Upper Deschutes Watershed Council
Technical Report

2016 Camp Polk Monitoring Report

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Introduction

UDWC and restoration partners implemented a suite of monitoring actions at Camp Polk Meadow (CPM) from 2010 through 2016 per the Whychus Creek Restoration Project at Camp Polk Meadow Preserve Monitoring Summary Table (Appendix A) and in accordance with project funding agreements. Restoration partners modified monitoring activities to respond to emerging conditions and needs. Parameters monitored in 2016 included:

- Channel dimension, pattern and profile
- Groundwater
- Continuous temperature
- Macroinvertebrates
- Fish populations *(O. mykiss* redds)
- Photopoints,
- Aerial imagery; and
- Birds

Riparian vegetation and invasive weeds are parameters which are included in the monitoring table but were not monitored in 2016. Riparian vegetation monitoring from 2010 through 2014 showed the seeded and planted riparian community at Camp Polk Meadow to be increasingly well-established and abundant, characterized by a strong native component and minimal cover of invasive weeds. 2015 vegetation monitoring efforts focused on mapping reed canarygrass, a highly invasive species that has altered wetland and stream ecosystems throughout the Pacific Northwest and which had been observed at increased abundance in the meadow. Deschutes Land Trust treated invasive weeds and reed canarygrass in 2016; their management actions are summarized in this report. Partners plan to map the extent of riparian vegetation at Camp Polk from high-resolution aerial imagery in 2017. UDWC and Deschutes Land Trust (DLT) will continue to evaluate vegetation (riparian community and invasive weed) monitoring needs at Camp Polk and tailor monitoring metrics and methods accordingly.

Monitoring activities and findings are summarized below.

Channel dimension, pattern and profile

Project objectives specific to channel dimension, pattern and profile included:

> Objective 1: Increase length of channel by 2,646 feet, increase number of pools from 14 to 27, and create more than 500 feet of new side channel habitat;
>
> Objective 2: Increase the entrenchment ratio from the existing 1.5 to a minimum of 23;
>
> Objective 5: Restore channel that meets the 36 dimension, pattern and profile design criteria established in (the) Restoration Plan

UDWC used aerial imagery to measure channel and side-channel as-built lengths. The total as-built length of the stream channel was 1.7 miles, approximately a half-mile (2640 ft) longer than the pre-project alignment; the length of constructed side channels totaled 4.2 miles. USFS completed a total station survey of the Camp Polk Meadow Project in August 2013. Surveyors measured channel attributes related to the 36 channel dimension and pattern design parameters specified. The number of pools increased to 34; the entrenchment ratio was 32. All of the parameters measured were within or approached the "as-designed" range (Appendix B). USFS and UDWC ran cross sections in project reaches 1-4 in 2016. These data will be used to evaluate ongoing channel evolution as UDWC continues to monitoring the project over time.

The six reaches within the Camp Polk Restoration project continue to each change and evolve. Geomorphologic changes, riparian vegetation growth and habitat quality observed in all reaches fall within the range of expected benefits for the project. In Reaches 1 and 2 Whychus Creek fully accesses the available floodplain at and below bankfull flows. As a result these reaches exhibit a high degree of channel evolution and habitat complexity including pools and riffles, off channel habitat, gravel sorting and deposition. In Reaches 3 and 4, Whychus Creek's restored channel has eroded both vertically and laterally into adjoining surrounding floodplain materials. While Whychus Creek does not yet fully access all the available floodplain at and below bankfull flows in these reaches, we are still seeing beneficial habitat evolution through development of deep pools, riffles, undercut banks, gravel point and mid channel bars (and associated riparian vegetation colonization) along with improved sediment sorting. Over time we expect continued sediment deposition processes to cause the channel to over time fully access it's floodplain in these reaches.

Groundwater

We sampled groundwater wells monthly from April through October 2016 to evaluate depth to groundwater in relation to the project objective of elevating the water table to within 2.0'of the surface. Monitoring was conducted during these months to track groundwater trends during the growing season, when groundwater is thawed, water availability is essential to support riparian vegetation survival, and runoff and snowmelt recharge groundwater. In 2015 we discontinued monitoring at Well 1 after a side channel head-cut back to the well, connecting surface and groundwater at the well site and calling into question the integrity of the well casing and function of the well. We recalculated monthly median values for March through October 2008-2015, the 2008 baseline mean growing season depth to groundwater, and the overall mean for each growing season 2009-2015, excluding values from Well 1 to allow comparison between years prior and subsequent to the 2015 failure of Well 1. We calculated all 2016 values using data from the remaining 6 wells. We calculated the mean value for each individual well as the mean of the April through October depths for each well. We calculated the mean growing season depth to groundwater as the mean of the median value of the six-well dataset for each month.

Groundwater well monitoring was initiated at Camp Polk in June 2007, resulting in an incomplete dataset for that year. In 2008 groundwater wells were monitored from April through October; the 2008 dataset represents the baseline for the project. Although Whychus Creek wasn't diverted into the constructed meadow channel until 2012, 2008 also represents the only year of true pre-project data given various sources of water introduced into the meadow beginning in 2009, including diversion of 1.5 cfs of water into the new channel beginning in June 2009 and maintained until the creek was diverted in 2012, and irrigation along the constructed channel at a rate of ~ 1"/week from April through October in 2010 and 2011.

The 2008 mean growing season groundwater depth was 4.98' (Table 1). This number decreased (groundwater rose toward the surface) as flows and irrigation were introduced into the meadow from 2009 through 2011, to 3.6' in 2011. The groundwater response following the February 2012 diversion of Whychus Creek into the constructed meadow channel was immediate and sustained: mean growing season depth in 2012, notably an exceptionally high water year, was 2.17'. Mean growing season groundwater depth since 2012 has fluctuated within approximately 0.6', between 2.18' in 2014, also a high water year, and 2.82' in 2013, a drought year.

The project objective for groundwater was to raise groundwater a minimum of three feet from the pre-project mean growing season depth to within approximately 2' of the surface, to 2.3' from the original seven-well 5.3' baseline depth or to 2' from the six-well pre-project mean growing season depth of 4.98'. Since diversion of Whychus Creek into the constructed channel at Camp Polk, the mean growing season depth to groundwater has remained relatively stable between 2.2' and 2.8' depending on water year, 0.2' – 0.8' below the revised project objective of 2' depth to groundwater and within 0.5' of the original objective. As importantly, riparian vegetation is thriving in the meadow, indicating sufficient hydrologic conditions for the obligate and facultative wet species planted across the floodplain. Median depth to groundwater in August, when groundwater is historically lowest, has ranged from 1.9'-3.5' since 2012, between 2' and 4.6' shallower than in 2007 and 2008, the two years before flows were introduced into the meadow. Despite mean growing season groundwater depth stabilizing up to 0.8' below the revised project objective, the persistence of an elevated water table throughout the growing season, the pre-project to post-project difference in August, and the success of riparian vegetation in the meadow suggest a meaningful degree of success in restoring meadow hydrology and floodplain connectivity and increasing the groundwater table and summer base flow (Project Goal 2). The observed increase in groundwater level is also contributing to restoration and enhancement of high quality riparian wetland habitat along the stream corridor (Goal 3), establishment of a minimum of 35 acres of wetland and riparian communities (Objective 4), and is very likely cooling summer stream temperatures to help meet Oregon's state temperature standards (Goal 5). Restoration partners expect groundwater levels at Camp Polk Meadow to continue to fluctuate from year to year as a result of inter-annual climatic differences in snowpack, runoff, precipitation, and air temperature. Groundwater levels may also continue to change in relation to ongoing channel evolution and increasing water demands of more abundant riparian vegetation. Groundwater monitoring results are presented in annual reports spanning 2010-2016 (www.upperdeschuteswatershedcouncil.org).

Table 1. Individual well and overall growing season mean groundwater depths at Camp Polk Meadow from 2007-2016

	Growing Season Mean Groundwater Depths (ft)							
	Project Hydrologic Events	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7	Overall mean growing season depth
2007		5.33	5.33	7.95	6.05	6.51	7.75	6.22
2008		5.02	5.08	7.29	4.34	4.55	5.07	4.98
2009	June: 1.5 cfs first diverted into new channel	4.27	5.20	7.14	3.75	3.97	5.25	4.69
2010	Irrigation (1"/wk) installed along new channel	3.71	4.94	6.87	3.31	2.95	4.49	4.03
2011	April-October: Irrigation along new channel	3.51	4.78	6.69	3.28	2.45	3.52	3.61
2012	February: Whychus diverted into new channel	1.91	2.81	3.83	2.13	1.35	2.36	2.17
2013		2.23	2.98	4.66	2.74	1.85	3.26	2.82
2014		2.23	1.53	3.41	2.16	1.85	3.10	2.18
2015		2.59	1.86	3.66	2.44	2.36	3.68	2.77
2016		2.72	2.00	3.52	2.30	2.17	3.47	2.73

Continuous Temperature

UDWC monitors continuous temperature at eleven locations along Whychus Creek from April through October, including at sites approximately 250 m upstream and downstream of the restored channel. We analyzed pre- and post-project data for 30 days from July 16 to August 15, limiting the analysis to a 30-day period to reduce the effects of inter-annual seasonal variation, and used these dates as representative of the period during which the hottest water day occurred most often between 2005 and 2015. To evaluate stream temperature dynamics in the restored meadow channel compared to the pre-project, straightened channel, we compared July 16-August 15 average temperatures and hottest water day temperatures at upstream (WC 19.50) and downstream (WC 18.25) sites, and average pre- and post-project differences between these metrics, for five years pre-project (2007-2011) to five years post-project (2012-2016). "Pre-project" and "post-project" intervals refer to data collected prior and subsequent to diversion of Whychus Creek into the constructed meadow channel at Camp Polk in February 2012. Dataloggers are accurate to 0.5°C. We report averages and differences to tenths; due to the consequent rounding there are some arithmetical discrepencies in numbers reported.

