Klickitat Watershed Enhancement Project (KWEP)

Yakima/Klickitat Fisheries Project (YKFP)

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I. Executive Summary

This report describes restoration and enhancement activities and on-going watershed monitoring in the Klickitat River subbasin implemented by the Klickitat Watershed Enhancement Project (KWEP). The activities described in this report are funded in part by the Bonneville Power Administration's (BPA) Yakima-Klickitat Fisheries Project (YKFP). Funds provided by BPA are matched with in-kind donations from the Yakama Nation in the form of materials and supplies, and cash donations awarded through the solicitation of competitive grants such as the Salmon Recovery Funding Board (SRFB) administered by the Washington State Recreation and Conservation Office. Project work emphasizes restoration and protection in watersheds and stream reaches that support restoration of native salmonid stocks, particularly steelhead/Rainbow Trout (*Oncorhynchus mykiss*), spring Chinook Salmon (*O. tshawytscha*), and Bull Trout (*Salvelinus confluentus*).

Major restoration activities this period focused on restoring floodplain connectivity, creating diverse active-channel hydraulic conditions (varying depths and velocities), enhancing the quality and quantity of salmonid rearing habitat, and restoring deformable stream banks and geomorphic processes to the valley bottom of the mainstem Klickitat River.

Restoration work during this reporting period included construction of Phase 6 of the Haul Road Project along the mainstem Klickitat River and the White Creek Large Woody Debris Project. The Haul Road project involved removal or reshaping 3.3 miles of floodplain road embankment in order to enhance riverine and floodplain function. Additionally, over a mile of rip-rap was removed to promote riparian forests for future wood recruitment and to encourage bank deformity while restoring river access to over 4 acres of floodplain. The White Creek wood replenishment project treated 40 individual sites over three stream miles to increase habitat diversity. Placement of 363 logs will improve structural capacity of the channel and assist in formation of structure-encouraging bed aggradation and substrate sorting.

Monitoring and assessment activities during this period focused on characterizing the hydrologic conditions in the mainstem Klickitat River and its tributaries. Activities included monitoring a network of stream gages, a subset of which have more focused objectives such as characterizing hydrologic conditions (Klickitat Delta Pilot Study and Big Muddy Creek). The purpose of these data collection efforts was to understand baseline or current conditions, develop insights related to land use planning, assist in developing new restoration projects that can improve watershed health and fisheries restoration effectiveness. Post-project monitoring occurs on select sites to document whether or not intended physical and biological responses occurred in order to allow for adaptive management and to refine future projects. Case studies of completed projects are shared at professional meetings to facilitate discussion and advance the knowledge and effectiveness of restoration science.

II. Introduction

The Klickitat Watershed Enhancement Project (KWEP) works to restore, enhance, and protect watershed function within the Klickitat River subbasin. Project work emphasizes restoration and protection in watersheds and reaches that support native salmonid stocks, particularly steelhead (*Oncorhynchus mykiss*; listed under the Endangered Species Act as "Threatened" within the Mid-Columbia Evolutionarily Significant Unit), spring Chinook Salmon (*O. tshawytscha*), and Bull Trout (*Salvelinus confluentus*; "Threatened"). Restoration activities focus on restoring stream processes by removing or mitigating disturbances to watershed function, improving habitat conditions, and improving and protecting water quality. Watershed and habitat improvements also benefit fall Chinook (*O. tshawytscha*), Coho salmon (*O. kisutch*), Rainbow Trout, Cutthroat Trout (*O. clarki*) and enhance habitat for many terrestrial and amphibian wildlife species. Protection activities complement restoration efforts within the subbasin by securing refugia and reducing habitat degradation. Since 90% of the off-reservation project area is in private ownership, cooperation and collaboration with state, federal, tribal, and private entities increases KWEP's overall effectiveness. KWEP's project selection and implementation strategy addresses goals and objectives presented in the 2004 *Klickitat Subbasin Plan* and the *Klickitat Lead Entity Salmon Recovery Strategy* (Fig. 1).

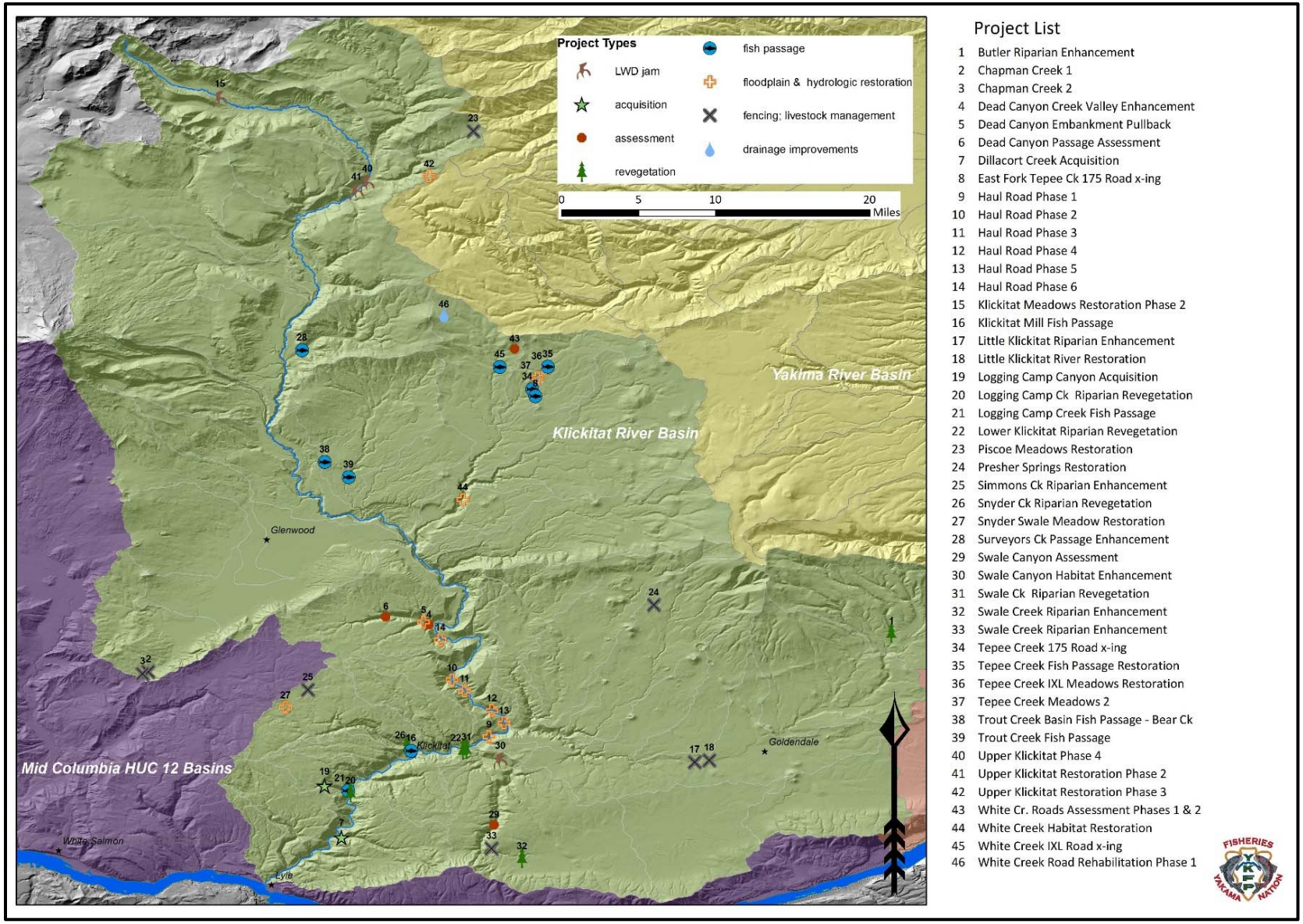
Project Goals

The overall goal of KWEP is to restore watershed processes to aid recovery of salmonid stocks in the Klickitat subbasin. KWEP employs three main approaches to achieve this goal:

• **Assess** watershed and habitat conditions to prioritize sites for restoration activities. *Assessing* conditions involves data collection, compilation, and review of existing and historic habitat and watershed conditions. Identifying and filling data gaps is an aspect of understanding restoration priorities.

• **Protect, restore, and enhance** priority watersheds and reaches to increase stream, wetland and riparian habitat quality. In-situ and watershed-scale restoration activities mitigate or alleviate conflicting historic, present, and/or future land uses. We prioritize *protecting* areas of existing high-quality habitat condition and preventing further habitat degradation. Finally, projects focus on *restoring* or *enhancing* areas of degraded stream channel and/or habitat condition to increase resiliency.

• **Monitor** watershed conditions to assess trends and effectiveness of restoration activities. *Monitoring* is a critical component for evaluating project success and guiding adaptive practices at both site-specific and basin-wide spatial scales. KWEP complements the Klickitat Monitoring & Evaluation Project (BPA project #1995-06-335) by assisting with data collection, providing Quality Assurance /Quality Control (QA/QC) and analyses of channel morphology, streamflow, temperature, habitat, and channel substrate data relevant to reaching desired conditions.



