Impact Evaluation Report

Washington Conservation Corps Restoration Methods

Washington Department of Ecology

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Prepared for:

Laura Schlabach
WCC IP, Compliance, and Communications Coordinator
Washington Conservation Corps
Washington State Department of Ecology PO Box 47600, Olympia, WA 98504

The Watershed Company

Title-page image: Aerial overview of project site, taken July 2021.

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The Watershed Company Contact: Nell Lund, PWS

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1 EXECUTIVE SUMMARY

The Washington Conservation Corps (WCC) in partnership with City of Bellingham, established, maintained and monitored a native plant restoration site near Anderson Creek in the Lake Whatcom watershed for a four-year period from 2018 through summer 2021. WCC hired The Watershed Company in 2017 to develop and evaluation plan, including a study design and maintenance and monitoring protocols. This study uses a quasi-experimental design with randomized control to ascertain correlations between site treatments and plant survival. The site treatments applied to native plant live stake are Plantskydd® application, blue tube installation, and a reference (control). Data collected were analyzed using a one-way Analysis of Variance (ANOVA). The approach tested the null hypothesis that there is no difference between native plant survival, deer browse, or stem damage among treatment groups.

The original study spanned one-year and was completed in 2018. Due to the short duration of the study and interest in gathering more information about the plant establishment period, WCC after coordination with The Watershed Company and City of Bellingham, decided to continue the maintenance and monitoring protocols an additional three years (2019-2021). The first year (2018) showed blue tubes yielded the highest plant survival, lowest string trimmer damage, but also the highest cost. This assessment, covering an additional three years (2019 – 2021) shows continued and statistically significant high native plant survival and low string trimmer damage for the blue tube treatment. The cost comparison indicates the blue tube treatment is relatively low cost over the long-term relative to the PlantSkydd® and reference treatments.

2 INTRODUCTION

The Washington Conservation Corps (WCC) is a service program that has been providing opportunities to young adults to protect and restore our natural environment since 1983. Improving habitat for state and federally listed species, including anadromous fish, is a primary goal of the WCC. WCC projects include wetland enhancement and restoration, and riparian corridor enhancement and restoration. The Washington State Department of Ecology (Ecology) administers the WCC program. Since 1994, WCC has been an AmeriCorps program.

To comply with AmeriCorps grant requirements and review their internal site restoration practices, the Washington Conservation Corps (WCC) hired The Watershed Company to prepare an Evaluation Plan in 2017. The WCC chose a restoration project they are implementing in partnership with the City of Bellingham, Washington. That site was established and monitored by the WCC in 2018 and results were reported in the October 2018 Evaluation Report. For this current report, a continuation of that project into 2019 through 2021 is evaluated.

The purpose of this impact evaluation report is to assess the effectiveness of different WCC restoration methods spanning a four year period. As the independent reviewer, staff from The Watershed Company tabulated and analyzed the data WCC crews collected.

3 PURPOSE

This evaluation seeks to answer the question, "Does additional investment in initial restoration techniques and post-restoration care of installed plants lead to increase in successful outcomes?"

More specifically, this study compares the relative benefits of two products commonly used to improve plant survival following installation: 1) solid tube tree protectors and 2) deer repellant. A literature review did not find any comparable studies of wetland native plant survival using these methods; however, both tube tree protectors and herbivore repellants have been reviewed for protection of agricultural crops (e.g., Zabadal and Dittmer 2000, Olmstead and Tarara 2001) and upland trees (e.g., Ward and Williams 2010, Randall 2012). This study evaluates the cost-effectiveness of the use of each of these two products relative to standard planting methods. The study uses native plant survival, evidence of plant damage, and persistence of treatment materials to determine the relative cost-effectiveness of each treatment method.

4 METHODS

4.1 Study Participants

This study was a collaborative project led by WCC, in partnership with the City of Bellingham. The City of Bellingham provided the restoration project site, a property owned by the City of Bellingham. Staff from City of Bellingham, WCC, and The Watershed Company collaborated on restoration methodologies, study questions of interest, and study design. WCC staff was responsible for coordination with the City of Bellingham and The Watershed Company. WCC supervisors and crew members implemented the planting project, conducted all maintenance activities, and collected and compiled field data. City of Bellingham and WCC funded the restoration project through a cost-share partnership (75/25). WCC funded the evaluation. City of Bellingham contributed staff time toward development of the evaluation plan and provided project implementation oversight. Staff from The Watershed Company developed the Evaluation Plan, assisted with plot set up in 2018, analyzed data provided by WCC in 2021, and summarized results in this report.

4.2 Site Layout

The evaluation was conducted at a 1.04-acre site in unincorporated Whatcom County near the City of Bellingham. The site is southeast of Lake Whatcom, in the Lake Whatcom Watershed (Figure 1). The restoration site is within a National Wetland Inventory (NWI) mapped wetland near Anderson Creek and downstream of Mirror Lake (Figure 2). Prior to restoration, the roughly rectangular site was initially covered in an existing reed canarygrass monoculture (Figure 3).