Three iterations of post-project data (2012-2014, 2012-2015, and 2012-2016) compared to 2007-2011 pre-project data suggest a warming trend along the restored meadow channel (Table 2). Data from 2012-2014 show cooler stream temperatures on average at the upstream and downstream sites compared to 2007-2011 data, with the pre-project-post-project average difference at the upstream site cooler by 0.5°C than downstream; net cooling occurred upstream, rather than net warming occurring downstream, with average 2012-2014 upstream temperatures 0.7°C cooler than from 2007-2011, and average 2012-2014 downstream temperatures 0.1°C cooler than pre-project. 2012-2015 data show an average pre-project to post-project difference of 0.7°C, reflecting a cooler post-project average temperature at the upstream site and a warmer post-project average temperature at the downstream site compared to pre-project data. The addition of 2016 data continued the trend, with the upstream average temperature cooler than pre-project and the downstream average temperature even warmer than from 2012-2015.

Recovery plans for Mid-Columbia summer steelhead cite reduced floodplain connectivity and function, including the contribution of reduced groundwater discharge to low flows and high water temperatures, as a limiting factor for steelhead in Whychus Creek. Restoration partners anticipated that restoring floodplain connectivity and function in Camp Polk Meadow would restore groundwater discharge in mid- to late- summer when flows are low and stream temperatures are high. Groundwater data showing an average growing season increase from 5' pre-project to between 2.2' and 2.8', and an increase in the average August median depth from 5' pre-project to 2.9' post-project, suggest groundwater is available to augment flow in late summer. However, any cooling effect of groundwater recharge that may be occurring at Camp Polk appears to be negated by warming of surface water, likely through a combination of increased residence time in a sinuous channel, flow already limited by significant diversions for irrigation allocated to multiple channels, and reduced riparian shading as trees and shrubs planted as seedlings continue to mature. Over the long term, restoration partners expect planted riparian species including alder, willow, and cottonwood to shade the meadow channel at Camp Polk.

The restoration approach and design used at Camp Polk is expected to restore floodplain connectivity and as a result also restore groundwater recharge, which can increase summer base flow, thereby reducing warming, and actively cool the stream. However, these effects of groundwater recharge are secondary drivers of high stream temperatures. The primary driver of high stream temperatures in Whychus Creek remains the dramatic reduction in streamflow resulting from diversions for irrigation (*2015 Whychus Creek Monitoring Report*, UDWC, 2016). Regression analysis of stream flow and stream temperature in Whychus Creek indicate that streamflow accounts for 83% of the water temperature condition (*2015 Whychus Creek Monitoring Report*, UDWC, 2016). Given this relationship, it is important to acknowledge the relatively limited degree to which stream or floodplain restoration can achieve significant reductions in stream temperature. Significant reductions in stream temperature will most effectively be achieved through substantial increases in stream flow.

Table 2. July 16-August 15 median average daily flow, average 7DADM temperatures and average upstream to downstream difference, and 7DADM temperature and upstream to downstream difference on the hottest water day of each year, at WC 19.50 and WC 18.25, pre- (2007-2011) and post- (2012-2014; 2012-2015; 2012-2016) diversion of Whychus Creek into the restored meadow channel.

	July 16 - August 15			Hottest Water Day			
	18.25 Avg temp (°C)	**19.5 Avg temp (°C)**	**18.25-19.5 Avg Δ (°C)**	**18.25 7DMAX temp (°C)**	**19.5 7DMAX temp (°C)**	**7DMAX Δ 18.25-19.5 (°C)**	**Median flow (CFS)**
2007	20.4	18.8	1.6	22.2	20.3	1.9	14
2008	17.3	16.4	0.9	19.6	18.3	1.3	31
2009	19.9	18.7	1.2	21.6	20.3	1.3	16
2010	18.6	17.3	1.3	18.9	17.6	1.4	26
2011	15.1	14.5	0.6	17.5	16.5	1.0	66
Pre-project Average	**18.3**	**17.1**	**1.1**	**20.0**	**18.6**	**1.4**	**30.6**
2012	16.5	15.4	1.1	18.9	17.3	1.6	51
2013	19.7	17.8	1.9	21.3	18.9	2.4	22
2014	18.3	16.3	2.0	19.4	17.4	2.1	37
2015	20.6	18.2	2.4	22.7	20.2	2.5	22
2016	20.1	17.5	2.6	21.6	18.8	2.8	27
2012-2014							
Post-project Average	**18.2**	**16.5**	**1.7**	**19.9**	**17.9**	**2.0**	**36.7**
Pre-project-Post-project Difference	-0.1	-0.7	0.5	-0.1	-0.7	0.7	6.1
2012-2015							
Post-project Average	**18.8**	**16.9**	**1.9**	**20.6**	**18.4**	**2.1**	**33.0**
Pre-project-Post-project Difference	0.5	-0.2	0.7	0.6	-0.2	0.8	2.4
2012-2016							
Post-project Average	**19.0**	**17.0**	**2.0**	**20.8**	**18.5**	**2.3**	**31.8**
Pre-project-Post-project Difference	0.8	-0.1	0.9	0.8	-0.1	0.9	1.2

Riparian Vegetation

UDWC began monitoring riparian vegetation at Camp Polk in 2010, the first growing season following riparian plantings in Fall 2009. We measured riparian plant survival including tree and shrub survival, one of several vegetation parameters identified in the Camp Polk monitoring plan, in 2010 and 2011 to assess establishment and need for re-planting. Survival approached 100% in both years and by 2011 differentiating between original planted individuals and new growth and detecting dead individuals was sufficiently difficult to bring into question the accuracy of results. However, the successful establishment of riparian vegetation was evident. From 2012-2014 we used a percent cover sampling methodology to quantify total cover and abundance of planted species.

Total vegetative cover within 100 ft of the main channel averaged 73% in 2014. Although 11% lower than the 84% reported for 2013, this difference is likely a result of sampling error associated with a relatively small sample (n=14), inclusion of two transects from Reach 1 where planting occurred two years later than on the rest of the project, and the patchiness and heterogeneity characteristic of plant communities. Planted riparian species cover averaged 29%, a small gain over the 27% reported for both 2012 and 2013. Cover of other species, both native and non-native, averaged 60% (compared to 76% in 2013), while priority weed species, namely cheatgrass (1.5%), accounted for only 1.8% of total vegetation. (Both planted species and other species could be detected and recorded on the same point, hence percentages for these two groups summed to more than the 73% total vegetative cover.)

Despite the lower measured abundance of total vegetation and the small increase in planted vegetation from 2013-2014, monitoring results describe a vegetation community that is well-established and abundant, characterized by a strong native riparian species component and minimal cover of invasive weeds. The abundance and composition of vegetation at Camp Polk Meadow in 2013 are consistent with achieving project goals. Riparian vegetation is flourishing, particularly willow and alder within 20-30 ft of the channel. A Deschutes Land Trust contractor who surveyed weeds at Camp in 2014 anecdotally reported that native perennial grasses and shrubs were in greater numbers and larger than in 2013. Along some reaches of the main stream channel, the riparian community has changed from a knee- to shoulder-high scattering of shrubs to a dense overhead canopy of willow and alder. Whereas the point-intercept sampling protocol implemented in 2012 was ideally suited for measuring percent cover (i.e. lateral growth) of a shorter herbaceous and shrub community, as the bigger species at Camp Polk Meadow have accelerated in vertical growth, the point-intercept protocol has become both less well-suited for measuring plants that are overhead and more difficult to implement. UDWC is currently exploring the use of aerial imagery to map the extent and density of riparian in the meadow. Vegetation monitoring results are presented in *Whychus Creek Restoration Project at Camp Polk Meadow Preserve: 2014 Vegetation Monitoring Report* (www.restorethedeschutes.org).