Project List

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Figure 1. KWEP projects completed to-date in the Klickitat River Subbasin

III. Work Elements/ Deliverables

Tributary Habitat Restoration and Protection

Klickitat River Floodplain Conservation and Restoration (Haul Road) Project – Phase 6

Background: The Haul Road project addresses a limiting feature (channel confinement) identified for the Klickitat River between river miles 18.3 and 32.2 (Fig. 3) by the Klickitat Subbasin Plan and Klickitat Lead Entity Salmon Recovery Strategy (KLESRS, 2013). This portion of the river has the greatest habitat complexity of any reach in the lower Klickitat River and provides critical spawning, migration, and rearing habitat for threatened winter and summer steelhead, Chinook Salmon (spring and fall runs), and Coho Salmon. This reach provides a high proportion of the basinwide spawning habitat for all three species, accounting for on average 19% (2-40%), 42% (24-65%), and 15% (0-37%) of the annually observed basinwide spawning for steelhead, fall chinook, and coho, respectively (2002-2014). A combination of channel encroachment, floodplain isolation by road fill and 1996 flood deposits have degraded riparian and floodplain conditions within the project area. The absence of other floodplain development coupled with less-confined valley conditions affords this reach greater resiliency to high-flow events than downstream reaches. The project is occurring in two stages: 1) acquisition (Phase 1 funding) and 2) restoration (all subsequent phases of funding). Columbia Land Trust (CLT) is the primary sponsor for the SRFB grant that funded the acquisition and subsequent restoration. KWEP is the technical lead for design and construction oversight of restoration activities, and assists with planning activities, which include Road Maintenance and Abandonment Plan (RMAP) revisions.

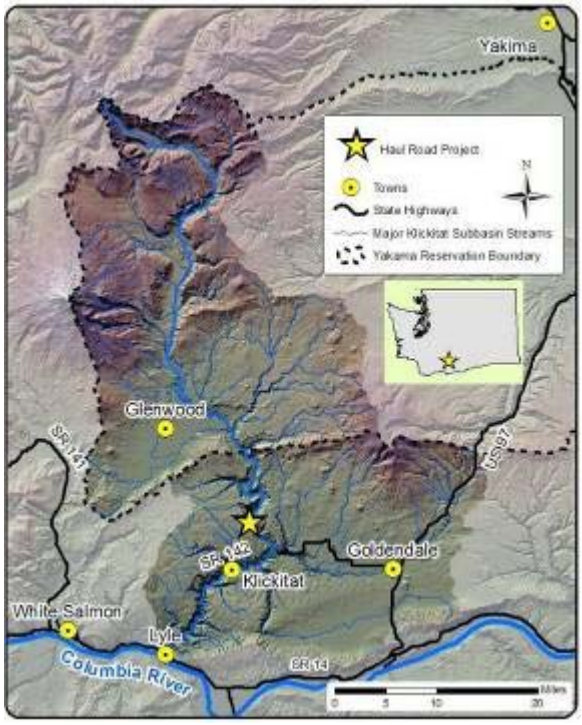


Figure 2. Klickitat River Restoration site location (star) within Klickitat watershed.

Project Goal: The overall project goals are to prevent habitat fragmentation and restore floodplain connectivity and geomorphic processes to the valley bottom that support listed anadromous fish species. CLT completed acquisition in 2007 of the road and 480 acres of private riparian and upland in-holdings which are within the Washington Department of Fish and Wildlife, Klickitat Wildlife Management Area (Conley 2008). Phase 1, completed in 2009, removed a cross-valley railroad embankment in Dead Canyon (tributary at upstream end of project reach). Phase 2 of the project addressed limiting features for a portion of this reach by restoring floodplain connectivity by pulling

back and re-vegetating fill materials in other portions to enhance riparian vegetation. Activities completed during Phase 2 included enhancement and restoration of riparian and floodplain habitat by modifying 2.1 miles (cumulative) of road to reduce channel confinement and restore floodplain access. The nature of valley type along the road removal locations resulted in 0.94 miles of restored floodplain access. Once road removal, grading, and habitat enhancement features were completed, approximately 7.5 acres of riparian and floodplain habitats were revegetated. Phases 3 and 4 cumulatively removed 3.25 miles of asphalt, restored access to 9.75 acres of floodplain, removed 14 culverts (including one on a seasonal fish-bearing tributary), placed 45+ pieces of wood to improve floodplain roughness and habitat heterogeneity, and restored the river's access to adjacent hillslopes. Phase 5 removed 1.7 miles of asphalt, restored 2.3 acres of floodplain, created 2.5 acres of additional instream habitat and two pools.

2017 activity: Project planning, administration, and construction activities to implement Phase 6 of the Haul Road Project occurred during the reporting period.

Planning - KWEP and CLT staff conducted several field visits to refine treatments and geographic scope of Phase 6 (Fig. 2). KWEP and CLT staff determined stationing for road segments delineated during the geomorphic assessment (Conley and Lindley 2012) and performed layout prior to soliciting bids for Phase 6. Phase 6 of the Haul Road received funding during the 2015 SRFB grant round. The SRFB funding received was significantly less than the total project costs to complete the nearly 3-mile-long project scope. A cost-share agreement between the Yakama Nation and Columbia Land Trust (CLT) facilitated financial BPA contributions to Phase 6 construction activities. BPA funding focused on road segments where removal of the road embankment reconnected floodplain. SRFB funding focused on road segments immediately adjacent to the mainstem Klickitat River where treatment types were full and partial fill removal (Fig. 4).

Administration – During the construction process, KWEP project staff supported CLT with permitting, Road Management and Abandonment Plan (RMAP) revisions, and contract administration. BCI Contracting Inc. (Portland, OR) was the prime contractor for Phase 6 in 2017. The former KWEP hydrologist provided field oversight of construction activities and directed fit-in-the-field implementation as an employee of CLT.

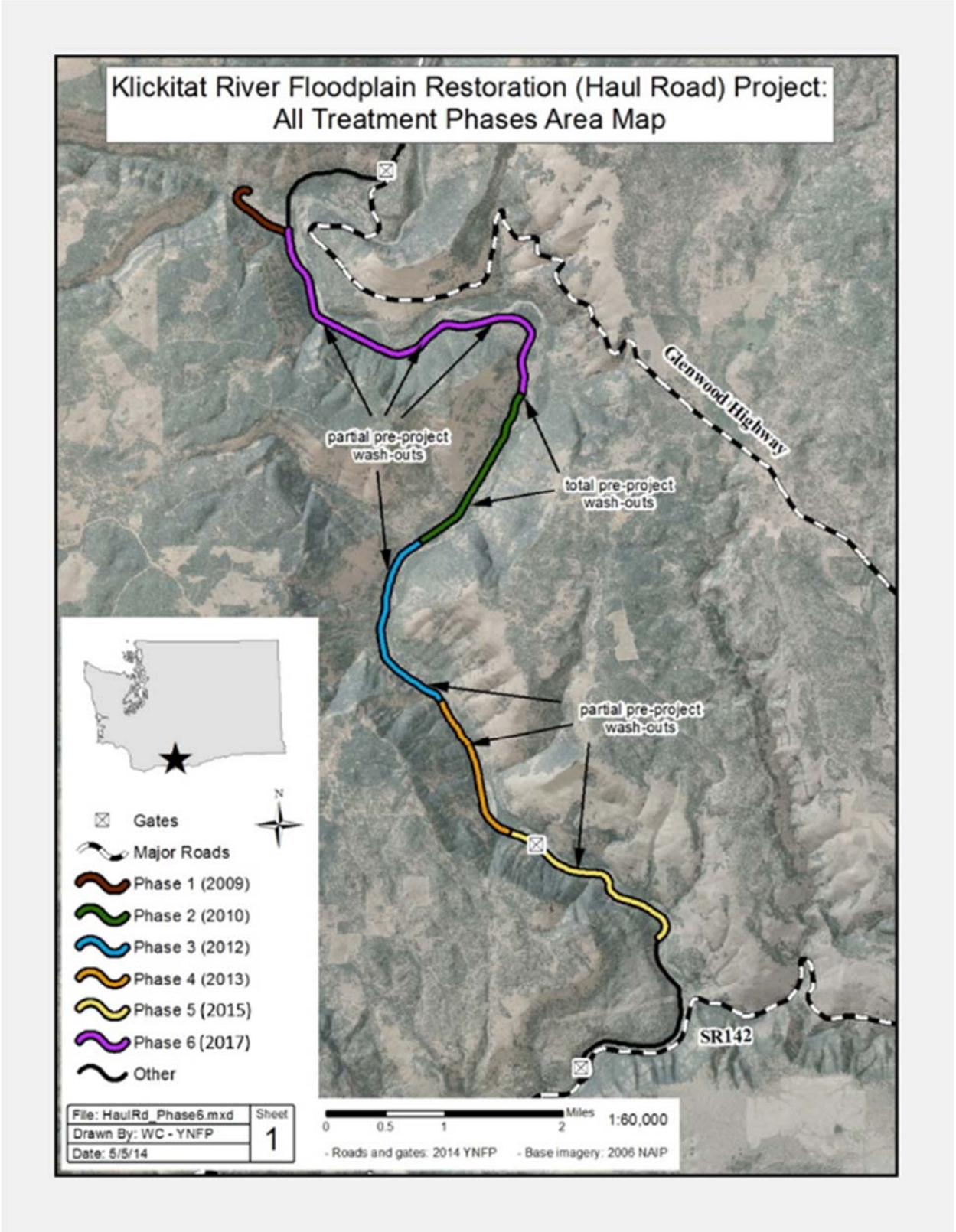


Figure 2. Klickitat River Floodplain Conservation and Restoration (Haul Road) – All-Phase Map, Phase 6 in reach in purple.

Construction – Construction activities took place June-September 2017. No major shutdowns occurred during the period. CLT was able to obtain an exemption from the Washington Department of Natural Resources in order to continue work during periods of high fire danger.

Construction activities completed in 2017 (Figures 3 and 4):

- Removal of approx. 2,400 linear feet of floodplain embankment to restore lost overbank flow connectivity and habitat access to floodplain and side channels
- Reconnection of 4 acres of contiguous floodplain
- Partial embankment removal to restore river access to pool-forming features (bedrock outcroppings)
- Removal of rip-rap and pullback of 5,641 linear feet of embankment encroaching on the active channel to:
    - Increase bank deformability
    - Restore conditions suitable for establishment of bank cover and long-term woody-debris recruitment
    - Restore recruitment pathway for colluvial materials
- Removal of 12 culverts and restoration of natural drainage, 11 cross drains, 1 non-fish bearing tributary

Figure 3. Example of bedrock outcropping pre-project (left) and bedrock reconnected to a side-channel of the Klickitat River (right).

