice	some stakes too shallow cuttings too small Ac sill log looks good if it holds

2010

Live Stem Quality					
Brush Layer	Good	Fair	Poor	2010 Total	2010 % Live Cuttings
1	2	1	1	4	10.5
4		1		1	5.3
6	17	5		22	22
9	5	1		6	17.1
12	4			4	21.1
16	5	1		6	8.5

Effective Length								
Brush Layer	Isolated Cuttings (count)	1	2	3	4	Total Effective Length (m)	2009 Brush Layer Length (m)	% Effective
1	1	2.32				2.82	10.2	27.6
4	1					0.5	4.8	10.4
6		2.99	6.34	2.88	2.72	14.93	17.4	85.8
9	2	3.22				4.22	7.9	53.4
12		1	1.42			2.42	4.4	55
16	4	1.55				3.55	17.9	19.8

2011

Live Stem Quality - 2011					
Brush Layer	Good	Fair	Poor	2011 Total	2011 % Live Cuttings
1		2		2	5.3
4		1		1	5.3
6	11	5	2	18	18
9		4		4	11.4
12	1	2		3	15.8
16		6		6	8.5

Effective Length - 2011								
Brush Layer	Isolated Cuttings (count)	1	2	3	4	Total Effective Length (m)	2009 Brush Layer Length (m)	% Effective
1	2					2.00	10.2	19.6
4	1					1.00	4.8	20.8
6		1.8	6.34	2.88	2.72	13.74	17.4	79.0
9	2	1.8				3.80	7.9	48.1
12	1	1.42				2.42	4.4	55.0
16	4	1.49				5.49	17.9	30.7

2012

Live Stem Quality - 2012					
Brush Layer	Good	Fair	Poor	2012 Total	2012 % Live Cuttings
1	1	1		2	5.3
4				0	0
6	18	4	3	25	25
9	5	1			0
12	4			4	21.1
16	8	1	1	10	14.1

Effective Length - 2012								
Brush Layer	Isolated Cuttings (count)	1	2	3	4	Total Effective Length (m)	2009 Brush Layer Length (m)	% Effective
1	2					2.00	10.2	19.6
4	0					0.00	4.8	0.0
6		1.75	6.35	2.44	2.98	13.52	17.4	77.7
9	2	2.12				4.12	7.9	52.2
12		2.45				2.45	4.4	55.7
16	5	1.4	1.25	1.48		9.13	17.9	51.0

Appendix 5. Invasive Plant Control Measures

There are several strategies that can be implemented to control the spread of invasive plants. The control method or combination of methods selected is dependent upon the goals and objectives and the weed species targeted[10] therefore it is helpful to be familiar with each plant's characteristics.

Reproductive characteristics of invasive plant species present in the Aberfeldie side channel study area.

Invasive Plant	Reproduction	Seed bank	Management Techniques
Absinth wormwood	50,000 seeds	Viable 3-4 years	Repeated mowing, herbicide, hand-pulling
Blueweed	2,800 seeds	Viable up to 3 years	Cultural, mechanical and herbicide
Bull thistle	4,000 seeds	Viable up to 3 years	Mowing, digging, herbicide
Canada thistle	1,500 seeds	Viable up to 3 years	Repeated mowing, intensive cultivation and herbicide
Common burdock	6,000 – 16,000 seeds	Unknown	Herbicide; prevent dispersal of burs
Common tansy	>1,000/m^2 [7] Rhizomatous roots	Viable up to 25 years	Herbicide, hand-pulling
Curled dock	30,000-60,000 seeds	Buried seed viable up to 80 years	Mowing to prevent seed production and herbicide application
Hound's-tongue	2,000 – 4,000 seeds	Viable for 2 – 3 years	Herbicide; prevent seed production
Perennial sow-thistle	1,400 – 35,000 seeds	Short-lived, 2 years	Mechanical, herbicide, hand-pulling
Spotted Knapweed	400 – 25,000 seeds	Viable + 7 years	Herbicide, hand-pulling and bio-control; prevent seed dispersal and establishment of new infestations.
Sulphur Cinquefoil	1,650 seeds	< 2 years	Prevent infestation; herbicide and hand-pulling.
Yellow hawkweed	60-1,500 seeds, stolons and rhizomes	n/a	Herbicide