Invasive Weeds

The Deschutes Land Trust has inventoried, mapped, and actively managed invasive plant species at Camp Polk Meadow Preserve since 2000. During the summer of 2006, prior to beginning construction at Camp Polk, weeds were inventoried and distribution maps and infestation levels were updated for priority weed species. The *Camp Polk Meadow Weed Management Plan,* developed in 2002 and revised every year starting in 2009, was updated to respond to these baseline conditions.

The spread of non-native, invasive plants in disturbed areas was anticipated to occur in the first few years following restoration construction. Pre- and post- construction weed treatments (chemical application and manual control) and weed population monitoring were planned according to the *Camp Polk Meadow Weed Management Plan* to maximize successful establishment of native plants. DLT has monitored priority weed species and implemented treatments annually between April and October since 2009. Changes in species density and distribution are recorded and mapped. Monitoring data are used in an adaptive management approach to plan monitoring and treatments for the following year.

By 2013 weed populations had been controlled to the extent that 2014 weed monitoring was reduced to once a month during June, July, and August. 2014 surveys detected spotted knapweed, common mullein, and bull and scotch thistle at lower abundances than in previous years; mustard, nightshade, and fiddleneck (a weedy native) populations were also much reduced. The expansion of reed canarygrass observed within and along the main channel in reach 2 in 2014 prompted an intensive reed canarygrass mapping effort in 2015, summarized in the Reed Canarygrass section of this report.

In addition to reed canarygrass mapping, weeds were surveyed and mapped in 2015 over four visits to the meadow, once per month from May through August (Appendix C; Appendix D). Species that continued to present a management concern as of 2015 included spotted knapweed, bull and Canada thistle, common mullein, and reed canarygrass. Spotted knapweed and bull thistle were found in sandbars, flood deposits, and dry side channels, suggesting that flood flows are likely introducing seeds of these species into the meadow. Common mullein also remained abundant throughout the restoration area. Volunteer crews hand-pulled (mullein) or clipped (knapweed and thistle) these species throughout the summer. Canada thistle continued to expand in the meadow despite sustained efforts to control it through clipping. In September 2015, DLT staff treated all major Canada thistle and co-occurring common teasel populations that could be safely treated with the herbicide Opensight (aminopyralid and metsulfuron methyl); additional treatments were anticipated to be needed in 2016 to control Canada thistle and teasel to the point where they can be controlled without the use of herbicides.

Management actions in 2016 continued to include hand-pulling and clipping of spotted knapweed, mullein, and bull thistle. The Canada thistle and common teasel populations treated in 2015 demonstrated improvements. One small, isolated population of Canada thistle to the west of the main populations exhibited very little re-emergence in 2016 and therefore was not re-treated. Canada thistle and teasel continued to flourish in areas of saturated soils and near water where DLT had not treated in 2015 due to restrictions specific to the herbicide used. Accordingly, in 2016 DLT treated dry areas with Opensight as in 2015, and treated populations growing in saturated soils with an aquatic version of 2,4D (Appendix E). DLT weed monitoring efforts in 2017 will focus on determining the efficacy of recent herbicide treatment strategies, adjusting treatment strategies, and re-treating remaining populations as funding permits. They will continue with hand-pulling, concentrating the majority of the hand-pulling efforts on mullein in the restoration area.

Reed Canarygrass

In fall 2014, the project team noticed a marked increase in reed canarygrass (RCG), a rhizomatous grass that has invaded wetlands throughout the continental US, in Camp Polk Meadow. RCG was known to occur in the meadow and had been actively controlled through manual and herbicide treatments and closely monitored from 2009 through 2012. By 2012, abundance of RCG in established populations had decreased, populations detected in the new meadow channel in 2011 were absent following diversion of Whychus Creek into the channel, and no new populations had been observed subsequent to 2011 treatments. Riparian vegetation monitoring and field observations showed native species to be increasing in abundance and successfully competing with weeds. Weed populations responded so positively to 2012 and 2013 control measures that in 2014 weed monitoring was reduced to once per month.

To evaluate the scope and severity of RCG expansion and identify management alternatives for controlling RCG, in 2015 UDWC and DLT staff mapped reed canarygrass in the meadow, reviewed available literature on reed canarygrass ecology and management, and developed a preliminary plan for controlling reed canarygrass at Camp Polk. Sampling efforts were focused in the upstream reaches of the project (Reaches 1 & 2) and along the main channel and side channels (Appendix D). RCG was found at relatively low abundance (<25% cover) throughout areas sampled. It was consistently found in riparian areas and side channels where the stream accesses the floodplain during high flow events, leaving soil moisture high, and in stream channels where sediment and woody material collect. We did not find reed canarygrass in drier areas above elevations typically flooded by high flows.

Treatment priorities and methods identified for Camp Polk respond to the flooding regime and plant community that characterize the meadow. Frequent flooding promotes RCG establishment by depositing sediment, RCG rhizomes and seeds onto the floodplain, particularly in Reaches 1 & 2; the planted native riparian community is well-established, diverse and abundant; invasive weeds other than RCG represent a small proportion of the community. Treatment recommendations are summarized as follows:

- Prioritize upstream reaches, the mainstem channel, dense monocultures, and new shoots ("starts") for treatment. Beginning treatment in the upper reaches of a focal area, addressing vectors, and eliminating small source populations are approaches that have been shown to significantly control RCG in wetland settings.
- Hand-pull starts and in-stream mats and dig up all roots.
- Backpack-spray logjams and well-established, high-density areas with glyphosate herbicide during late summer low flows. A USFS study on the Metolius River found backpack spraying to more effectively control ribbongrass, another *Phalaris* species, than wand application. RCG was consistently found at relatively higher abundances on logjams in the main and side channels at CPM.
- Experimentally solarize dense monocultures above high water. Although solarization has been shown to be effective in controlling dense stands of RCG, restoration partners are wary of floodwaters degrading plastic and introducing plastic fragments into the stream environment.
- Monitor but defer treatment of RCG sparsely interspersed with native riparian vegetation.

Deschutes Land Trust incorporated these recommendations to identify a RCG treatment plan for 2016 that included application of an aquatic glyphosate herbicide in priority treatment areas to prevent reed canarygrass from forming monocultures, choking side channels, and out-competing natives.

DLT prioritized 2016 RCG treatment areas into 3 categories. Treatment of the main new channel through the restored area was highest priority for treatment due to the low infestation of RCG and greatest chance of successfully limiting its spread in this area. Treatment of the smaller connecting and side channels was a secondary priority. Treatment of the old channel was lowest priority due to the density of infestation, density of surrounding native vegetation and access difficulty. Use of solarization and hand-pulling / digging was not deemed an economical or effective strategy at this time. Treatment with an aquatic glyphosate product mixed with an aquatic surfactant was completed via backpack sprayer by a licensed herbicide applicator. All three categorized areas mentioned above were successfully treated in August and September 2016 (Appendix E). Several weeks later, die-off of RCG stands was evident. DLT's 2017 RCG management activities will include determining efficacy of the 2016 glyphosate treatment, and adjusting the treatment strategy and retreating as needed.

Ultimately DLT aims to reduce the RCG population to the extent that it can be controlled in the future exclusively through hand-pulling. Active prevention of RCG establishment at future projects will be facilitated by intensifying RCG management efforts at the time when the stream is reconnected to the floodplain, and by strategically developing funding and allocation of resources for RCG control. Reed canarygrass mapping and literature review findings are presented in *Reed Canarygrass at Camp Polk Meadow Preserve: 2015 Monitoring Report* (www.upperdeschuteswatershedcouncil.org).

Macroinvertebrates

Macroinvertebrates were sampled at Camp Polk in 2005, 2009, and 2011-2016. Samples were collected at the temperature monitoring locations upstream and downstream of Camp Polk in all eight years. Two sites sampled in 2005, 2009, and 2011 in the old, straightened channel were re-located to the new channel following diversion of the stream in 2012, and sampled in the new channel from 2012-2016.

ORDEQ (Oregon Department of Environmental Quality) and Grande Ronde IBI (Index of Biological Integrity) ratings for the four Camp Polk monitoring sites, calculated from ten community metrics (e.g. total number of species, number of sensitive species) indicated relatively good biological conditions in 2016, with all sites scoring as slightly or minimally impaired (Table 3). Although the mean 2016 IBI score for the four sites is not significantly different than the mean for other years, ORDEQ IBI scores indicate improved conditions in 2016 over 2011-2015. The three downstream sites, which had in some years between 2011 and 2015 scored as moderately impaired, in 2016 scored as slightly impaired; the upstream-most site scored as minimally impaired, the first time since 2005 that a Camp Polk site scored as minimally impaired, and one of relatively few minimally impaired scores across years and sites. Grande Ronde IBI scores indicated minimal impairment at all Whychus Creek sites in 2016. The Grande Ronde IBI differentiates only three biological condition categories, and scoring ranges were designed to reflect biotic communities in the northeastern Oregon streams for which the GRIBI was developed, with a much lower site score corresponding to minimal impairment (≥ 26 summed score) than for the ORDEQ IBI (> 39 summed score). However, GRIBI scores for Whychus correlated strongly to ORDEQ IBI scores.