The site was divided into 45 experimental plots. The center of each plot was marked in the field using a sturdy metal or wood stake, marked with the assigned plot number (1-45) and treatment (R-reference, D-deer deterrent, or T-protective tubes). Each experimental plot was approximately 1,000 square feet in area.

One treatment was randomly assigned to each plot using a random number generator, until each treatment was assigned to 15 plots. A map of assigned plot numbers and treatment locations is shown in Figure 3.

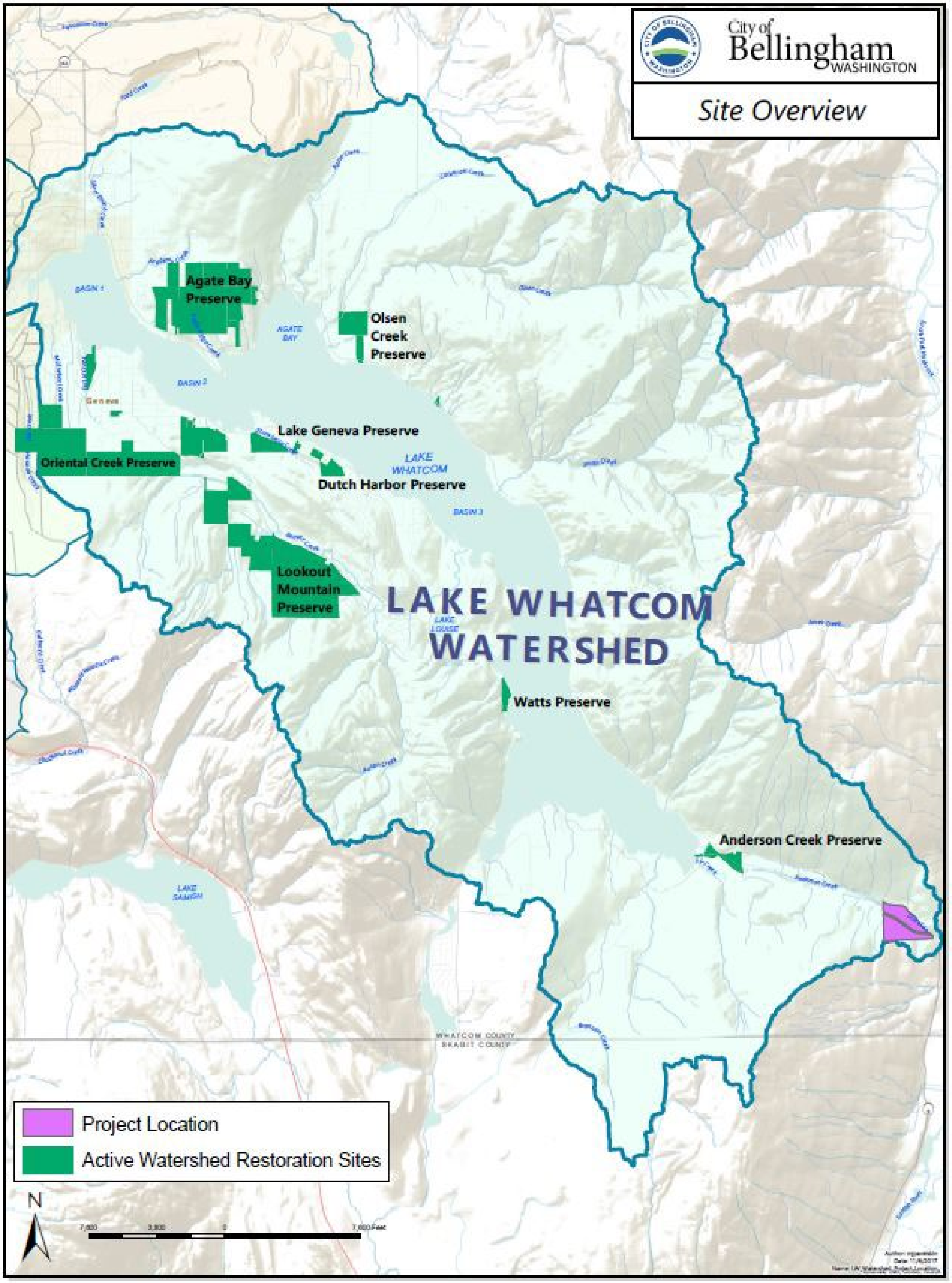

Figure 1. Lake Whatcom Watershed map with the City of Bellingham-owned property where the restoration area is located marked in pink.