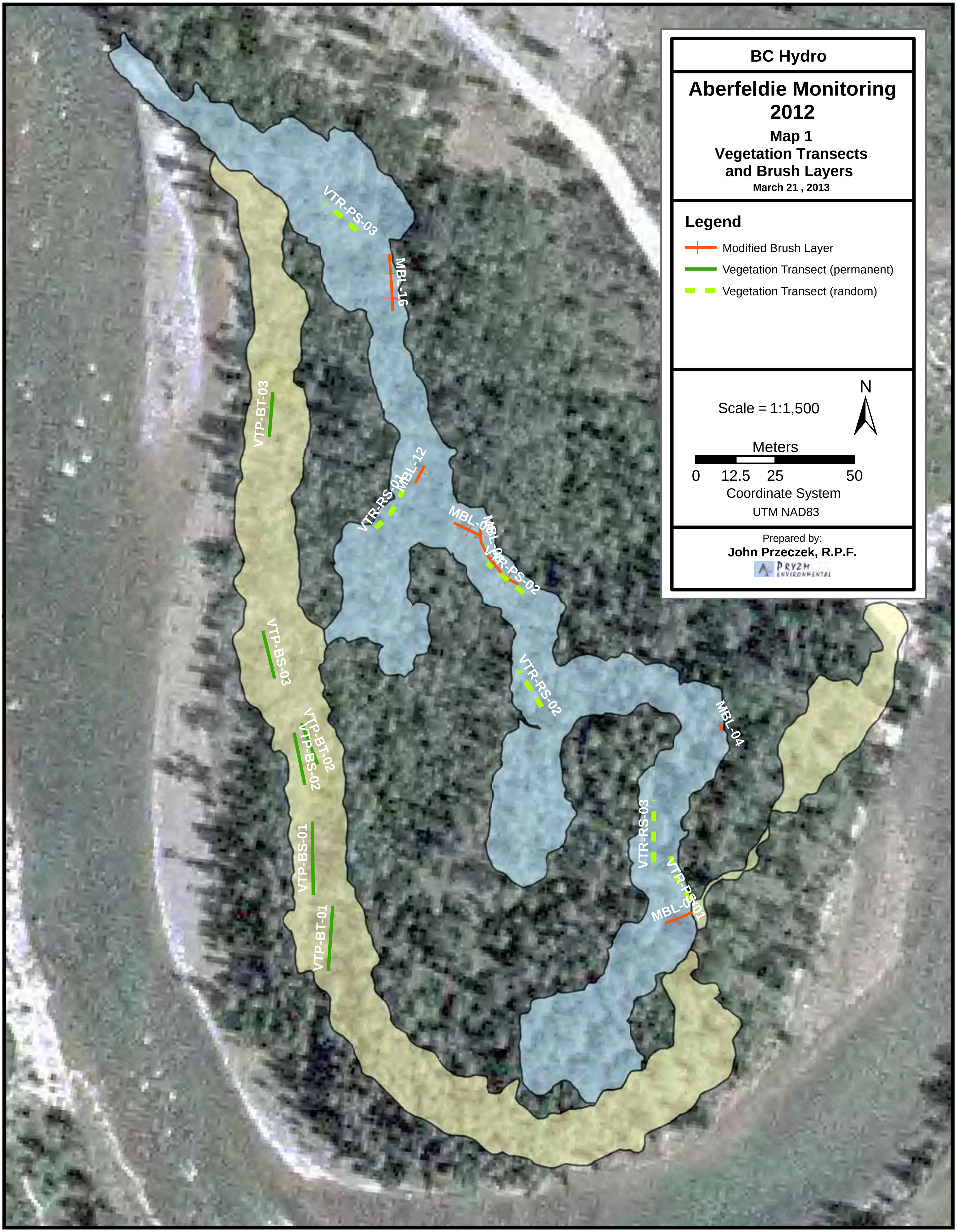
[10] Information for this section was taken from: Government of British Columbia, <http://www.for.gov.bc.ca/hra/Plants/index.htm>.