Figure 4. Floodplain roughness elements installed in former roadway corridor to reduce avulsion risk.

Revegetation: In November of 2017, Washington Department of Ecology Conservation Crews (WCC) replanted the project site with native vegetation (Fig. 5 and 6). Three crews planted approximately 5600 plants in five work weeks. Potted native shrub and tree stock grown at the Klickitat Field Office or purchased from Humble Roots Nursery accounted for the majority of plant materials installed this fall. Bareroot conifer seedlings were purchased from Lava Nursery in Parkdale, OR and livestake cuttings of easily rooted black cottonwood were purchased from the Washington Association of Conservation Districts' Plant Materials Center in Bow, WA. Planting units are based on groupings of similar types of road removal treatments and site conditions (A-H, see Table 1). Planting prescriptions match site conditions (floodplain, upland, LWD jam installation, etc) to maximize plant regrowth on disturbed soils to reduce erosion, provide riparian shade, and provide leaf material for consumption by invertebrates.

Table 1: Planting Prescriptions: Quantities and species of plants installed in fall 2017 by Planting Unit

Species	Unit A	B	C	D	E	F	G	H	Subtotal
Oregon Grape	82	13	11	83	4	9	19	54	275
Cottonwood, Black	38	134	0	166	0	0	0	162	500
Dogwood, Red osier	0	53	34	0	0	9	0	0	96
Douglas Fir	16	0	57	249	85	90	98	0	595
Hawthorn, Black	0	13	22	33	9	18	39	27	161
Mock Orange	32	13	11	49	9	4	19	6	143
Oak, Oregon White	16	26	11	33	37	9	19	6	157
Ponderosa Pine	65	93	171	199	80	144	354	135	1241
Rose, Woods	73	120	102	66	35	31	19	6	452
Willow, Coyote	0	0	68	0	0	18	0	13	99
Willow, Scouler's	49	241	79	298	0	144	157	270	1238
Serviceberry	24	26	22	33	4	45	98	81	333
Golden Currant	82	26	22	33	9	18	39	27	256
Choke cherry	13	27	13	13	13	13	13	13	118
Subtotal	493	785	623	1255	272	539	874	800	**5641**

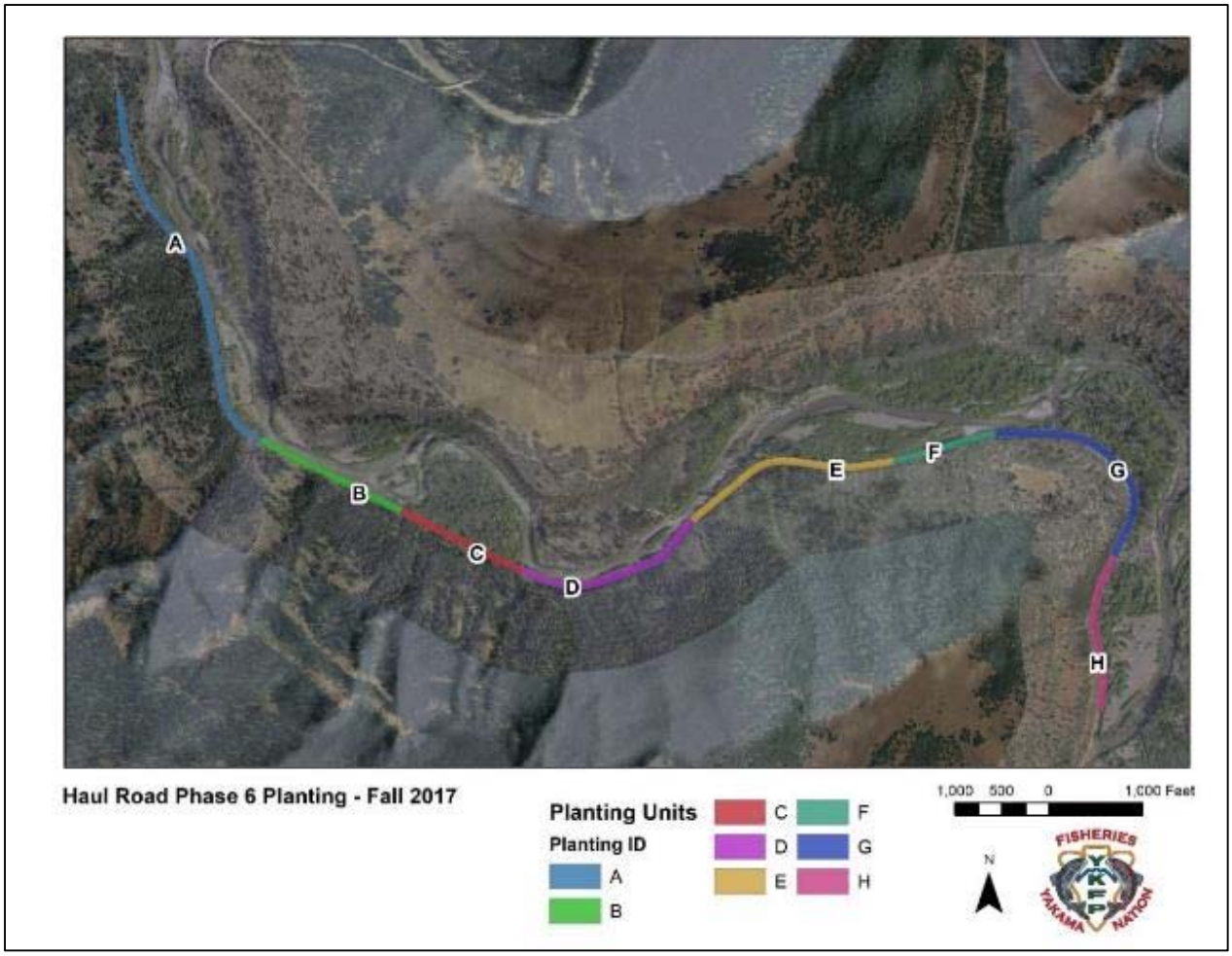


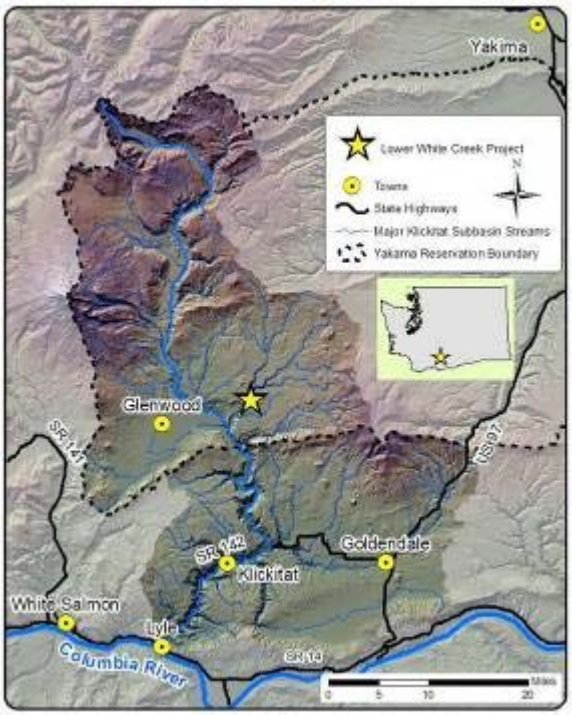
Figure 5. Haul Road Phase 6 Revegetation Planting Units.

Figure 6. Washington Conservation Corps crew at Haul Road Phase 6.

White Creek Large Woody Debris Project

Introduction: The White Creek watershed as a whole is likely the most important spawning and rearing tributary watershed within the Klickitat subbasin. In recent years (2009-2016), the White Creek watershed on average has accounted for 47% (20-72%) of the observed steelhead spawning in the entire Klickitat subbasin.

Site and Watershed Description: The White Creek watershed is 138 square miles in area. Elevations range from 1140 to 5100 ft.; most of the watershed lies between 2500 and 3300 ft. in elevation. Average annual precipitation is between 20 and 29 inches, with roughly half falling as snow. Current stream habitat conditions in White Creek reflect past riparian timber harvest and road construction throughout the watershed; instream wood levels are low in some reaches and base flows are very low to non-existent in many reaches. Changes in channel morphology relate to livestock grazing, road interactions, and in some locations, historic removal of LWD. The watershed lies within the Yakama Reservation Closed Area where commercial timber harvest has occurred since the 1950s. Current and future land uses include timber harvest and livestock grazing.



Currently, most of the incised reaches in the White Creek watershed (upstream of the project reach) go dry between July and October. Anecdotal accounts from the 1960s suggest that at least some of these reaches were historically perennial. Many of the same reaches show signs of bed armoring and have a simplified morphology with low pool frequencies, rectangular, canal-like cross sections, and an absence of large woody debris (LWD). Impacts from grazing (in the form of altered riparian vegetation, bank erosion, and channel incision) are also evident in several meadow reaches within the watershed. Anecdotal evidence, along with watershed size, elevation, and precipitation, suggest that more reaches historically had perennial flow.

The project reach encompasses the upper 3 miles of the perennial portion of lower White Creek and the lower 2 miles of Brush Creek. The seasonal dewatering of upstream reaches makes this area particularly important as refugia for juvenile rearing during the late summer and early fall months. However, poor habitat conditions limit capacity in this area.