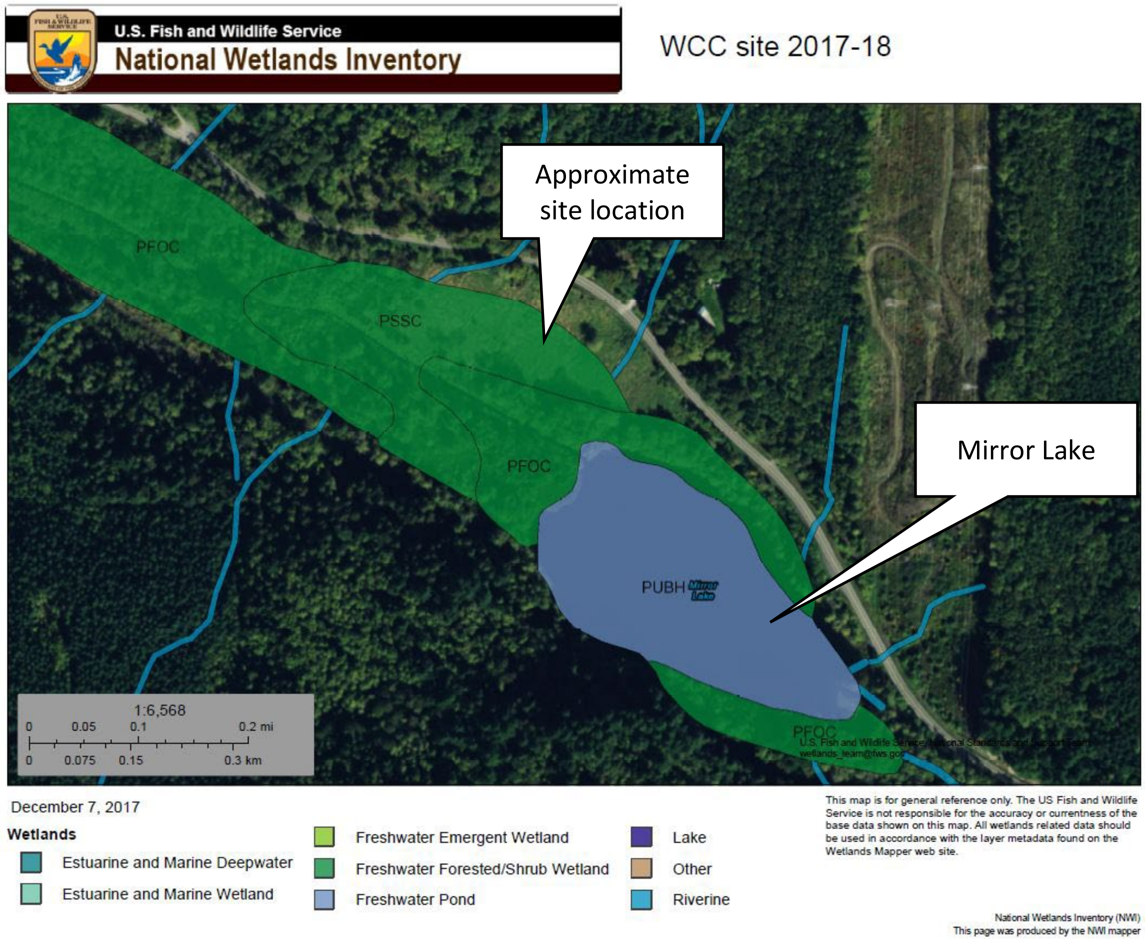

Figure 2. NWI map showing wetland conditions within the proposed study site.