IBI individual richness metrics suggested improving conditions at Camp Polk in 2016 over previous years, while individual sensitivity and tolerance metrics indicated a decline in stream conditions. Taxa richness and Plecoptera and Trichoptera richness all increased over previous years, although Ephemeroptera richness decreased. The number of sensitive taxa decreased, and percent tolerant taxa, a negative metric, increased, indicating a response to deteriorating conditions.

EPT richness is an additional community metric used in many indices of biological integrity. As a combined group, EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa are among the most sensitive stream organisms, and EPT richness is thus a simple biological measure of stream conditions. Mean EPT richness for the four Camp Polk sites in 2016 was higher than in any previous year (significantly higher in 2016 than in 2011); a similar trend was observed for seven downstream sites, with a higher 2016 mean than in 2005 and from 2012-2015.

PREDATOR scores for the four Camp Polk sites in 2015 and 2016 suggest a return to the fair and good biological conditions observed in 2005 and 2009, improved from nearly uniform poor conditions from 2011-2014. Scores from the PREDATOR model, which evaluates stream condition according to the proportion of macroinvertebrate taxa expected at a site versus the proportion observed, were significantly higher at Camp Polk sites in 2016 than in 2014, 2013 and 2012; scores for downstream sites were also significantly higher than in 2014. (Scores for upstream sites did not differ significantly from those in any other year). While predictive models such as PREDATOR are often considered more sensitive and accurate than IBIs, on Whychus, despite high 2016 PREDATOR scores generally aligning with 2016 IBI scores, PREDATOR scores correlate poorly with IBI scores (Pearson’s $r = 0.185$), bringing into question how well the parameters of this model describe the Whychus system. While we continue to use the PREDATOR model as one method to evaluate macroinvertebrate community data, we place greater confidence in metrics that more directly reflect a biological response to stream conditions.

Despite macroinvertebrate community metrics indicating improved biotic conditions in Whychus, several metrics suggest a community response to warmer stream temperatures and a higher fine suspended sediment load throughout Whychus in 2015 and 2016, in contrast to trends indicating cooler temperatures and reduced fine sediment from 2009-2014. The temperature preference (weighted mean temperature optima) of taxa comprising the macroinvertebrate community at Camp Polk increased for the third year in a row; the mean community temperature optima for upstream sites was higher than in any other year, and for downstream sites was higher than in the last three years. The mean community sediment optima (% fine suspended sediment; %FSS) was lower at Camp Polk sites in 2016 than in 2015, but higher than in 2014 and significantly higher than in 2012, while mean community sediment optima was higher at upstream sites than from 2012 to 2015, and at downstream sites than from 2013-2015. Temperature optima of replacement taxa (taxa not expected but observed) and missing taxa (taxa expected but not observed) at Camp Polk sites suggest a cooling trend through 2012 followed by warming since 2012. Sediment optima of missing taxa indicate lower sediment conditions since 2005; replacement taxa show no sediment trend.

Overall, the Whychus Creek macroinvertebrate community demonstrates improved conditions since 2005; the 2009-2016 communities are distinctly different than the 2005 community, characterized by more sensitive taxa and more taxa associated with flowing water and cooler stream temperatures, a trend also observed at Camp Polk sites. The warming trend observed from 2014 through 2016, reversing an earlier cooling trend at Camp Polk and downstream sites, may signal a response to larger climate stressors. It is worth noting that the assemblage of macroinvertebrate species in the new channel is entirely a product of colonization following diversion of the stream, signaling conditions in the new channel are sufficient to support a robust macroinvertebrate community. The 2016 macroinvertebrate report, *Effectiveness Monitoring in Whychus Creek; Benthic Macroinvertebrate Communities in 2005, 2009, and 2011-2016*, will be available on the UDWC website at www.upperdeschuteswatershedcouncil.org in April 2017 following final revisions.

Table 3. Selected macroinvertebrate metrics, direction of change, and years from which 2016 was significantly or almost significantly different for each metric.

Metric	Direction of change	2016 significantly different than	2016 different than but not significantly
ORDEQ IBI			
Scores	Improved (increased)		2015, 2014, 2013, 2012, 2011, 2009, 2005
Taxa richness	Improved (increased)	2014, 2012	2011
Ephemeroptera richness	Declined (decreased)	2015, 2012	
Plecoptera richness	Improved (increased)	2005	
Trichoptera richness	Improved (increased)	2011	2015, 2014
Number of sensitive taxa	Declined (decreased)	2014	
Percent tolerant taxa (negative metric)	Declined (increased)	2014, 2012	2013, 2009
EPT richness	Improved (higher)	2011	2014
PREDATOR O/E scores	Improved (higher)	2014, 2013, 2011	2012
Temperature metrics			
Community temperature optima	Declined (higher)	2011	
Cool indicator taxa	Declined (fewer)	2012	2013, 2009
Warm indicator taxa	Declined (more)	2014, 2012, 2011	2013
Sediment metrics			
Community sediment optima	Declined (higher)	2012	2014

Low sediment indicator taxa	Improved (more)		2015, 2005
High sediment indicator taxa	Declined (more)	2014	

Fish Populations

PGE discontinued juvenile density surveys at Camp Polk following diversion of Whychus Creek into the new channel in 2012; no juvenile density surveys have been conducted in the restored meadow channel at Camp Polk to date. USFS or PGE surveyed O. mykiss redds at Camp Polk (RKM 25, PGE Reach 5) in every year from 2007-2016, in the ditched, pre-restoration channel from 2007 to 2011 and in the restored meadow channel from 2012-2016 (PGE Reach 5). In 2016 surveyors found seven redds at Camp Polk during the course of five surveys between April 8 and June 17, more than three times the two redds found in this reach in 2015. Redd numbers at Camp Polk have fluctuated between two and eight redds since 2006; notably some of the highest numbers of redds in the reach were found in post-project years, seven in 2016 and six in 2012. More redds have been detected at Camp Polk than at any other site except below Alder Springs since 2012.

Photopoints and Aerial imagery

Photographic monitoring was conducted in 2016 at photopoints throughout Camp Polk Meadow. A select portfolio from photo monitoring comparing photopoints from 2008/2009, 2015, and 2016 is presented as Appendix F. We included 2008, pre-construction photopoints where available; where 2008 photos were not available we used 2009 photos for the pre-project comparison.

New aerial imagery was flown by USFS in 2016; the orthorectified photomosaic files are stored on the UDWC server.

Bird Surveys

Since 2006, volunteers from Deschutes Land Trust, Central Oregon Birder's Association, and the East Cascades Audubon Society have conducted presence/absence bird surveys year-round throughout Camp Polk Meadow. The survey protocol was designed to support analysis of changes in the number, composition, and frequency of species detected over time, and specifically before and after the diversion of Whychus Creek to the new channel in 2012. 2016 marked the final year of surveys under this protocol; analysis is ongoing and is anticipated to be completed in spring 2017. Raw data are available upon request.

APPENDIX A. Whychus Creek Restoration Project at Camp Polk Meadow Preserve Monitoring Summary Table

Whychus Creek Restoration Project at Camp Polk
Monitoring Plan Summary
January-16