One critical factor associated with the project is access difficulty. There is road access at RM 3.2 and 9.6. In between these access points, White Creek flows through a canyon bordered by steep slopes with walls up to 700' high.

Fisheries Significance: During winter and spring, adult mid-Columbia River steelhead are regularly observed throughout the project reach. Juvenile *O. mykiss* are observed in the area year-round. Juvenile and adult steelhead and resident rainbow trout will be the primary beneficiaries of this project,

through improved spawning and rearing habitat. There are no artificial or natural barriers to steelhead downstream of the project reach, though shallow water depth limits adult passage during drought years (e.g. WY 2005, 2015).

Problem: Much of the White Creek mainstem has a simplified, plane-bed channel form, and physical habitat conditions are correspondingly poor as evidenced by low pool and LWD frequency and low pool quality.

A 6-mile-long reach (RM 9.6 to RM 3.2) that includes the project reach was initially assessed for summer refugia habitat in early September 2004 (Conley 2005). Additional habitat surveys and annual PIT-tagging efforts have been conducted since 2009. This reach was selected because it has clearly experienced simplification, and it straddles the transitional zone of perennial water presence. Fish stranding in the summer is common upstream of the Brush Creek confluence (RM 5.0). Given the coarse nature of valley-bottom sediments throughout the reach (i.e. low potential for long-term floodplain storage) and generally close proximity of bedrock, it seems most likely that baseflow hydrology is currently governed by groundwater inputs from aquifers associated with the Columbia River basalts that underlie the watershed. In the assessed reach, pools only account for 14% (by length) of the channel. Pool quality is poor to marginal with residual depths averaging 1.7' (n = 55) and 2/3 of pools having less than the average depth. Bed armoring is particularly evident through the project reach where bed materials typically consist of cobbles and boulders. Active-channel LWD frequency is low and averages 6.3 large logs (>50 cm diameter) and jams (cumulative) per mile.

The condition of the project reach is a function of both local and watershed-scale factors including:

Historic riparian harvest - The presence of riparian stumps and yarding corridors throughout the reach suggest historic riparian clearcutting as a probable cause of low cover and in-channel LWD frequency (Conley 2005).

Increased peak flows associated with forest road drainage and density - Increased peak flows associated with road development in the headwaters have likely had negative consequences for stream channel morphology and habitat. Hydrologic modeling (U.S. Army Corps of Engineers, Hydrologic Engineering Center-Hydrologic Modeling System, HEC-HMS) of upstream subwatersheds suggests road density has increased peak flows for a 2.5-year recurrence storm from 5.5 to 31.8% and 0.6 to 16.0% for a 100-year recurrence storm (northwest hydraulic consultants, nhc 2003). The proposed project area is located roughly 10 miles downstream of the modeled subwatersheds, and the intermediate topography is of considerably lower relief than the modeled subwatersheds, thus, peaks are attenuated somewhat before reaching the project reach. Treatments to reduce water and sediment delivery from the forest road network to streams in the White Creek headwaters were initiated on ten road segments in 2005, followed by three fish passage and longitudinal connectivity projects (2007-2008), and two meadows restoration projects on approximately 1 mile of Tepee Creek (2007-2013).

Historic debris torrent(s) - Scour marks on trees and deposits in the upper mile of the reach suggest one or more debris torrents have occurred in recent history (Conley 2005). Torrents may have been associated with one or more historic road crossing failures as evidenced by chunks of concrete within the channel 3/4 mile downstream of the current 207 Road crossing. The 207 Road crossing appears to

have been relocated (downstream) from its former alignment and is of appropriate size. Future failure risk of 207 crossing is considered very low.

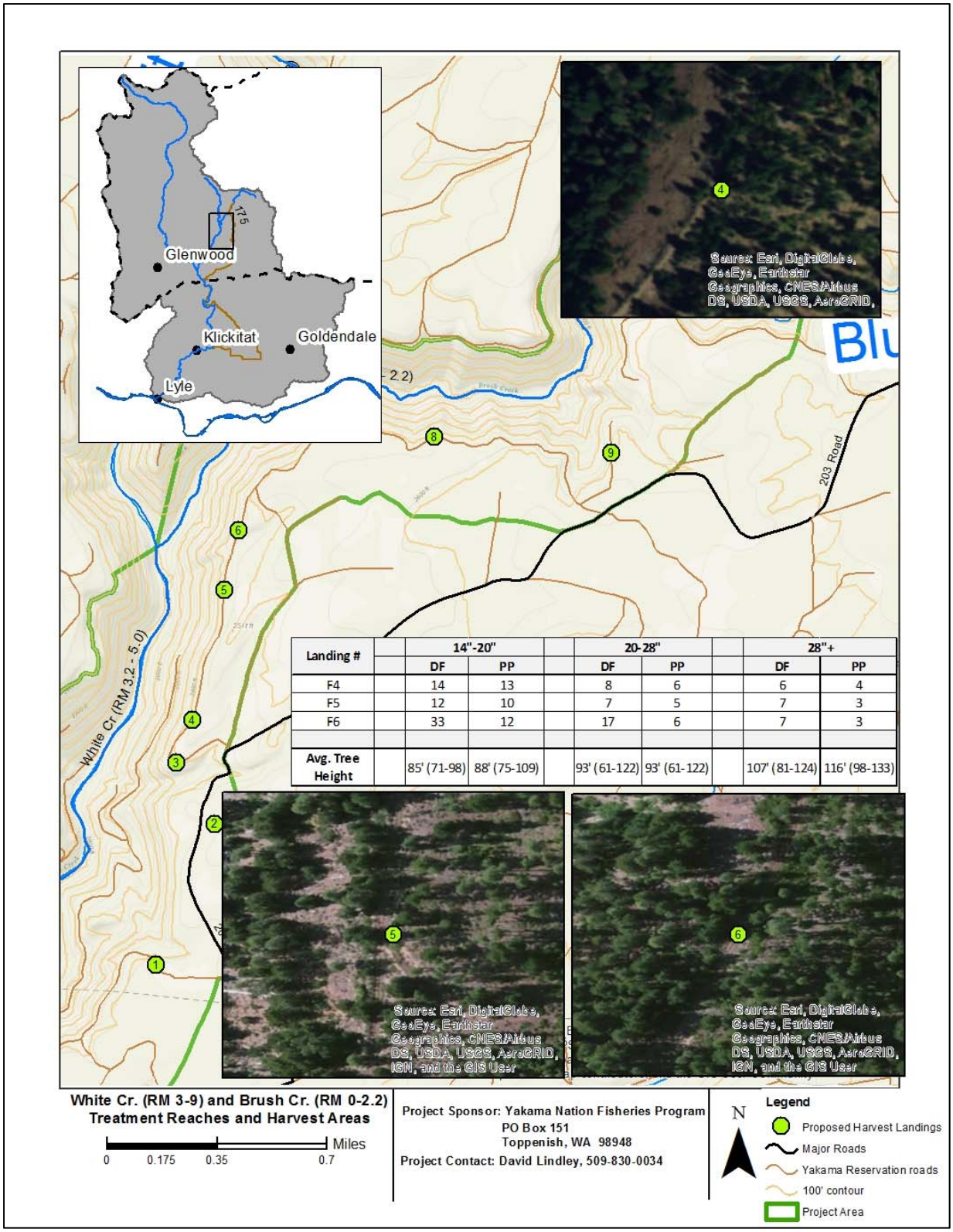
Incision of upstream reaches - Site indicators and aerial photo interpretation suggest that many upstream reaches are now incised. Hydraulic modeling has indicated that some reaches currently contain a 10-year-recurrence flood within the banks (Interfluve 2004). This loss of floodplain connectivity prevents energy dissipation and conveys more water and eroded sediment to downstream reaches. Restoration of floodplain connectivity and habitat improvement within incised reaches has been a priority for the past decade.

Project Goal: The overall project goal is to improve habitat conditions by increasing LWD frequency and pool quality along 2 miles of White Creek and 2 miles of Brush Creek. Treatments will specifically target improving juvenile rearing conditions; increased sediment sorting and deposition is anticipated to improve spawning conditions. LWD treatments will increase active channel roughness and should increase overbank flow frequency.

2017 activity: Project planning and development involved selection and location of LWD harvest units, permitting, treatment-site identification and sketches, and baseline stream-habitat inventory were conducted during the reporting period.

LWD Harvest - Due to the remoteness of the project, sites and limited access points to the canyon portion of White Creek it was determined that using a helicopter for the placement of LWD would be the best approach. Given the need for rootwads, ground-based harvesting techniques were necessary. This limited harvest operations to gentler slopes. To facilitate efficient helicopter placement, trees had to be staged within close proximity (approx. 2500') to installation/treatment sites. To minimize cost, handling needs to be minimal; hence, harvest units are within skidding distance of staging areas (Fig. 7).

Based upon review of aerial photos and topography, several suitable stands in vicinity of the eastern canyon rim appeared to be suitable given their location and the apparent size distribution of trees. Staff evaluated road access and qualitatively assessed stand conditions through site visits. Followed by a simple timber survey of the most promising stand in T7N R 14E S30, BIA staff from the Glenwood Ranger Station marked 500 trees at nine landing locations along the canyon rim of White and Brush Creeks in the fall of 2016. In summer 2017 Tiin-Ma Logging Inc. of White Swan, WA was selected via a competitive bidding process to conduct harvesting and staging activities. For logistical reasons one of the harvest units was not entered, thus Tiin-Ma harvested 477 trees, 75% of which had intact rootwads. Tiin-Ma also graded and prepped a critical access road. To facilitate quick and efficient rigging of the logs during helicopter operations, logs were arranged at the landings in individual rows with one end of the log propped off the ground. Logs with rootwads were braced off the ground by their roots, while logs without rootwads were placed on a "bunk" log to prop one end off the ground (Fig. 8).