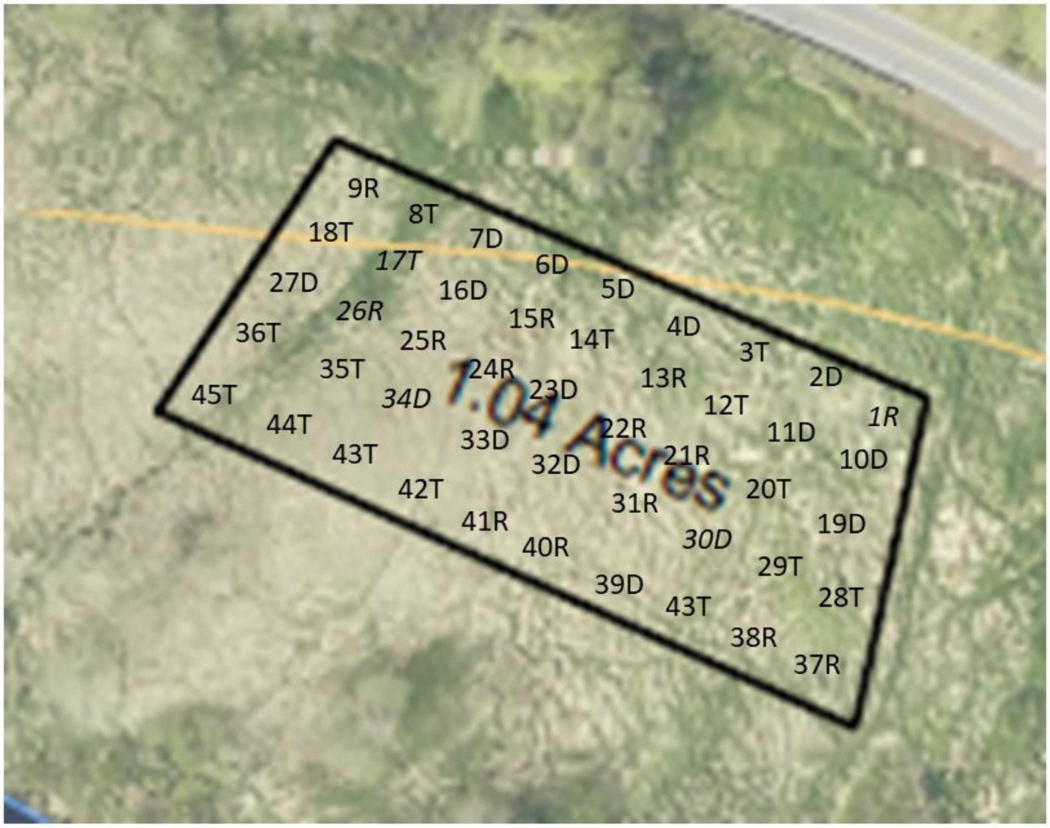

Figure 3. Outline of study area in black with locations of experimental plots.

4.3 Planting and maintenance

The sample plots were established at the beginning of 2018. Maintenance and monitoring were completed per plan in 2018. The WCC decided to continue maintenance and monitoring in partnership with the City of Bellingham through 2021 to support a longer-term assessment of treatment options. A single year of maintenance and monitoring is insufficient to determine successful plant establishment. The restoration goal of native plant establishment requires a longer monitoring period, typically three to five years.

Installation & Year-1 (2018)

The experimental plots were established in winter 2018. Plants were installed on January 29th and 30th, 2018. Planting methods, density, and species were established consistently among all of the experimental plots. Since the site is within an NWI mapped wetland, only wet-tolerant native plant species were planted. Plants included cottonwoods (*Populus balsamifera*), willows (*Salix* spp.), red osier dogwoods (*Cornus sericea*), and spiraea (*Spiraea douglasii*). All plants were installed as stakes. Plants were marked with flagging tape to facilitate identification throughout the study period.

The first round of treatment was applied in winter 2018. Following initial planting, each plot was treated according to the treatment assigned. Treatment plots were established on January 31st, 2018. For the deer deterrent, Plantskydd® was applied according to manufacturer specifications immediately following plant installation (February 6th, 2018) and once in spring during leaf out (April 23rd, 2018). The central plot posts and measuring tapes were used to identify the boundaries of each plot for application purposes.

Maintenance practices were limited to mowing using a string trimmer, and these actions were consistent across the entire site. Mowing occurred on April 20th and July 30th through August 2nd, 2018. The second mowing occurred over multiple working days because crews shut down each day at 1 pm due to elevated industrial fire precaution levels at that time.

Year-2 (2018-2019)

Year-2 maintenance and monitoring were conducted on the same general seasonal timeline. The over-winter application of Plantskydd® was done on October 24, 2018; the spring application was done April 24, 2019. The entire site was brush-cut using string trimmers once in spring (April 15, 2019) and twice in summer (July 2, 3 and 8, 2019; and August 12 and 13, 2019).

Year-3 (2019-2020)

Year-3 maintenance was slightly altered due to COVID-19 pandemic constraints. The over-winter application of Plantskydd® was done on schedule in winter on December 26, 2019; the spring application was delayed to summer (July 14, 2020) due to the global COVID-19 pandemic. Additionally, a mandated statewide shutdown delayed brush-cutting in spring 2020. Brush-cutting was done twice in summer on July 6 and 9, 2020 and again on September 2 and 3, 2020.

Year-4 (2020-2021)

Year-4 maintenance and monitoring were back on-schedule. The over-winter application of Plantskydd® was done on December 23, 2020; the spring application was done April 27, 2021. The entire site was brush-cut using string trimmers once in spring (April 23, 2021) and twice in summer (July 16, 2021; and August 6, 2021).

4.4 Data collection

Experimental plots were monitored immediately after plant installation in the winter of 2018, and again in the late summer of 2018 through 2021.

Data collection and monitoring photographs were documented in summer of each monitoring year. Data collection for Year-3 (2020) was slightly delayed to early September due to pandemic delays. Below are the data collection dates for each monitoring year.

Year-1 (2018)	August 15, 2018
Year-2 (2018-2019)	August 14, 2019
Year-3 (2019-2020)	September 8, 2020
Year-4 (2020-2021)	August 9, 2021

Sampling occurred within a 15-foot by 15-foot sub-plot, as shown in Figure 4. When collecting survival plant counts, string trimmer damage counts, and blue tube counts, only installed plants with a main stem inside each sub-plot were counted. When assessing deer browse, overhanging branches within each sub-plot were included.