Monitoring Parameter	Goals[1]	Protocol/Citation	Reporting	Location	Season	Frequency	Duration	Years													Lead	Annual Budget	Baseline	Notes
							Years -->	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017				
								B = Baseline; I = Implementation; PP = Post Project; TBD = To Be Determined																
Priority 1[2]																								
I. Hydrology																								
Groundwater	2, 3, 5	Groundwater well measurements. S:\UDWC\Projects\Metolius & Whychus\Camp Polk\Monitoring\Groundwater\Data\Monitoring Well Protocol	Annual groundwater monitoring report written by UDWC intern	2 x-sections of 5 and 2 wells	Thaw and growing season, March - October	Monthly March - October	2007 - 2017. Installed in 2007.			B	B	I	I	I	PP	PP	PP	PP	PP	PP	UDWC	Installation (2007), maintenance, data management	2008	Assistance from UDWC intern, UDWC or DLT volunteer.
Temperature Heterogeneity	1,5	2010 Temperature Heterogeneity at Rimrock Ranch and Camp Polk Meadow; Benewah Creek Model Watershed Effectiveness Monitoring 2009	UDWC Intern or Monitoring Coordinator	Pools and downstream riffles within existing channel reach (pre project) and new channel (post project)	July (hottest days of the year)	Once, post phase II construction.	2013. Additional monitoring will depend on results from 2013.						B			PP			DISCONTINUED		UDWC	Labor for field work and write up.	2010	DIiscontinued post-2013 monitoring. Summary of 2013 findings included in 2013 Pelton Camp Polk Monitoring Report. Baseline study conducted at Rimrock Ranch and Camp Polk by an OSU student.
II. Water Quality																								
Continuous Temperature	1, 2, 5	Data collected with Vemco temperature dataloggers. UDWC QAPP 2008, SOP 2008.	Written evaluation of temperature at monitoring sites upstream and downstream of Camp Polk by Monitoring Coordinator	Above new channel (RM 19.50); Below new channel (RM 18.25).	April - October	Annually	2007 - 2017. Begun in 2007.	B	B	B	B	B	B	B	PP	PP	PP	PP	TBD		UDWC	Deployment, audits, maintenance, data management	Upstream data from 1998, 2000-2012; Downstream data 2001, 2003-2012 (UDWC)	Camp Polk sites are a subset of the Whychus Creek Model Watershed Monitoring
III. Geomorphology																								
Channel dimension, pattern and profile	3,4, 5	Full Channel survey / total station survey with cross-sections and 2009 Lidar data	Paul Powers, Fisheries Biologist, and Cari Press, Hydrologist, Deschutes National Forest	16 cross sections; entire project reach	Summer or fall	2009: Reaches 2-5; 2013: As-built for Reaches 1-6, cross sections for Reach 1 and 6.	Evaluate need for additional surveys after 2013 pending further changes to system					B				PP			PP		UDWC w/ field work conducted by USFS	Labor for field work and write-up	Lidar data was collected in 2009 post Phase I construction	Given the ongoing dynamic evolution of the channel, a second total station survey will be conducted in 2016
IV. Biological Parameters																								
Riparian Vegetation - Transects	1, 2, 3, 4	Percent cover monitoring. 2012 Camp Polk Vegetation Monitoring Report	Annual vegetation monitoring report written by UDWC intern	Twelve stratified randomly located transects in riparian beltwidth	First week of August	Annually	2012 - 2017								B	PP	PP	PP	TBD		UDWC	Labor for field work and write-up (Monitoring Coordinator, Intern). Consulting contract with Karen Allen.	2012	Replaces Riparian Plant Survival. UDWC Intern, Monitoring Coordinator
Riparian Vegetation - Grids	1, 2, 3, 4	Percent cover monitoring. 2010 U of O CPM Vegetation Monitoring Report.	OSU Field Course Reports (Formerly U of O)	Five transects and grids along monitoring well cross sections	Summer	Annually 2007-2010; evaluate frequency in 2013.	Resume in 2013 or later depending on vegetation conditions.			B	B	PP	PP			PP	PP		DISCONTINUED		Karen Allen, Matt Orr (OSU).	In-kind from UofO field ecology course.	2007 (Grid #1), 2008 (Grids #2,3), 2009 (Grids #4,5), 2010 (Grids #1,2,3)	Discontinued after 2014 due to change of U of O faculty priorities. Independent UofO work not coordinated by UDWC or DLT.
Riparian Plant Survival	1, 2, 3, 4	Belt transects perpendicular to channel. 2010 Camp Polk Vegetation Monitoring Report.	2010 and 2011 Camp Polk Vegetation Monitoring Reports written by UDWC intern	Twelve stratified randomly located transects in riparian beltwidth	Summer	Annually	2010 - 2011						B	PP				REPLACED WITH RIPARIAN VEGETATION - TRANSECTS			UDWC	Labor for field work and write-up; Contract with Karen Allen (2010 and 2011)	2010	Discontinued in 2012 due to abundance of vegetation and inability to distinguish planted individuals and detect dead plants.
Invasive Weeds	3	Direct observation focusing on targeted species. 2006 Weed Monitoring and Evaluation	Annual DLT report summarizing Weed Management Plan, Weekly Weed Monitoring Reports and Monthy Accomplishments	Restoration project area delineated by implementation boundary on implementation schematics (2009)	Spring, Summer, Fall	Annually	Funding through 2013. Should continue as long as possible		B			I	I	I	PP	PP	PP	PP	PP	PP	DLT	Labor for weed removal including manual and herbicide applications, materials and reporting.	DLT 2006	Annual Weed Management Plans
Macroinvertebrate sampling	1, 5	Level 2 Benthic Macroinvertebrate survey. 2009 Whychus Creek Monitoring Technical Report.	Excerpted from annual Whychus Creek Monitoring Technical Report by Monitoring Coordinator.	Two original sites (UDWC 2009); two sites in new channel established in 2012 (UDWC 2012)	Third week of August	2005, 2009, 2011 - present; Annually depending on status, trends and funding	2011-2017	B				B		B	PP	PP	PP	PP	PP	PP	UDWC	Labor for write-up and/or in-kind.	UDWC 2005	Camp Polk sites are a subset of the Whychus Creek Model Watershed Monitoring
Fish Habitat	1	Refer to Camp Polk Restoration Plan Appendix B and E	Excerpted from Whychus Creek Monitoring Technical Report by Monitoring Coordinator.	Within project reach, as determined by PGE, ODFW and UDWC	Summer	1997; 2008-2009; TBD	Assess ongoing changes to system and collaborate with PGE to determine post-2011 survey				B	B							PP		PGE, ODFW, UDWC	Labor for field work and write-up	ODFW 2008-2009	Camp Polk sites are a subset of the Whychus Creek Model Watershed Monitoring
Fish Populations	1	Refer to Camp Polk Restoration Plan Appendix B and E	Results of Camp Polk fish surveys reported by PGE, USFS or ODFW	Within project reach, as determined by PGE, ODFW, USFS, and UDWC	Spring, Summer	Annually as part of PGE reintroduction monitoring or by ODFW/USFS	Continue through 2017			B							PP	PP	TBD		PGE, ODFW, UDWC	Labor for field work and write-up	PGE 2007	Camp Polk sites are a subset of the Whychus Creek Model Watershed Monitoring
V. Photographic Monitoring																								

Monitoring Parameter	Goals[1]	Protocol/Citation	Reporting	Location	Season	Frequency	Duration	Years													Lead	Annual Budget	Baseline	Notes
							Years -->	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017				
								B = Baseline; I = Implementation; PP = Post Project; TBD = To Be Determined																
Photopoints	1, 2, 3, 4	Established photopoints using DLT protocol.	Annual photo management by DLT; Photopoint binders (2008 pre-implementation photos, 2009 and 2010 Phase I implementation photos)	Various points throughout Camp Polk Meadow Preserve that are good vantage points of the restoration project area.	Summer	Set up in 2008 (year 1); repeated in 2009 Immediately following construction (Year 2); 2010-2015 (Years 3-8)	Continue through 2017				B	I	I	I	PP	PP	PP	PP	PP	PP	DLT	Labor for field work and write-up	2008 and/or 2009	Photo points were established in 2008 and modified after phase 1 construction. After phase II, we will reassess if all photopoints should be monitored in the future.
Aerial photos	1, 2, 3, 4	Aerial imagery is accessed online from USDA Imagery: http://gis.apfo.usda.gov/gisviewer/.	Trackand report most recent year for which imagery is available.	Whole site	Summer	Annually as available	Continue as long as possible				B	I	I	I	PP	PP	PP		PP	PP	UDWC	Labor - Deb, Lauren - NAIP transfer, management	2008 NAIP	
Priority 2 [2]																							2004?	
VI. Supplemental Monitoring																								
Bird surveys – presence and breeding data	3	Spring/fall migration counts, Christmas Bird counts, Breeding bird atlas surveys	DLT, intern, or volunteer	Throughout meadow and existing & new riparian corridor	Spring, summer, fall, winter	2000 (pre-implementation); Annually 2008-2017	2008-2017				I	I	I	I	PP	PP	PP	PP	PP		DLT	In-Kind	DLT 2000	
Vegetation Community Mapping	2, 3	USACE Wetland Delineation or GPS mapping of wetland areas and communities.	Whychus Creek Restoration Project: Vegetation Monitoring Report 2010	Throughout meadow, as in 2007	Spring, early summer	Once, post phase II construction.	Evaluate - 2017?			B							EVALUATE				UDWC	Labor for field work and write-up. Contract with Karen Allen.	Wetland Delineation (2007)	Complete mapping as long as possible after Phase II construction.

#1: Project Goals:
1. Provide 1.7 miles of high quality redband trout, chinook and steelhead spawning and rearing habitat.
2. Restore functioning meadow hydrology, including floodplain connectivity, an increase in the groundwater table and enhanced summer base flow.
3. Restore and enhance high quality riparian wetland habitat along the stream corridor.
4. Provide natural channel stability, including dimension, pattern and profile that meets reference conditions.
5. Decrease stream temperatures to help meet Oregon's State Temperature Standards.