Landing #	14"-20"		20-28"		28"+	
	DF	PP	DF	PP	DF	PP
F4	14	13	8	6	6	4
F5	12	10	7	5	7	3
F6	33	12	17	6	7	3
Avg. Tree Height	85' (71-98)	88' (75-109)	93' (61-122)	93' (61-122)	107' (81-124)	116' (98-133)

Figure 7. Harvest specifications and landing locations for three landings near the confluence of Brush and White Creeks.

Figure 8. Aerial view of landing layout and access road, logs staged individually.

- *LWD Placement* – One heavy-lift helicopter firm responded to the request for proposals that was advertised in June 2017: Columbia Helicopters Inc. of Aurora, OR. The size, weight and greenness of the stockpiled wood required an aircraft with a maximum lift capability of 26,000 pounds. Columbia Helicopters is the only US-based company that operates a fleet of Boeing Chinook helicopters that can meet this lift specification. Staff from Columbia made several site visits with the YKFP project manager to inspect the landings and stockpiled wood and to assist in scoping out a suitable service landing for refueling and storage. A suitable service landing was located on private property along the Glenwood Highway, approximately 5 air miles from the treatment sites.

Over the course of three days (October 27-29, 2017), Columbia placed 363 logs via 169 individual lifts. Over the three days, the heavy-lift work totaled 14 hours of flight time for placement and 2 hours of mobilization to the project site from Aurora, OR. The 169 lifts had an average weight of 16,000 lbs. The weight capacity of the helicopter was reached multiple times and logs had to be bucked at the landing in order to reduce the weight. Maximum lift weights were near 23,000 lbs to facilitate aircraft maneuverability under load in a forested canyon. Columbia provided project management staff, multiple riggers at the landing sites, and rigging stream crews.

Placement of the individual logs and construction of complex wood structures occurred at 40 sites. There were two ground-based teams working streamside in the canyon reach. One team consisted of two Columbia riggers and a YKFP habitat biologist, and the second team had two Columbia Riggers and a geomorphologist from InterFluve Inc. The biologist and geomorphologist provided directives on the

specific location and orientation of logs placed. One team would work with the helicopter crew to complete 1-2 sites, and then the helicopter would move to the second team to treat 1-2 sites. This leap-frogging method allowed for an efficient use of the helicopter that avoided any down time. The number of logs at a particular site ranged from 5-40 logs (Figures 9 and 10). Site locations are shown in 11 and 12.

Figure 9. Pre- and post-project photos of the Brush Creek and White Creek confluence pool.

Figure 10. Typical examples of cluster log placements.

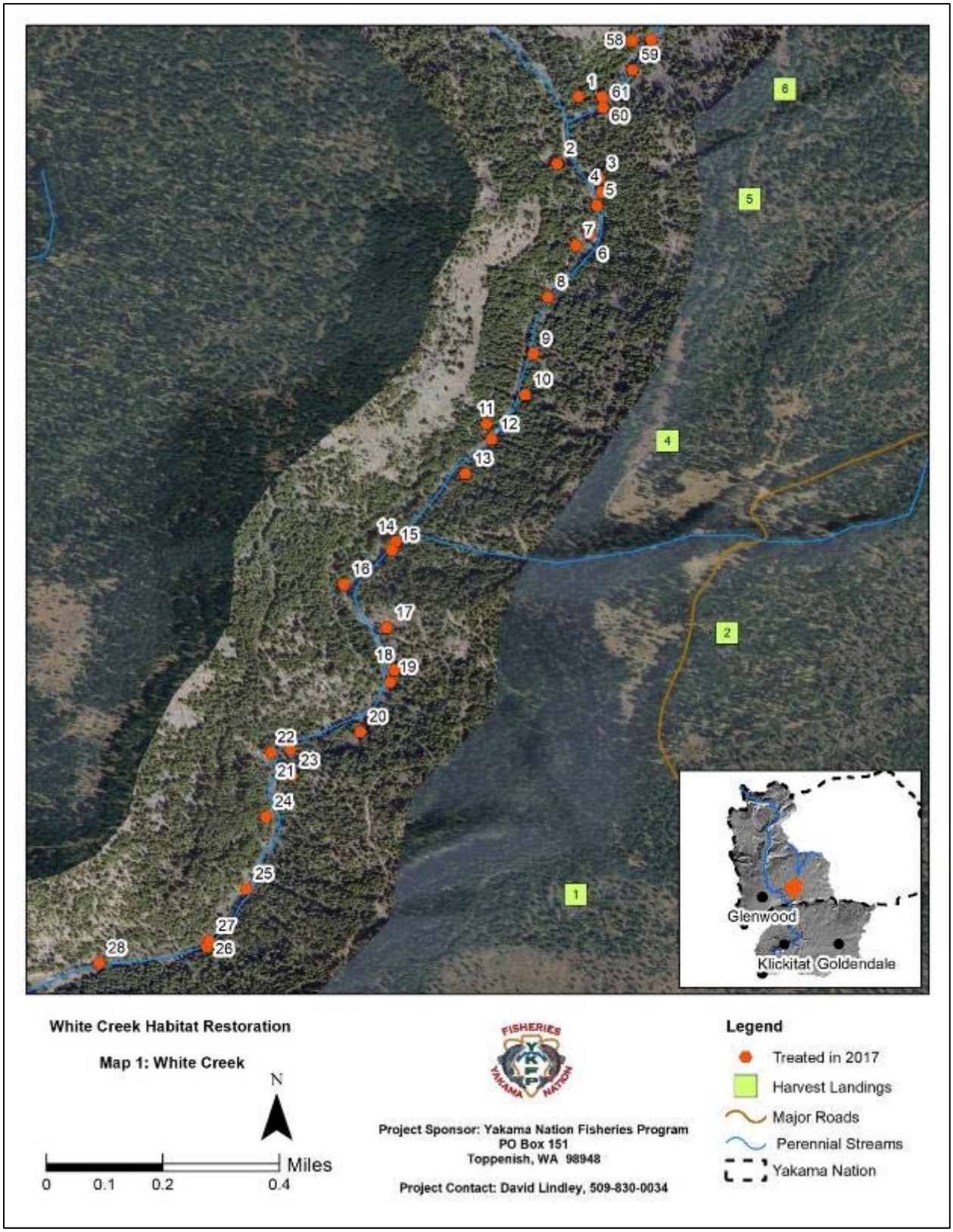


Figure 11. Large Wood treatment sites along mainstem White Creek, Klickitat River basin.

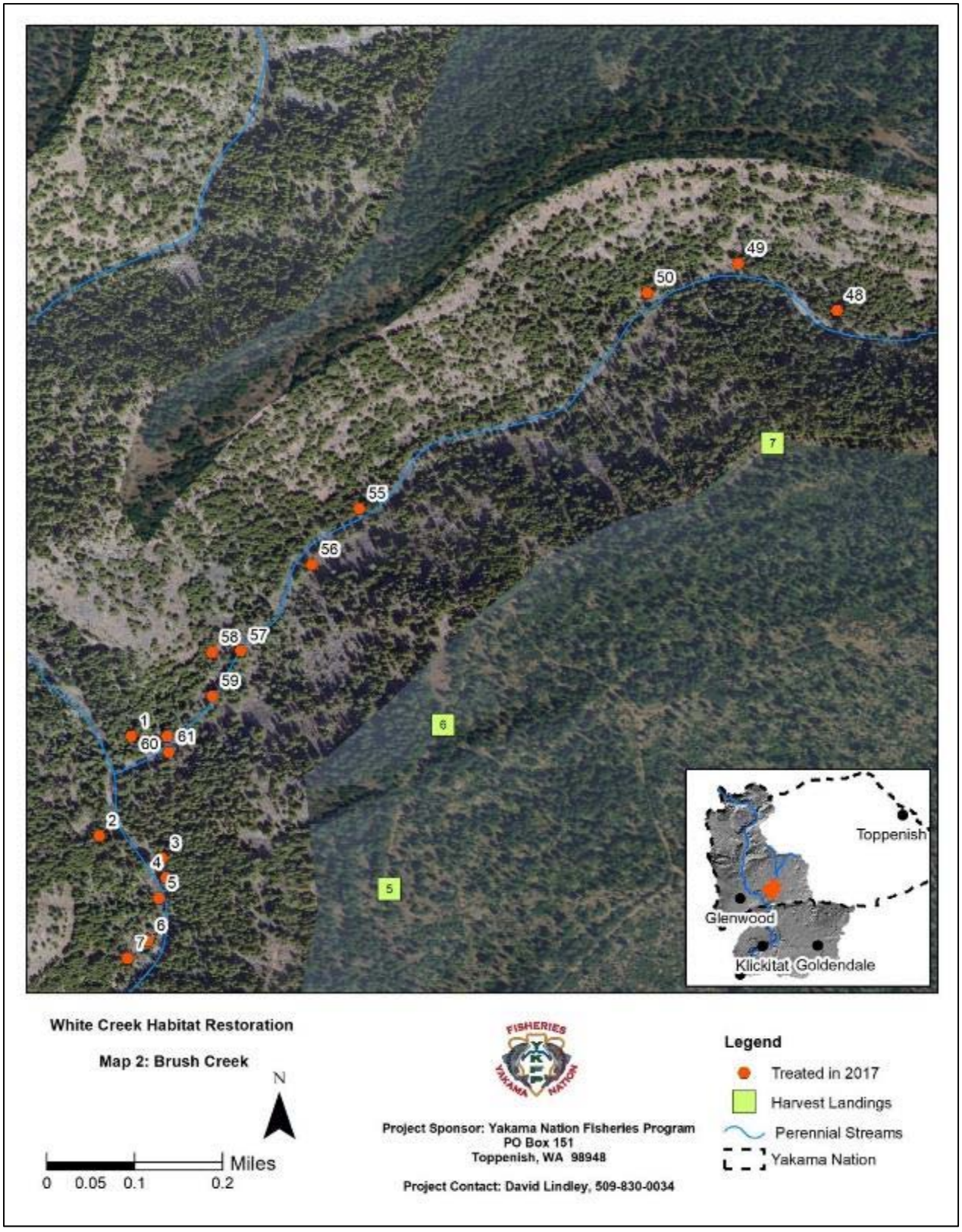


Figure 12. Large Wood treatment sites along Brush Creek, Klickitat River basin.