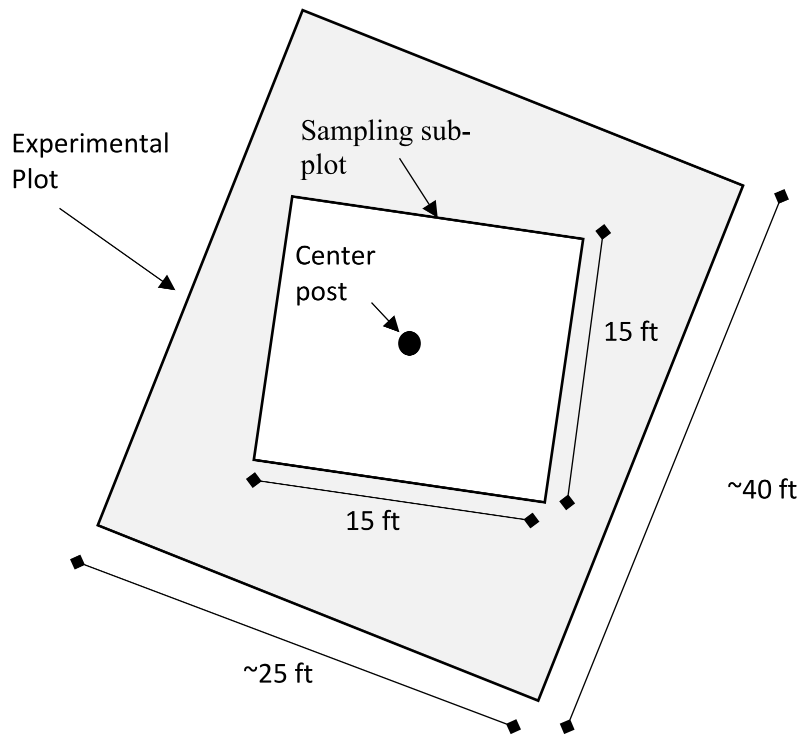

Figure 4. Diagram showing approximately layout of experimental plots, center posts, and sampling subplots. As shown above, the sub-plot does not need to be precisely aligned with the boundaries of the experimental plot.

Using a random number generator, two plots of each treatment type were selected for a permanent photo point. Photo points were taken at the same point and direction. Photo-points were recorded in winter and summer of each monitoring year. Photo-points were documented at the following plots:

Reference	Deer Repellent	Blue Tubes
Plots 22 and 31	Plots 10 and 27	Plots 12 and 14

Winter Data Collection

All native plants within a 15-foot by 15-foot sub-plot near the center of each plot were counted immediately following initial installation in 2018 and each winter thereafter through winter of 2021 (Figure 4). Winter data collection was limited to installed plant counts. A location near the center of each plot was selected to minimize the effect of potential drift from adjacent treatments.

Late Summer Data Collection

Late summer data collection started in late summer of 2018 and continued each summer thereafter up through 2021. Late summer monitoring is conducted near the end of each annual growing season after the restoration actions and repeated each subsequent summer of the monitoring period. Each plot was re-evaluated using a 15-foot by 15-foot sub-plot near the center of each plot (Figure 4). Again, measuring tapes were used to mark the edges of the 225 SF sample area within each plot. Sample areas were located around the central stake in each plot. Summer data collection was recorded as summarized in Table 1 below.

Table 1. Summer data collection summary for each treatment

Data to collect within each 225 SF sub-plot by treatment	Treatment		
	Reference	**Deer deterrent**	**Protective tube**
Installed plant live/dead counts	X	X	X
Deer browse damage, 1-5 scale estimate	X	X	X
Percent native plant cover, cover class estimate	X	X	X
Blue tube counts			X
Count of string trimmer damaged plants	X	X	X

Each living native plant was counted within the sub-plot. Any dead plants within the sub-plot were counted separately.

Evidence of deer browse was qualitatively evaluated in terms of intensity of browse damage. In addition, percent native plant cover within the sub-plot was visually estimated using the cover class method.

Where blue tubes were used, the number of blue tubes remaining on each live and dead plant within the sub-plot were counted.

Each plant within the sub-plot was inspected for damage from string trimming. The number of plants with string trimmer damage was recorded.

WCC crews estimated percent cover for native plants in each sub-plot. A Visual Cover reference data sheet was used to help standardize cover estimates.

Cost

In order to understand the relative cost effectiveness of each treatment approach, the City of Bellingham provided invoices or total costs for all treatment materials. The City also provided an estimate of labor hours for each treatment. Labor costs are assigned by adding educational award amount and insurance costs to the minimum wage for each year. The total annual education award for each year was divided by 2080 hours (40 hours x 52 weeks) to estimate an hourly cost per staff. Insurance cost used the hourly estimate established in the 2018 report and an annual 3% cost of living increase was applied in years 2019-2021. Labor rate calculations for each year are detailed in the table below.

Table 2. Estimated hourly labor costs, 2018-2021.

Year	Minimum wage	Education award	Insurance*	Total hourly
2018	$ 11.50	$ 2.79	$ 3.71	$ 18.00
2019	$ 12.00	$ 2.85	$ 3.82	$ 18.67
2020	$ 13.50	$ 2.93	$ 3.94	$ 20.37
2021	$ 13.69	$ 2.98	$ 4.05	$ 20.72

* insurance cost assumes a 3% cost of living increase per year.

The cost was estimated in each year by treatment. Annual treatment supply costs and field time were provided by WCC for the cost estimates. Time spent collecting final annual data in summer of each year was omitted from the cost estimate; since this is an artifact of this study.