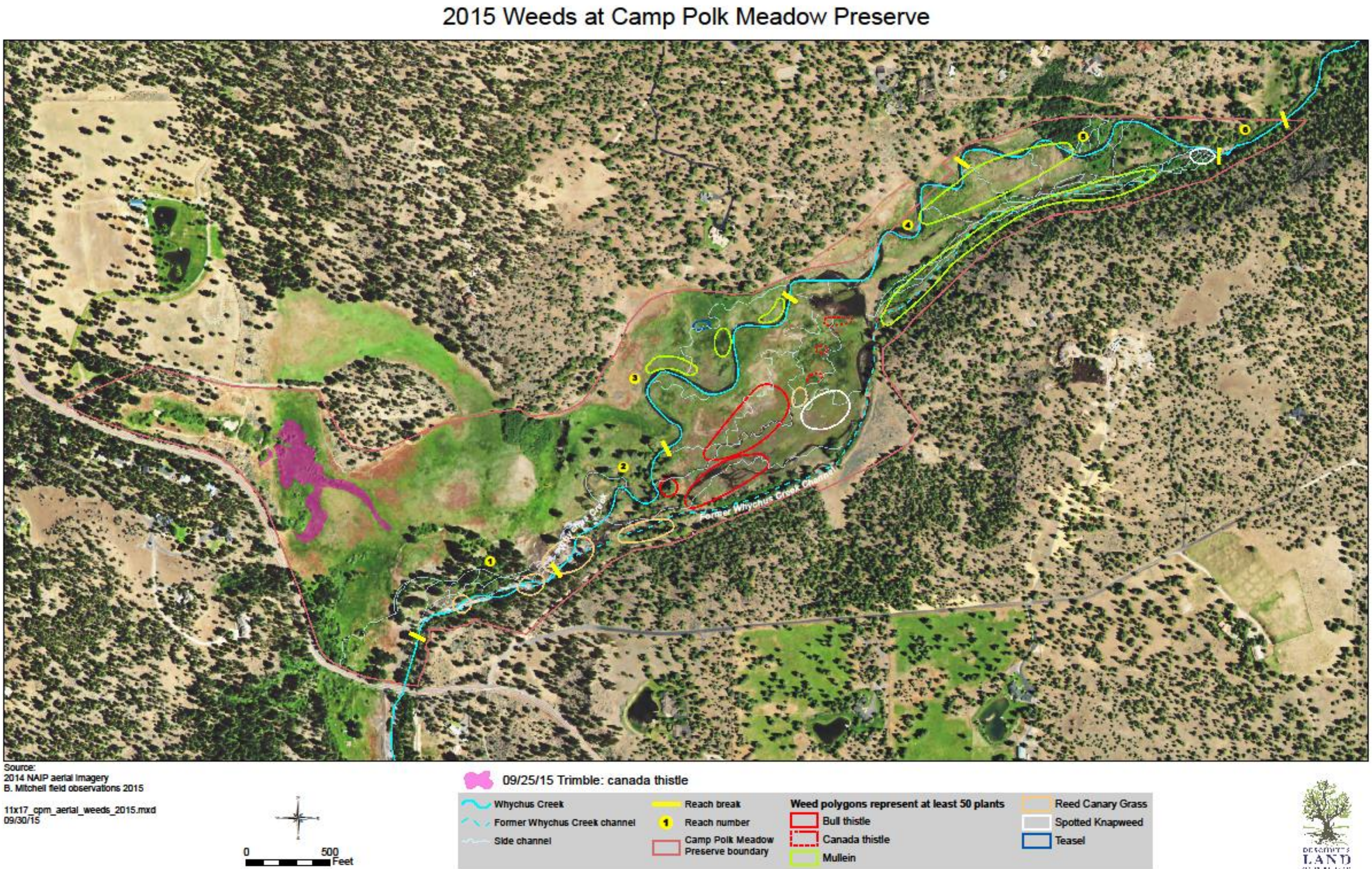
#2: Monitoring Priorities. Priority 1 monitoring is that which helps define project success and for which funding will be prioritized. Priority 2 monitoring is above and beyond that suggested to evaluate the success of the project, but which would provide valuable data if resources are available .

APPENDIX B. Camp Polk Meadow channel dimension and pattern design parameters

Variables	Existing	As Designed		Monitoring: 2013	
	Mean	Mean	Range	Mean	Range
Stream Type	F1-4, B3, C4	C4/E4	C4-E4	C4	C4-D4
Bankfull width (W_{bkf}) (riffle)	33	32	30-37	31.25	26-37
Bankfull mean depth (d_{bkf})	1.6	1.9	1.4-2.1	1.60	1.25-2
Width/Depth ratio (W_{dkf}/d_{bkf}) (riffle)	24	17	15-23	19.53	13-25.6
Bankfull X-sect. Area (A_{bkf}) (ft^2)	60	60	42-64	51.20	40-60
Bankfull discharge, cfs (Q_{bkf})	288	288	----------	288.00	----------
Bankfull Max. depth (d_{max}) (ft)	2.2	2.4	1.9-2.8	2.80	2.1-3.4
Width of flood prone area (W_{fpa}) (ft)	50	1000	700-1300	1000.00	700-1300
Entrenchment ratio (W_{fpa}/W_{bkf})	1.5	33	23-43	32.00	23-43
Valley Width (ft)	1000	1000	700-1300	1000.00	700-1300
Meander length (L_m)	----------	390	275-500	396.00	210-540
Meander length / Bankfull width	----------	12	8.6-17	12.67	8-14.6
Radius of curvature (R_c) (ft)	----------	75	60-90	61.00	41-100
Radius of curvature/Bankfull Width	----------	2.3	1.9-2.8	1.95	1.6-2.7
Belt width (W_{blt}) (ft)	----------	207	83-367	214.00	145-371
Belt width/Bankfull Width	----------	6.5	2.6-11.5	6.85	5.6-10
Sinuosity (str. Length/valley dist.(k))	1.1	1.6	-------	1.55	-------
Valley slope (ft/ft)	0.01	0.01	-------	0.01	-------
Average slope ($S_{avg}=S_{valley/k}$) (ft/ft)	0.009	0.007	-------	0.006	-------
Max pool depth (d_{pool}) (ft)	3	5	4-7	4.50	4-6
Pool width (W_{pool}) (ft)	30	28	25-33	26.00	23-36
Pool head width (ft)	----------	<28	26-30	<28	26-30
Pool tail width (ft)	----------	32	32-40	36.00	32-40
Pool Length (ft)	----------	161	100-244	161.00	100-244
Pool Length/Riffle Length	----------	1.2	1 - 2	0.99	1 - 2
Pool to pool spacing (p-p)	----------	130	48-225	160.00	50-280
Pool to pool spacing/Riffle Width	----------	4.3	1.5-7	5.12	1.5-7
Riffle slope (S_{riff}) (ft/ft)	0.0095	0.014	.007-.03	0.011	0.0067-0.018
Riffle slope/ave. water surface slope	1.05	2.3	1.16-5	1.83	1.1-5
Riffle Length (ft)	----------	148	49-225	162.00	50-280
Run slope (ft/ft)	0.084	0.084	0.02-0.12	0.08	0.02-0.12
Run slope/ave. water surface slope	9.3	14	3.3-20	14.00	3.3-20
Run Length (ft)	10	10	3 - 18	10.00	3 - 18
Glide Slope (ft/ft)	-0.04	-0.04	-0.0014 - -0.08	-0.04	-0.0014 - -0.08
Glide Slope/ave. water surface slope	0.044	-6.5	-0.23 - -14	-6.50	-0.23 - -14
Glide Length (ft)	20	29	6 - 52	25.00	6 - 50