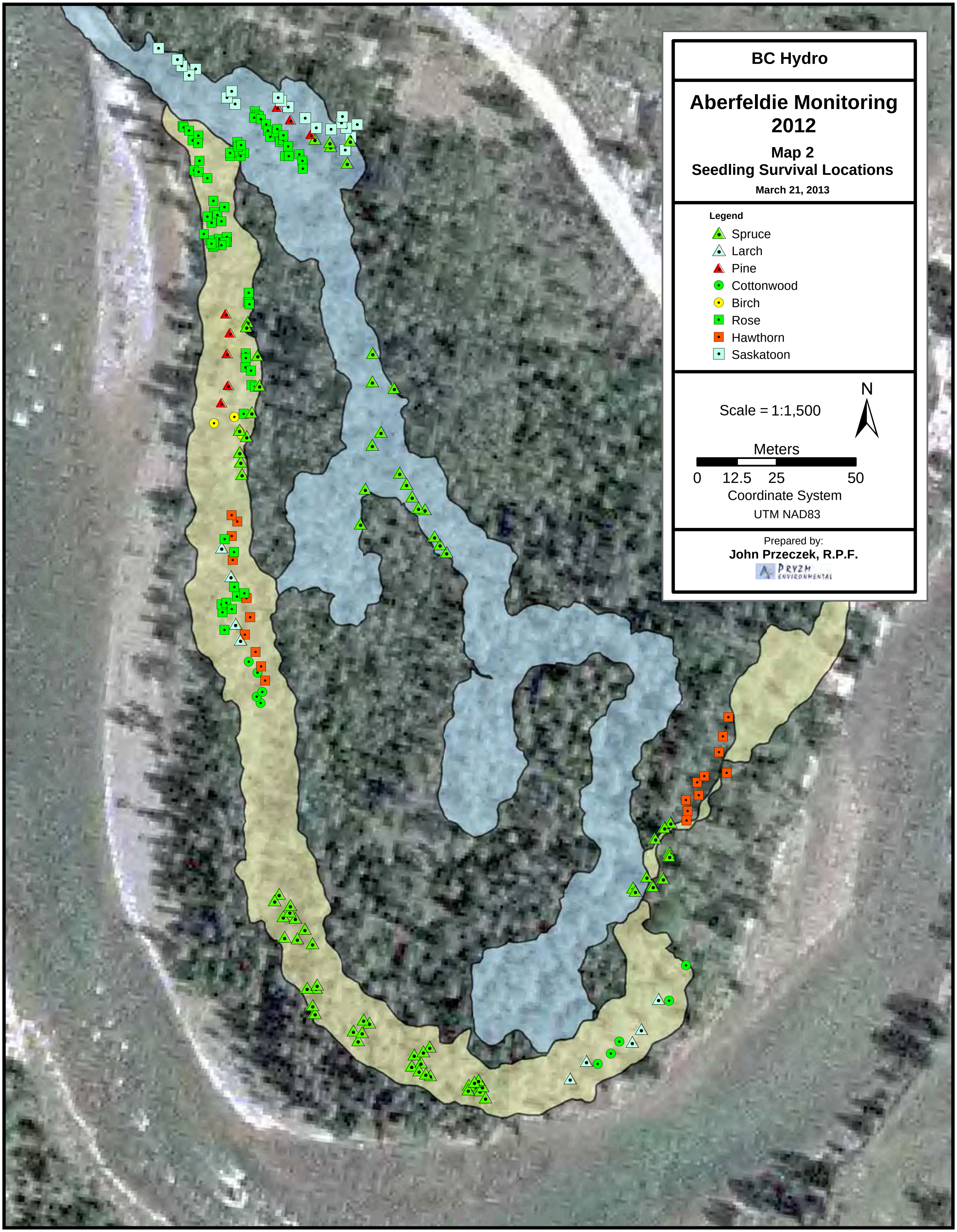
The following table provides a summary of the strategies that we believe are best suited to the Aberfeldie side channel study area.

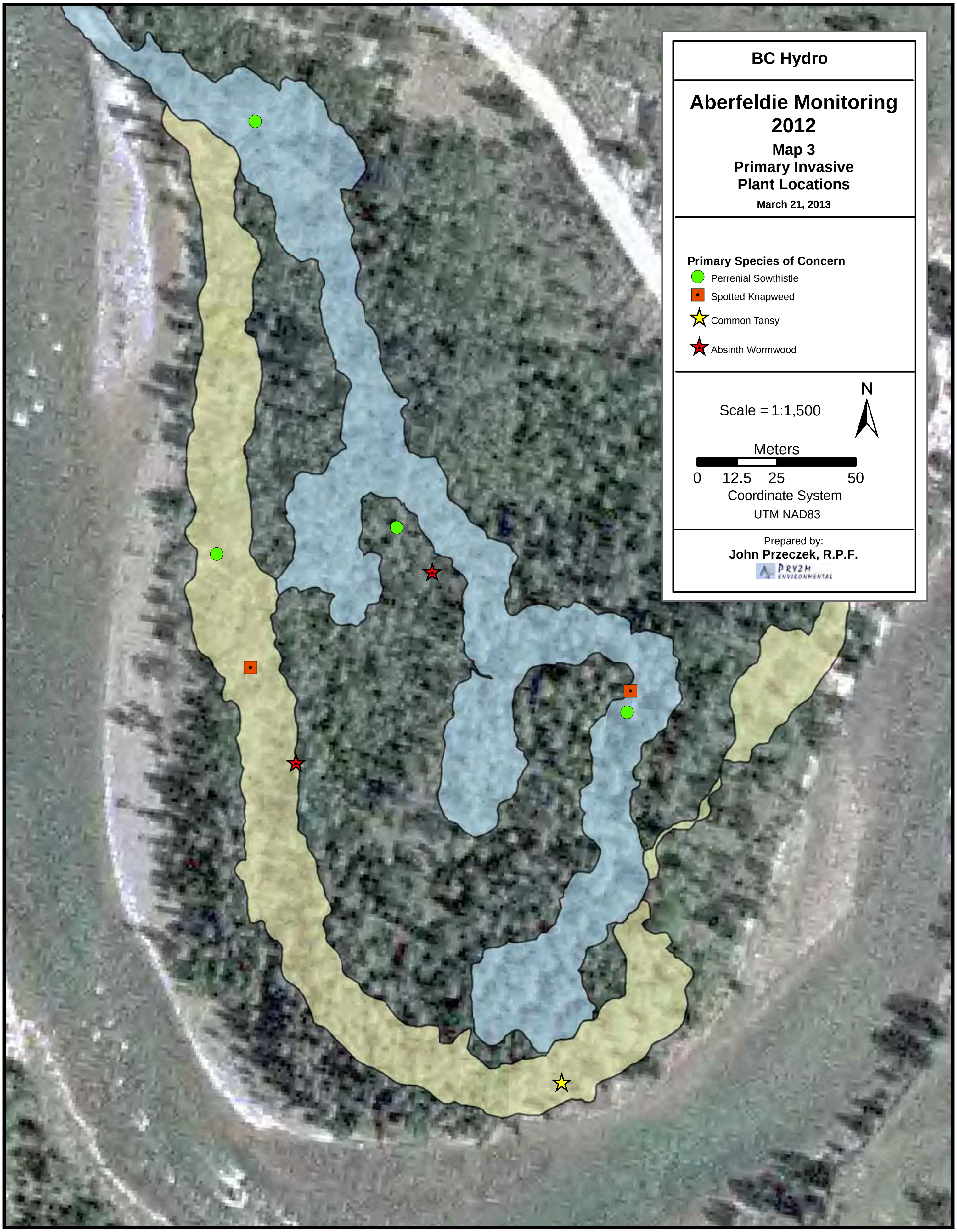
Weed control strategies suitable to the Aberfeldie side channel project area.