4.5 Statistical Approach

The study uses a quasi-experimental design with randomized control to ascertain correlations between site treatments and plant survival. The study consists of randomized plots, including untreated control (reference) plots as detailed in Section 3.2 above.

Data collected on plant survival, deer browse, and string trimmer damage were analyzed using a one-way Analysis of Variance (ANOVA). The approach tested the null hypothesis that there is no difference between native plant survival, deer browse, or stem damage among treatment groups.

To keep the plot sizes at a practical scale and allow space for necessary replicates on the 1.04-acre site, the statistical significance was determined using an alpha of 0.1. Given the statistical design, a sample size of 15 sites each for a control and each treatment provided a power of 0.8 to detect a large effect ($f=0.4$).

In addition, we identified the mean percentage of blue tubes remaining on plants in the blue tube treatment plots to determine longevity of that treatment method.

The survival, browse, and damage measures were compared to the cost of each treatment method to provide a cost-benefit comparison among treatments.

5 RESULTS

The relative performance of each treatment over the 4-year monitoring period is summarized below following the established metrics of native plant survival, string trimmer damage, and deer browse. Costs associated with the treatments over the monitoring period are estimated and summarized.

5.1 Native Plant Survival

The significantly higher native plant survival noted in year-1 (2018) for the blue tube treatment was sustained in years 2 through 4. By the end of year 4 (2021) average survival for the blue tube treatment was 74 percent, compared to 42 and 41 percent respectively for Plantskydd® treatment and the Reference plots (Figure 5, p= 0.012). Annual average native plant survival, standard deviations, and p-values are summarized in Table 3 below.

Table 3. Average native plant survival for each treatment, Years 2018-2021.

Year	2018		2019		2020		2021	
Treatment	Avg. Native Plant Survival	Std dev.	Avg. Native Plant Survival	Std dev.	Avg. Native Plant Survival	Std dev.	Avg. Native Plant Survival	Std dev.
Plantskydd®	64%	21%	60%	32%	46%	27%	45%	28%
Blue Tubes	86%	17%	80%	18%	76%	18%	74%	12%
Control	68%	21%	52%	23%	45%	26%	42%	26%
p-value	0.010		0.012		0.012		0.012	

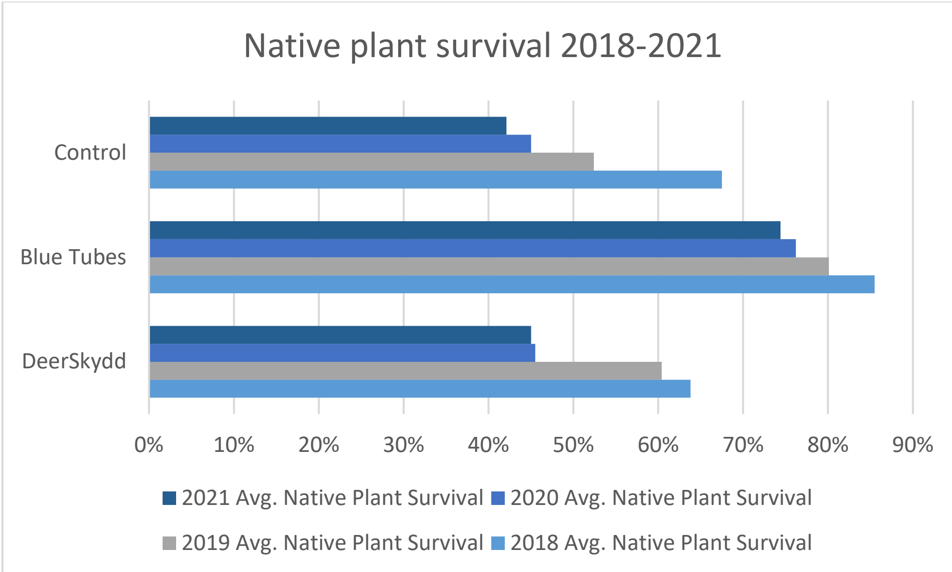

Figure 5. Native plant survival for each treatment over the past 4 years.

Blue Tube Longevity

In year 1 (2018) nearly 90 percent of blue tubes remained by the August sampling period. By year 4 (2021) approximately half of the originally installed blue tubes were still present. As the chart below shows, plants with a blue tube exhibited a high rate of survival.