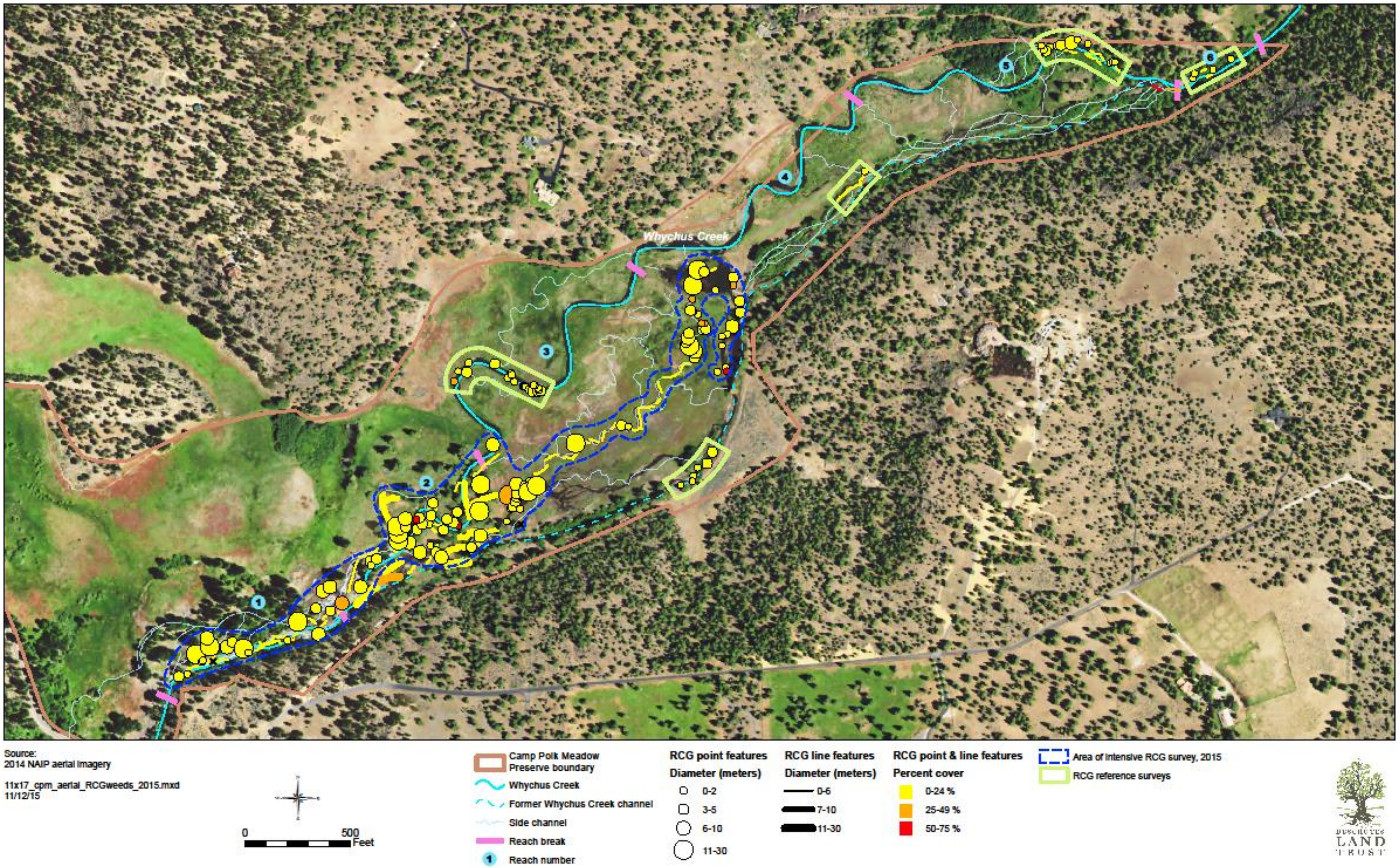
For Project Goals and Objectives:	Existing	As Designed	As Built: 2013
Total mainstem channel length (ft)			
Total side channel habitat length (ft)			
Number of Pools	14	27	34

APPENDIX C. 2015 distribution of priority weed species of concern at Camp Polk Meadow.

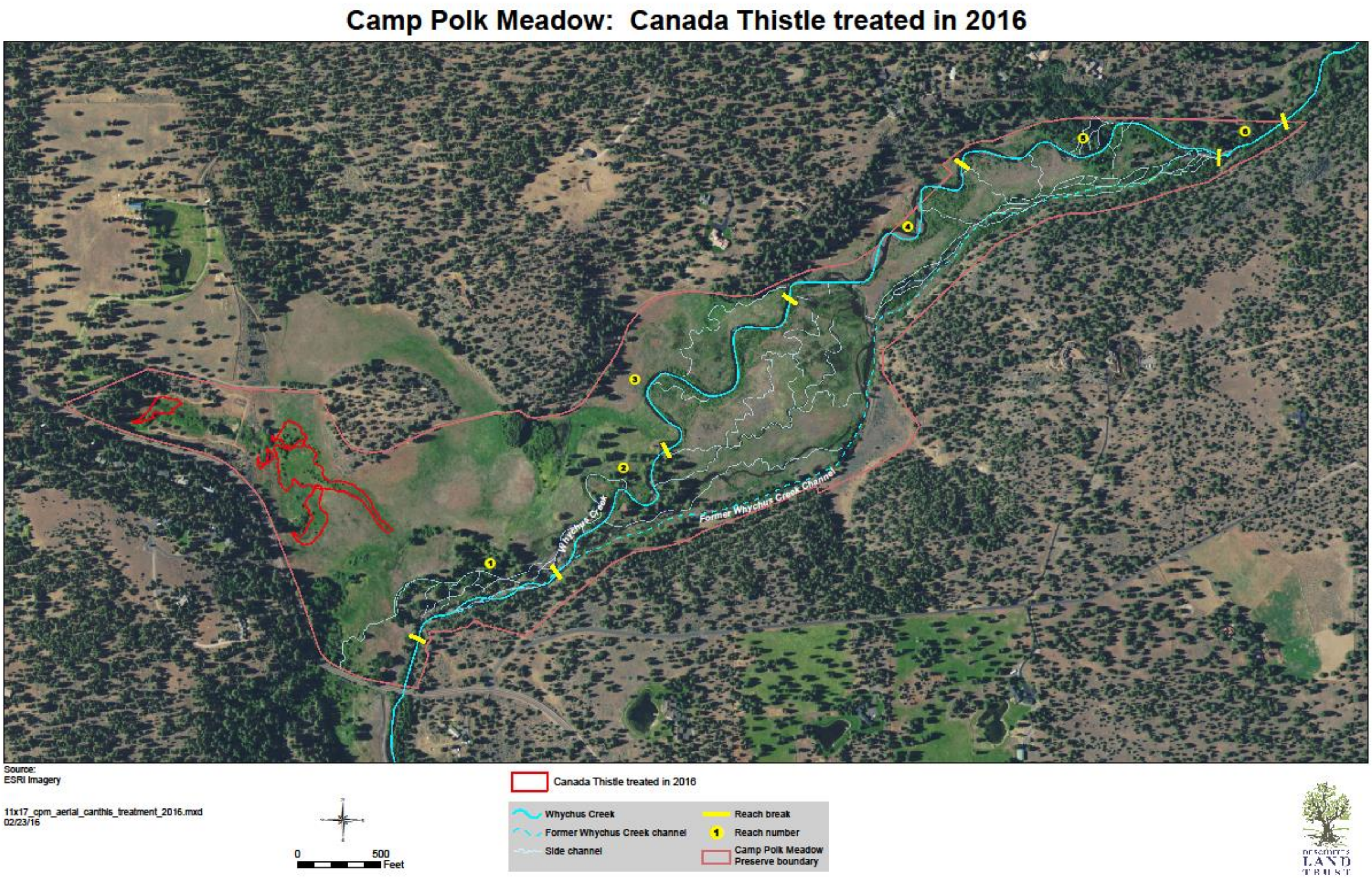


APPENDIX D. 2015 distribution of reed canarygrass at Camp Polk Meadow

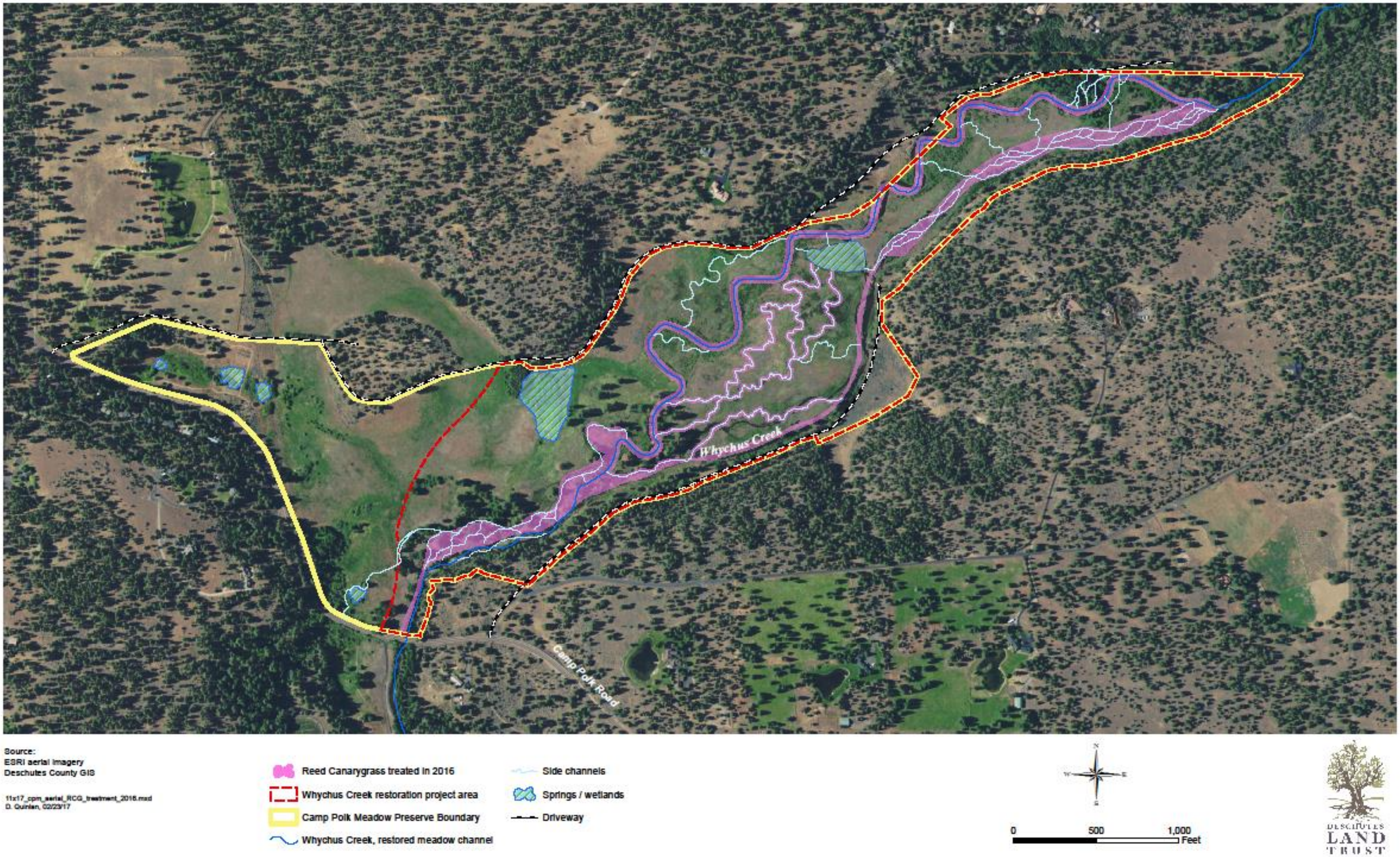
2015 Reed Canarygrass at Camp Polk Meadow Preserve