Tepee Creek Phase 3 Project Design

Introduction: The Tepee Creek Meadows Restoration Phase 3 Project is the continuation of an ongoing effort to improve aquatic habitat conditions for ESA listed *O. mykiss* on a local and watershed scale by focusing on restoring incised, degraded, and disconnected sections of headwater meadow streams throughout the Tepee Creek watershed, a tributary of White Creek.

Site and Watershed Description: The forested portion of the Tepee Creek watershed has generated commercial timber harvest since the 1950's. Timber harvest, road construction, road maintenance, and cattle grazing will continue into the foreseeable future. An estimated 2 to 4 feet of channel incision has occurred and tall-unvegetated streambanks are evidence of the extent of down-cutting that has occurred. Lateral erosion occurs as the tall steep banks collapse and slough fine sediments into the stream channel. Due to the height of the incised channel, the channel has a larger than natural capacity that captures floods within the banks and limits overbank flow and associated energy dissipation onto the adjacent floodplain. This results in a higher-energy stream environment where bed and bank erosion rates will continue to degrade and habitat conditions will decline. The elevation of the channel bed is several feet below the floodplain. This elevation difference results in the channel exacerbating draining of the meadow, which in turn decreases groundwater elevations and the duration of groundwater inputs into the stream.

Fisheries Significance: Tepee Creek is a tributary to White Creek in the Klickitat River subbasin, and provides critical spawning and rearing habitat for ESA-listed Middle Columbia River steelhead. Recent studies have indicated that Tepee Creek accounts for on average 13 percent of the observed spawning in the Klickitat subbasin, although percentages as high as 31 percent have been noted (Yakama Nation Fisheries Program 2002-2015 spawner survey data). More extensive spawning occurs lower in the White Creek drainage, which has been identified as one the most important tributaries in the Klickitat River sub-basin for steelhead production, recently accounting for up to 40 percent of the observed steelhead spawning.

Perennial flow is limited in Tepee Creek. Meadow enhancement projects are intended to increase water-holding capacity of upland meadows and extend the duration of perennial flows. The current low-/no-flow period in late summer/early fall presents a population bottleneck for juvenile *O. mykiss* due to stranding and desiccation. The Yakama Nation Fisheries Program has been researching *O. mykiss* life history strategies in the White Creek watershed for the past seven years. Annual electrofishing surveys have been conducted at spatially dispersed sites (25) throughout Tepee and White Creeks. Fish are caught, identified, measured, and PIT-tagged. Analysis of PIT-tag data suggests that juveniles rear in Tepee Creek for 1-3 years, and significant seasonal movements are necessary to access perennial habitat. Fish that exit White Creek as one-year-olds typically spend an additional year rearing in the mainstem Klickitat River. The percentage of tagged fish that are subsequently detected exiting White Creek at a fixed PIT-tag array near the confluence of White Creek and the Klickitat River are consistent across both treatment and control sites within White Creek suggesting that the restored areas do not create "sinks" that redistribute fish and provide habitat that encourages a resident life history strategy. Consistently the Tepee Creek IXL project reach (restored in 2007) has a greater abundance of fish

compared to other Tepee Creek sites, which suggests that spawning within the project reach of a similar downstream project and in crushed gravel is successful.

Problem:

Currently, most of the incised reaches in the White Creek watershed (including the project reach) dry up from July through October. Anecdotal accounts from the 1960s suggest that at least some of these reaches were historically perennial. Many of the same reaches showing signs of bed armoring are also characterized by a simplified morphology with low pool frequencies, rectangular, canal-like cross sections, and an absence of large woody debris (LWD). Impacts from grazing (in the form of altered riparian vegetation, bank erosion, and channel incision) are evident in several meadow reaches within the watershed. Anecdotal evidence, along with watershed size, elevation, and precipitation, suggest that more reaches historically had perennial flow.

Project Goal: Increase floodplain groundwater storage to benefit *O. mykiss* rearing habitat that is prevalent in Tepee Creek downstream of the project site.

Project Objectives:

- Upon completion of the project, restore overbank flow within the project reach to a 2-year or less recurrence interval.
- Reduce bank erosion, down-trailing, and siltation due to unrestricted cattle grazing by constructing a buck-and rail-fence that will exclude cattle from the meadow during the grazing season (May-October).
  Increase floodplain groundwater storage throughout the meadow reach in order to extend/augment late season flows in Tepee Creek. A network of monitoring wells collecting shallow-groundwater-elevation data will document groundwater elevations.
- Provide an armored section of channel to transition the raised channel bed to the lower, untreated channel-bed condition at the downstream reach terminus.

Project Narrative: In order to improve conditions at the Tepee Creek project site, the channel bed will be raised to the elevation that existed prior to perturbations stemming from road construction, forest practices and cattle grazing and subsequent erosion and incision. This approach is anticipated to provide direct benefits to the meadow by increasing the elevation of the water table, improving seasonal storage, and potentially extending the duration of surface flow in Tepee Creek. Additionally, the channel will be configured to increase the frequency of over-bank flooding, which will improve wetland habitats, distribute flows across a greater wetted width, and decrease flow velocities. These actions are anticipated to help prevent further down-cutting of the channel and mitigate erosive process conditions, which will ultimately provide downstream benefits to Lower Tepee Creek and White Creek.

2017 activity: Project planning, development, and design progressed during the reporting period. KWEP staff worked with a design team from InterFluve Inc. to generate a project design inclusive of fill types, quantities and a cost estimate (Fig. 13).

The Tepee Creek longitudinal profile suggests that scouring has resulted in significant channel degradation, causing the channel to incise up to 3-4 feet in some locations within a historic channel alignment. The proposed design incorporates raising the bed using common borrow material sourced on site or imported from nearby borrow sources. The common borrow will contain largely fines that will act to limit the degree of subsurface flow. The common borrow will be capped by a rock mix to prevent erosion of the underlying fines. The downstream-most section of fill is the steepest (1.91%), transitioning to the downstream end of the project. This steep zone can withstand higher channel shear than the other sections. An 18" thick layer of graded (Type 2) crushed rock will be placed over the soil fill and along streambanks for 550 feet of stream. This Type 2 rock will also extend out into the confluence region of the tributary and fill a 4-foot scoured region near the outlet of an existing culvert.

The proposed channel then transitions upstream to 0.87% slope, following the average slope of the valley bottom. The smaller (Type 1) crushed rock will serve as a 9" blanket to protect the underlying soil fill for 485 feet of stream. As the upstream portions of the channel taper into less impaired areas, the channel fill-depth decreases. The valley slope also decreases, so a channel slope of 0.39% allows using exclusively topsoil fill material for the upper 335 feet of channel.

The size of the prescribed imported gravel material was informed by hydraulic modeling. The type 1 and 2 rock (6 and 12 inch minus) is of sufficient size to prevent mobilization during high flow events. The intent of the oversized rock is to impose a new geology on the stream so that regardless of future timber, grazing and land management practices that are outside the scope and domain of this project, the stream will not incise again. The reduction in channel slope and the larger bed material coupled with the change in grazing practices will prevent a recurrence of bed degradation and enable the stream to contact its floodplain.

A tributary enters the downstream portion of the Tepee Creek project reach and passes through a 24" culvert where it crosses the Tepee Creek Road. The tributary upstream of the culvert is also showing signs of recent incision, and has begun to down-cut 1-2 feet. Fill material (topsoil) in this location will raise the elevation two feet to restore the stream to its original level. Raising the culvert will help prevent recurring incision by imposing a shallower slope. In order to maintain the necessary road fill over the top of the culvert, the roadbed will be lifted one foot to provide adequate cover.

Hydraulic conditions throughout the Tepee Creek project area were modeled using the U.S. Army Corps of Engineers Hydraulic Engineering Center River Analysis System (HEC-RAS 5.0.3). The HEC-RAS 5.0 series uses a two-dimensional (2D) hydraulic modeling component to perform hydraulic computations. Results include lateral inundation extents throughout the model mesh region, estimates of water surface elevations sometimes influenced by complex flow paths, shear-stress values for the designated discharge hydrograph, as well as velocity, magnitude and direction.

The proposed changes to Tepee Creek were represented in the 2D model by duplicating the existing conditions model and incorporating the new grading into the modeled terrain surface. The same synthetic hydrograph was applied at the boundaries, and resulting hydraulic output was compared to existing conditions. By raising the channel bed, greater connectivity is observed at almost all flow

scenarios and small flood benches are wetted annually. Increased inundation, decreased and more varied velocities, and greater flow dispersion are observed in the modeled proposed future conditions. Figure 13 shows the proposed elevation changes to the Tepee 3 project site.