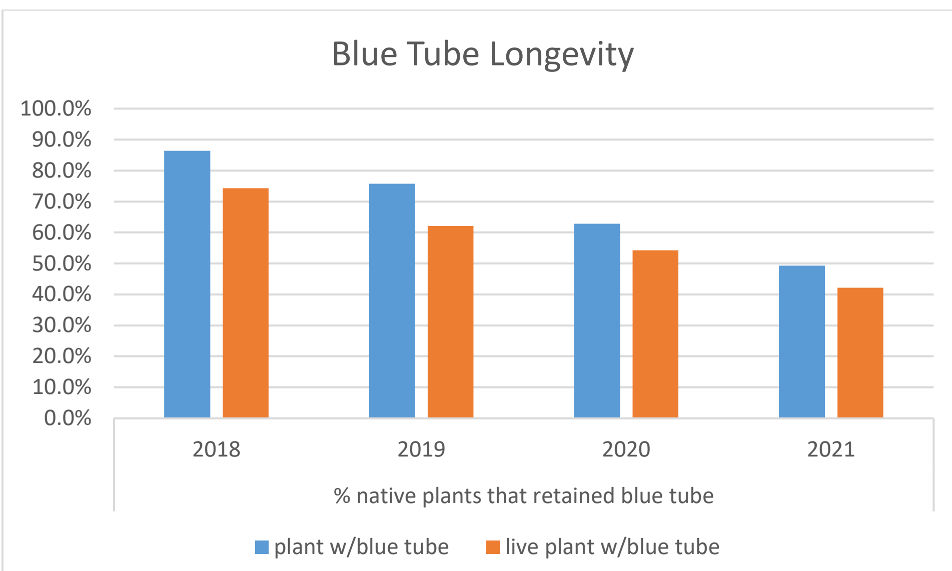

Figure 6. Percentage of blue tubes present in each monitoring year.

Plant Survival by Species

Four different native plant species were installed throughout the sample plots in roughly equivalent quantities. Plant species installed in this wetland environment were black cottonwood (*Populus balsamifera*), Hooker's willow (*Salix hookeriana*), red-osier dogwood (*Cornus sericea*), and Douglas spiraea (*Spiraea douglasii*). The interaction between plant species survival and treatment method is not significant (p = 0.55).

5.2 String Trimmer Damage

Blue tubes provided statistically significant native plant protection from string trimmer damage. String trimmer damage was significantly lower in the blue tube treatments compared to the reference and Plantskydd® treatments in all monitoring years (p-values in Table 4 below).

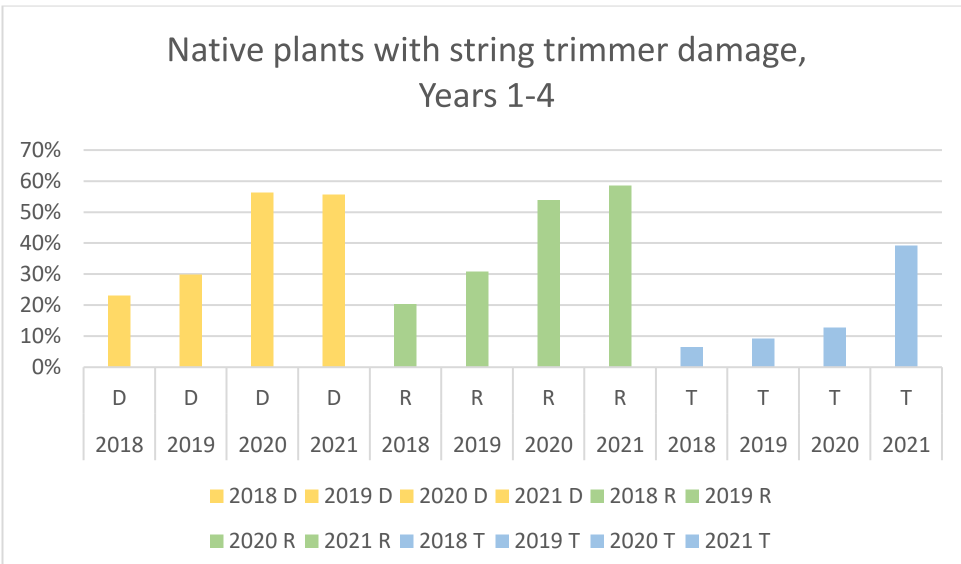

Figure 7. String trimmer damage for each treatment in years 1 through 4.

Table 4. Average string trimmer damage in each monitoring year.

	String Trimmer Damage (Avg. # of plants)			
Treatment / Yr.	2018	2019	2020	2021
Plantskydd®	2.33	3.00	3.00	5.60
Blue Tubes	0.60	0.87	1.20	2.38
Control	2.07	3.13	5.47	6.78
p-value	0.003	0.000	0.000	0.019

5.3 Deer Browse

Damage from deer browse remained low among all treatments over the monitoring period (3% or less annually). There was no significant difference between the frequency of deer browse damage among treatments in years 1 and 2 (2018 and 2019). However, in years 3 and 4 (2020 and 2021) did yield a statistically significant difference among treatments, both p-values are less than 0.1. Data for years 3 and 4 shows plants in the blue tube plots exhibited more deer browse than the Plantskydd® and control treatments (see Table 4 below).

Table 5. Deer browse for each treatment in each monitoring year.

	Deer Browse (Avg. # of plants)			
Treatment	2018	2019	2020	2021
Plantskydd®	0.2	1.7	1.1	0.9
Blue Tubes	0.1	2.4	3.3	2.5
Control	0.3	1.5	1.1	1.1
p-value	0.534	0.273	0.000008	0.0004

5.4 Cost Estimates

Initial start-up cost is highest for the blue tube treatments, both in terms of labor and materials compared to both Plantskydd® and reference treatments (Table 5). The initial year-1 cost estimates assumes 667 plants were planted across all plots in each treatment; the total cost per plant surviving to Year 1 is estimated in Table 5 below.