Strategy	Advantages	Limitations	Comments
Biological	Cost-effective on large infestations. Self-perpetuating. Self-dispersing. Long-term.	Takes time to establish. Does not eradicate weeds. Not effective in all habitats.	Includes a variety of different target insect species. Optimal where infestations are too extensive to be reduced effectively and economically by other treatment strategies
Mechanical	All types: applicable near water. Prevents seed production.	All types: Must repeat. Labour-intensive. Can be costly. **H**: creates soil disturbance. Root fragments may remain. Moist or loose soils required. **M**: roots remain, resprouting. Timing important.	Includes: hand-pulling/digging (**H**), mowing/cutting (**M**). Suitable for small infestations.
Herbicide	No soil disturbance. Kills whole plant. Residual herbicides will affect seed bank and emerging plants.	Soil and water limitations. Long-term costs. Can affect non-target vegetation.	It is important to choose the appropriate herbicide that targets the invasive plant of interest. The location (e.g. proximity to water) and longevity (e.g. long lasting in soil) will also affect herbicide choice. Effective application should be completed at the appropriate growth stage. Use the right herbicide on the right location at the right stage of growth.

Appendix 6. Maps


BC Hydro
Aberfeldie Monitoring 2012
Map 1
Vegetation Transects and Brush Layers
March 21 , 2013
Legend
Modified Brush Layer
Vegetation Transect (permanent)
Vegetation Transect (random)
Scale = 1:1,500
N
Meters
0
12.5
25
50
Coordinate System
UTM NAD83
Prepared by:
John Przeczek, R.P.F.
VTR-PS-03
MBL-16
VTP-BT-03
MBL-12
VTR-RS-01
VTR-PS-02
VTP-BS-03
VTR-RS-02
MBL-04
VTP-BT-02
VTP-BS-02
VTR-RS-03
VTP-BS-01
VTR-PS-01
VTP-BT-01


BC Hydro
Aberfeldie Monitoring 2012
Map 2
Seedling Survival Locations
March 21, 2013
Legend
Spruce
Larch
Pine
Cottonwood
Birch
Rose
Hawthorn
Saskatoon
Scale = 1:1,500
N
Meters
0
12.5
25
50
Coordinate System
UTM NAD83
Prepared by:
John Przeczek, R.P.F.
PRYZM ENVIRONMENTAL


BC Hydro
Aberfeldie Monitoring 2012
Map 3
Primary Invasive Plant Locations
March 21, 2013
Primary Species of Concern
Perrenial Sowthistle
Spotted Knapweed
Common Tansy
Absinth Wormwood
Scale = 1:1,500
N
Meters
0
12.5
25
50
Coordinate System
UTM NAD83
Prepared by:
John Przeczek, R.P.F.
PRYZM ENVIRONMENTAL