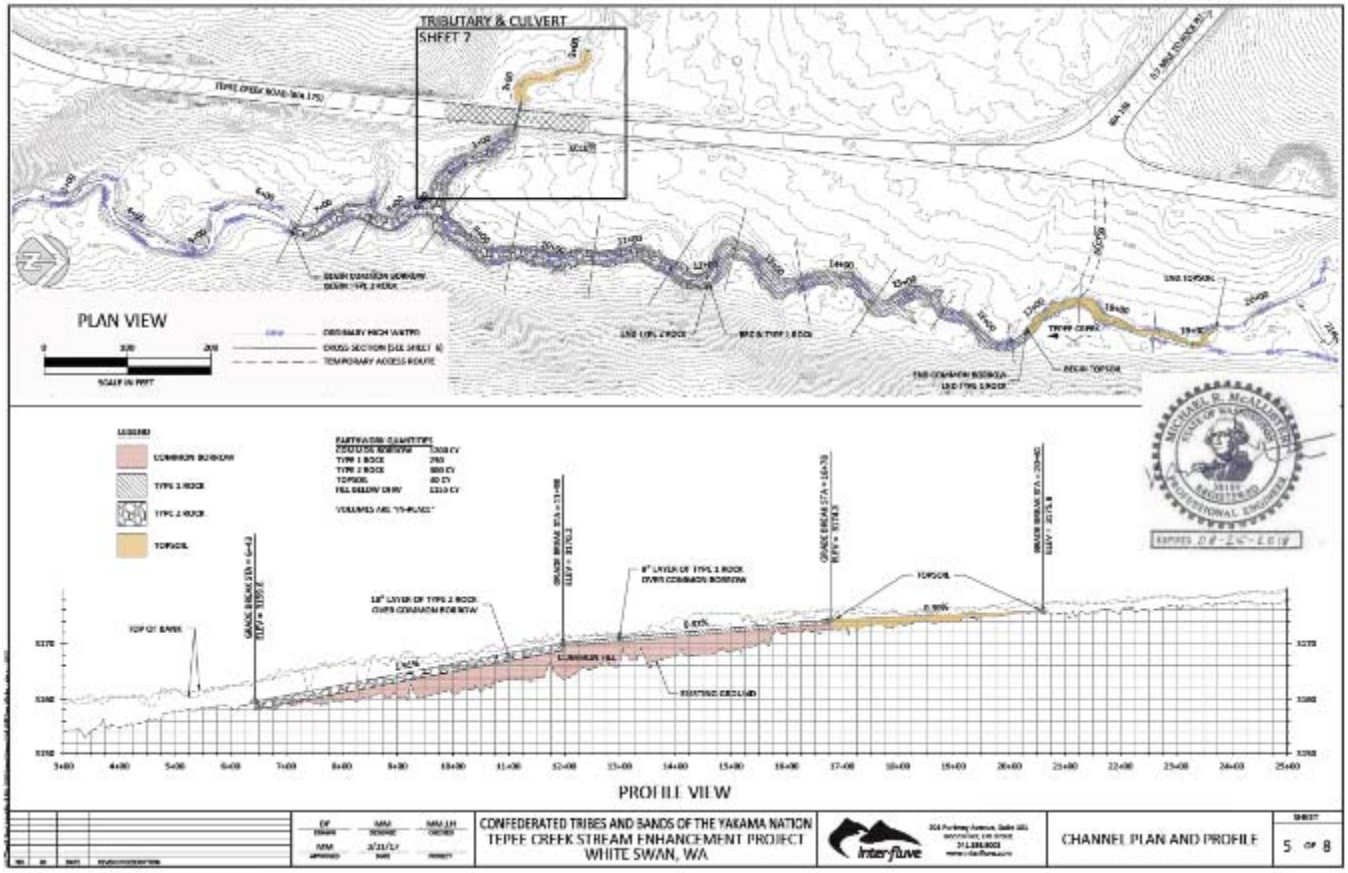


Figure 13. Plan and profile view of Tepee Creek Phase 3 Project Design.

Manage Native Plant Nursery

KWEP personnel constructed a small nursery at the Klickitat Field Office (KFO) in Wahkiacus, WA in 2006 to reduce the costs associated with revegetation efforts. Maintaining a supply of locally-adapted and locally-sourced plants that can generate a source of in-kind match for grant-based funds remains an important component of KWEP's work. The nursery consists of constructed wooden frames sized appropriately to hold treepot style containers (Stuewe & Sons, Corvallis, OR). KWEP staff harvest live cuttings from native hardwoods each spring prior to leaf-out, cut material to size, and root it in a planting medium in containers. KWEP staff irrigate three times weekly throughout the growing season and out-plant stock at restoration sites, often in the same year. The nursery has the capacity to grow 3,600 containerized plants in treepots with additional irrigated space to house purchased plants or holdovers from a previous growing season.

In 2017, KWEP grew approximately 3,400 plants at the KFO nursery. Containerized plants consisted of a mix of species harvested from cuttings, including Coyote willow (Salix exigua), Scouler's willow (*Salix scouleriana*) and black cottonwood (*Populus trichocarpa*). Additionally, KWEP staff grew out bare-root

seedlings purchased from the Washington Association of Conservation Districts Plant Material Center. A Washington Conservation Corps (WCC) crew planted all the plants grown at the KFO Nursery at the Haul Road Phase 6 project site in the fall of 2017.

Invasive Plant Control

Typically, sites selected for restoration or enhancement projects have a history of disturbance or perturbation. As a result, non-native vegetation is typically present to a degree and poses a potential threat to be "released" once soils are disturbed during construction activities. In order to prevent spread and assist with native plant establishment, KWEP personnel make annual visits to project sites both pre- and post-treatment to monitor and control invasive plants.

KWEP staff made site visits to fourteen completed project sites (totaling 63.75 acres) in 2017 in order to evaluate the establishment of native plants and manage invasive species. Treatment of invasives involved manual pulling of target species, primarily knapweed and non-native thistles. The initial pass through each site removes large or obvious invasives, followed later by a second pass to focus removal on newly emergent plants and those missed previously. On-reservation, the Yakama Nation currently has a no-spray policy, thus KWEP uses hand removal. Off-reservation, KWEP consults with Klickitat County Noxious Weed Board (KCNWB) staff in order to develop the most effective strategy for a given site.

Tributary Habitat RM&E

Habitat Enhancement Project Monitoring

KWEP staff annually visit past project sites to photo-monitor performance of treatments implemented since 2002. Staff take photos at specific photo-monitoring locations within project areas. Prominent landmarks (trees, rocks, stumps) or stations along the stream continuum orient/locate photo points. A consistent annual photo record facilitates comparisons between and among years to determine changes occurring over time, and facilitates adaptive management, if needed. Photos utilized throughout this document are a result of photo documentation at project sites.

All photos taken as part of photo-monitoring are saved digitally, filed electronically in subdirectories by their respective project name and stored on the KWEP server. Figures 3 and 4 show examples of photographic comparisons of pre- and post-project monitoring in the first section of this report, entitled the "Tributary Habitat Restoration and Protection". An aerial photo (Figure 14) from a recent visit at Tepee Creek Phase 2 documents 2017 conditions.

Figure 14. Tepee Creek Phase 2 site conditions as observed during June 2017 monitoring visit.

Streamflow Monitoring

KWEP staff, cooperatively with Klickitat M&E and the YN Water Program (YNWP), monitor stream flows throughout the Klickitat sub-basin using thirteen gages that continuously collect stage height and temperature. These efforts are critical for understanding status and trends of water resources that support threatened and endangered (T&E) species in the Klickitat basin and tributaries. Stream flow data informs the development of on-the-ground habitat restoration projects, effectiveness monitoring of past projects, status and trends of fisheries research throughout the basin, and operations at the Lyle Falls Adult Fish Trap.

In the past, YKFP took physical discharge measurements to develop site-specific rating curves (stage-discharge relationship) for each site. Stage heights are plotted on the rating curve to represent continuous discharge measurements at the gage. Periodically YKFP or YN Water Program staff take physical discharge measurements to validate or update the rating curve. In 2017 cooperative activities included discharge measurements at Summit Creek, Tepee Creek above IXL, Tepee Creek above 175 Rd (Table 3). Fewer instantaneous discharge measurements were taken during 2017 due to closure of YN forestlands for wildfire precaution in August and September.

During the reporting period, staff made 48 visits to thirteen sites with data loggers for maintenance, data downloads, and field calibration of loggers. Activities conducted at all thirteen sites are summarized in Table 2. Services performed by KWEP and YNWP at 13 stream-gaging sites in the Klickitat subbasin in 2017 Table 3. WY17 data collected by YNWP personnel at sites where KWEP operates continuous dataloggers.Graphs of 15-minute-increment stage data for Water Year (WY) 2015, 2016 and 2017 at stream gaging sites on White and Tepee Creeks are presented in Figures 15 and 16.

Table 2. Services performed by KWEP and YNWP at 13 stream-gaging sites in the Klickitat subbasin in 2017.

Site	Q	Staff Read	Crest Read	Download	Maint	Survey	Total Visits
Big Muddy Creek @ 255 x-ing	-	-	-	-	-	-	-
Dillacort Creek	-	4	-	3	1	-	4
Klickitat River @ Klickitat Hatchery	-	-	-	-	-	-	-
Klickitat River blw Summit Ck	-	3	-	1	-	-	3
Klickitat River @ Wahkiacus	1	10	-	9	-	-	10
Logging Camp Creek	-	3	-	3	-	-	3
Snyder Creek	-	3	-	3	-	-	3
Summit Creek nr mouth	1	4	-	3	1	-	6
Swale Creek nr mouth	-	3	-	3	-	-	3
Tepee Creek abv. 175 Rd	1	4	-	4	-	-	5
Tepee Creek abv. IXL Rd	2	4	-	4	-	-	6
Wheeler Creek	-	2	-	2	-	-	2
White Creek nr mouth	-	3	-	3	-	-	3
Grand Total	**5**	**43**	**0**	**38**	**2**	**0**	**48**

Table 3. WY17 data collected by YNWP personnel at sites where KWEP operates continuous dataloggers.