Maintenance over years 2, 3 and 4, show a steady decrease in blue tube treatment cost relative to plant survival in the treatment plots. Subsequent costs for years 2 through 4 are estimated based on materials, labor and plant survival data for each treatment (Table 6 below).

Table 6. Total costs of installation and maintenance for each treatment in 2018.

	Reference	Plantskydd®	Blue Tubes
Materials	$701.42	$819.79	$1,354.69
Labor	$1,056.00	$1,344.00	$2,136.00
Total	$1,757.42	$2,163.79	$3,490.69
Approximate cost per plant surviving Year 1	$3.87	$5.07	$6.09

Table 7. Total cost for continued maintenance in monitoring years 2 (2019), 3 (2020) and 4 (2021).

		Reference	Plantskydd®	Blue Tubes
2019	Materials	$0.00	$108.60	$0.00
	Labor	$3,584.89	$4,481.11	$3,584.89
	Total	**$3,584.89**	**$4,589.71**	**$3,584.89**
	survival counts	78	87	112
	Approximate cost per plant surviving Year 2	$45.96	$52.76	$32.01
2020		Reference	Plantskydd®	Blue Tubes
	Materials	$0.00	$108.60	$0.00
	Labor	$1,955.13	$2,932.70	$1,955.13
	Total	**$1,955.13**	**$3,041.30**	**$1,955.13**
	survival counts	67	65	106
	Approximate cost per plant surviving Year 3	$29.18	$46.79	$18.44
2021		Reference	Plantskydd®	Blue Tubes
	Materials		$46.89	
	Labor	$2,354.25	$3,846.38	$2,354.25
	Total	**$2,354.25**	**$3,893.27**	**$2,354.25**
	survival counts	63	64	104
	Approximate cost per plant surviving Year 4	$37.37	$60.83	$22.64

Blue tubes are the costliest treatment in Year 1 (2018). However, it is the least costly treatment per plant in years two through four (2019-2021).

6 DISCUSSION

Extending the study protocol to cover four years of plant performance at the Anderson Creek Restoration site allows for a greater understanding of how the three different restoration treatments (reference, Plantskydd®, blue tube) support native plant establishment. Planting site assessments of three to five years, and in some cases ten years, more closely follows plant establishment monitoring for permitted restoration or mitigation sites. Plant establishment typically takes about three years, although environmental stressors can increase the establishment period. Plants are commonly large enough to compete with most invasive plants after at least five years of maintenance. As the site photographs in Appendix A show, the restoration plants are still small in stature after four years and would benefit from continued maintenance. At this site the primary invasive plant is reed canarygrass. At sites like this one, the installed plant canopy should ultimately shade out the reed canarygrass. Reed canarygrass does not grow as vigorously in a shaded environment.

The blue tube treatment exhibited the highest native plant survival, least string trimmer damage, and lowest cumulative costs over the first four years relative to use of a deer repellant (Plantskydd®) and the untreated reference plots. Blue tubes were lost to the surrounding environment over the monitoring period. Approximately half the blue tubes were missing by year 4 (2021). The success of the blue tubes should be considered against the environmental impact of inadvertently littering this plastic material in the restoration site vicinity. For this study, missing blue tubes were not replaced during monitoring and maintenance activities. A future study may include an assessment of how many loose blue tubes were retrieved from the project area, and thereby kept out of the environment long-term. Incorporating blue tube clean up in the maintenance protocol would increase labor costs somewhat and alter total costs accordingly. Additionally, blue tube removal costs are not accounted for in this assessment. When site maintenance is discontinued the blue tubes need to be removed. This will increase labor cost in the final year of site work.

Blue tubes did not protect the plants from deer browse. In fact, the data shows slightly higher deer browse in the blue tube plots. In spite of this, overall, blue tube treated plots exhibited the highest survival.

This study shows that the Plantskydd® deer repellant is more costly per plant after year 1 relative to blue tubes. The only statistically significant result for deer browse over the monitoring period was that deer browse was slightly higher in the blue tube plots as noted above. The Plantskydd® treatment requires additional material and labor costs but does not yield significantly less deer browse than documented in the reference plots. As noted in the year 1 (2018) monitoring report, other studies have documented limited effectiveness of the Plantskydd® treatment. Other studies of the effectiveness of Plantskydd® have found that the repellent effect does not extend beyond one meter from the treated area (Nolte and Wagner 2000), so it is unlikely that the close proximity of treatments in this study design affected deer browse throughout the study area. In order to test this possibility, Plantskydd® could be applied at restoration plots with greater separation among plots.

Although the pandemic caused a delay in maintenance in year 3 (2020), that did not appear to generate significant changes in treatment performance.

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Appendix A

Reference Photographs

Direct link to photographs: https://thewatershedcompany.sharefile.com/d-s1fd527ef6b4648c9aacf75eb251512a1