APPENDIX E. 2016 weed treatments at Camp Polk Meadow



Camp Polk Meadow: Reed Canarygrass Treatment 2016



APPENDIX F. Selected 2008/2009, 2014, and 2015 photopoint photos from Camp Polk Meadow


2008

2009

2010

2011

2012

2013

2014


2008


2016


2008


2016


2008


2016


2015


2016


2009

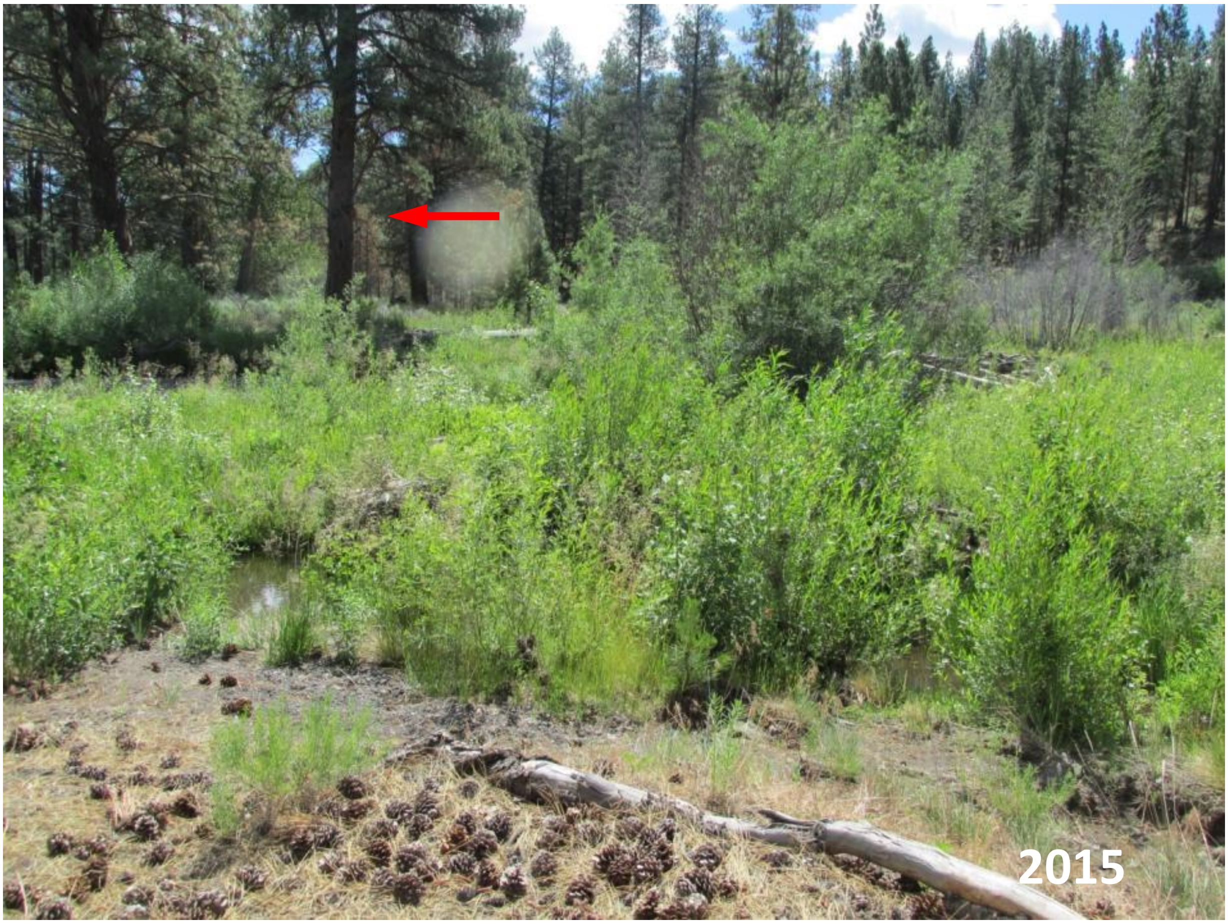

2016


2015


2016


2008

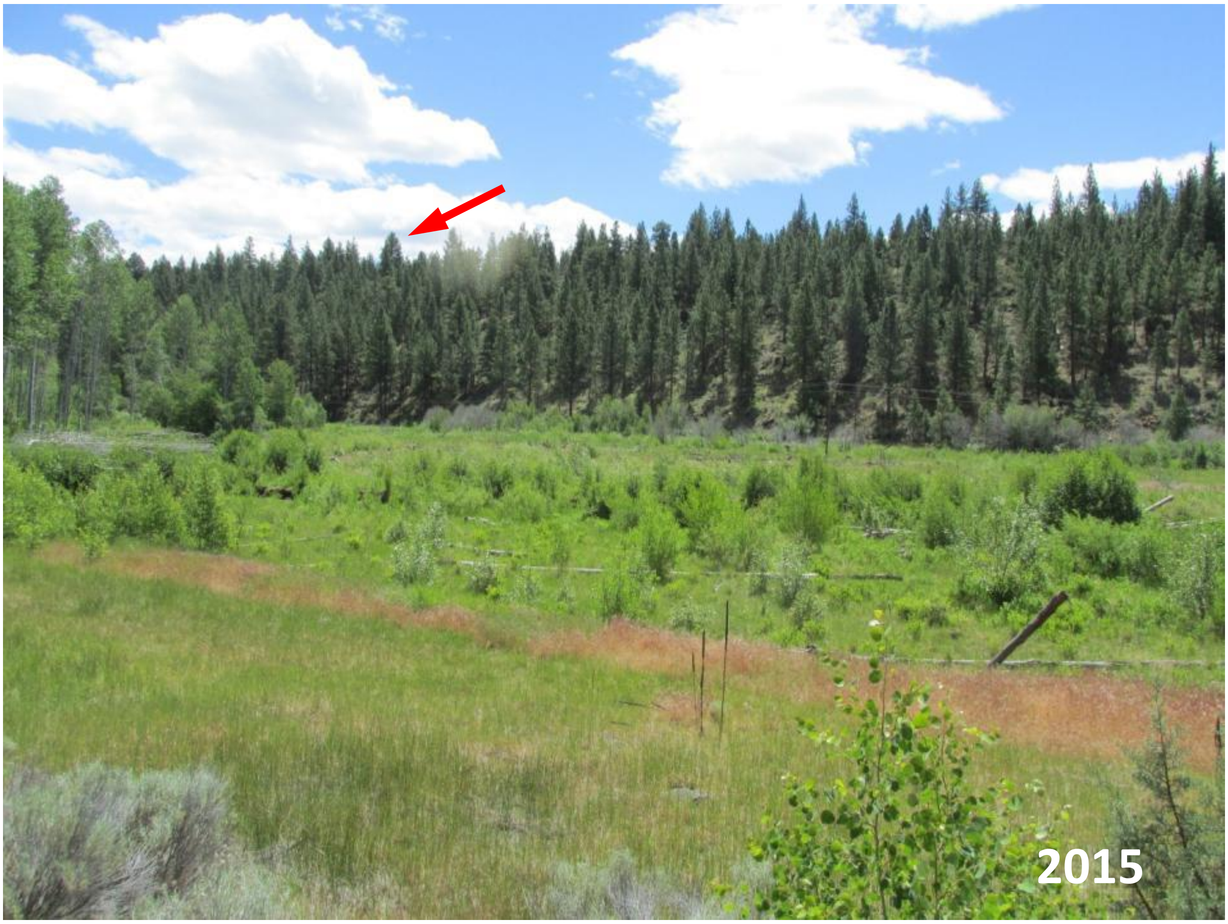

2016


2015


2016


2009


2016


2015


2016


2009


2016


2015


2016


2009


2016


2015


2016


2009


2016


2015


2016