Site	Date	Stage	Discharge
Summit Creek nr mouth	12/14/2016	4.93’	10.9 cfs
Swale Creek nr mouth	No Measurements		
Tepee Creek abv. IXL Road	4/26/2017	4.43’	22.6 cfs
Tepee Creek abv. IXL Road	3/17/2017	4.20’	6.6 cfs
Tepee Creek abv. 175 Road	4/26/2016	1.65’	23.2 cfs
White Creek nr mouth	No Measurements		

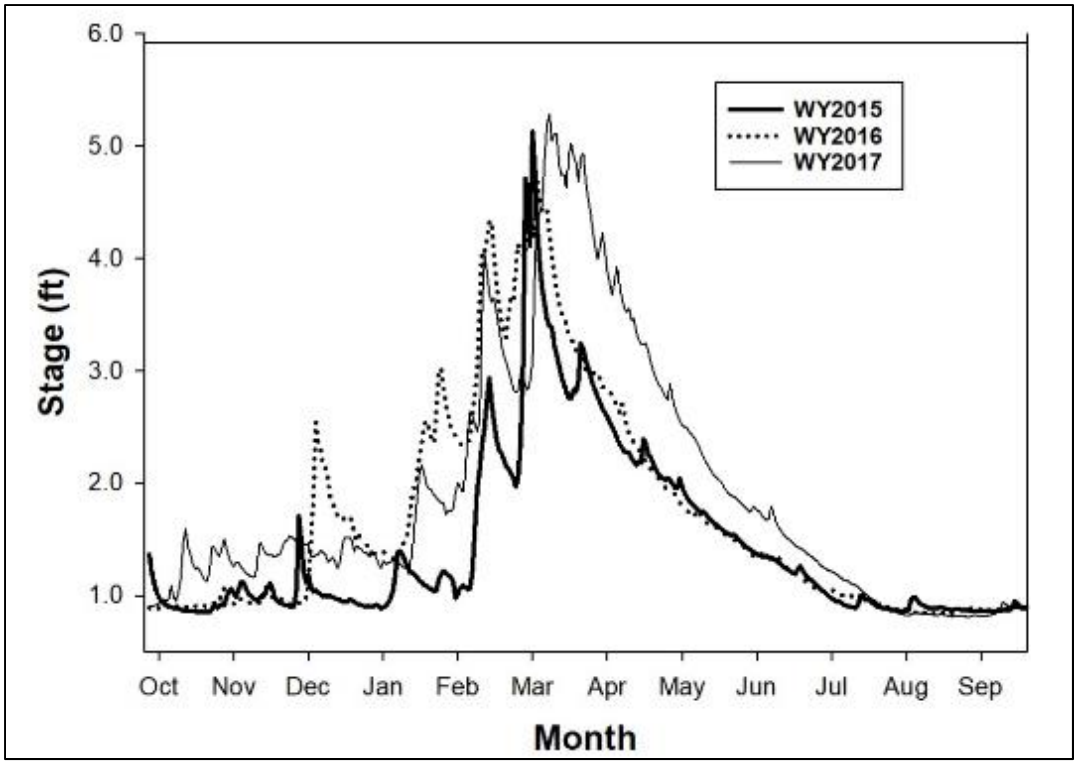


Figure 15. White Creek stage at the gaging site near the confluence with the Klickitat River for Water Years 2015, 2016 and 2017.

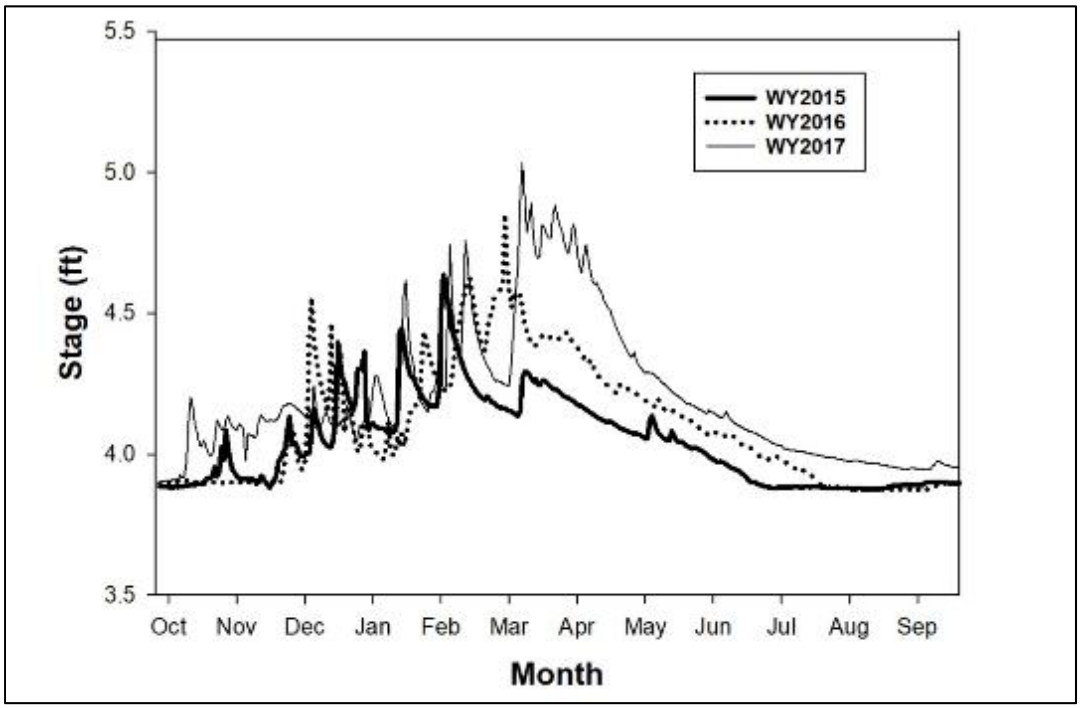


Figure 16. Tepee Creek stage at the gaging site near the intersection of the IXL and 175 roads for Water Years 2015 and 2017.

Food Web Study on Tepee and White Creeks

The objective of the food web study is to examine how instream restoration efforts along a 0.7-mile section of Tepee Creek affect aquatic and terrestrially derived invertebrate prey sources and the diet of residualized *Oncorhynchus mykiss* and juvenile steelhead. Specific objectives of the study include the following:

- Quantify riparian habitat conditions in treatment and control-reach sample sections.
- Compare invertebrate abundance, biomass and composition from benthic, drift, and allochthonous sources among treatment and control-reach sample sections.
- Compare fish diet (abundance, biomass and composition) among treatment and control reach sample sections.
- Evaluate seasonal variation in prey availability and diet of residualized *Oncorhynchus mykiss* and juvenile steelhead trout in sub-reach sample sections.

Methods

Study Area

Tepee Creek, a tributary to White Creek, is one of the major tributaries supporting natural production of steelhead in the Klickitat subbasin. The White Creek watershed is 138 square miles in area. Elevations range from 1140 to 5100 ft. though most of the watershed lies between 2500 and 3300 ft. in elevation. Average annual precipitation is between 20 and 29 in., with roughly half falling as snow. Current habitat conditions in Tepee Creek and White Creek reflect past riparian timber harvest and road construction throughout the drainage. Instream large woody debris (LWD) levels are low in some reaches, and base flows are very low to non-existent in many reaches. Changes in channel morphology are attributable to numerous landscape-level activities such as livestock grazing, road interactions, up-slope timber harvest, and in some locations, historic removal of instream LWD.

Study reaches are located on Tepee Creek (treatment) and White Creek (control). There are four sample sections within each reach. The control and treatment study reaches have similar drainage areas and channel morphology. Sample section lengths range from 61-101 m in Tepee Creek and 80-107 m in White Creek. Bankfull widths ranged from 10.7-26.1 m and 16.3-28.8 m in Tepee Creek and White Creek, respectively. Pool-riffle sequences characterize sample sections.

During 2017, fish abundance surveys and groundwater monitoring was conducted. KWEP staff monitored groundwater elevations throughout 2017 via physical measurements and continuously deployed dataloggers (Figs. 17 and 18). Klickitat M&E personnel led fish abundance surveys conducted in June 2017. Results presented in Klickitat M&E annual reports.

Fish abundance

M&E staff estimated juvenile *O. mykiss* (Steelhead/Rainbow trout) populations using a multiple-pass electroshocking technique at four Tepee Creek (treatment) and White Creek (control) reaches. All juvenile steelhead and Rainbow Trout greater than or equal to 65 mm in length receive a Passive

Integrated Transponder (PIT) tag, and staff measure length and weight. A fixed PIT-tag detection array installed by the M&E project at the mouth of White Creek will facilitate survival and migration timing analysis on those fish tagged within the project reach.

Groundwater

Twelve shallow (~6.5'-deep) wells were installed to characterize existing groundwater conditions. They will be used for post-project effectiveness monitoring of meadow groundwater levels if future funding permits. Two wells are located outside of the project reach as controls (one upstream and one downstream). The remaining ten wells are dispersed strategically throughout the project reach to characterize local hydrogeology (Fig. 17). Six wells (including both controls) have sensors that measure and record water level once every hour. KWEP staff have downloaded data several times per year using a field computer. Staff take manual measurements of water level with an e-tape at the remaining six wells approximately once per month (on average). Data from three wells with continuous sampling are depicted in Figure 18. In-stream construction of riffles and wood placement was initiated in October 2012 and completed in November 2013. Continuous groundwater elevation data from 2017 in Wells 1 and 6 reveal a prolonged period of raised ground water elevations (approx. 8 months) compared to before the project, followed by a recession in October to base-level elevations. Similar time periods in 2010-2012 show brief periods of elevated groundwater followed shortly by a receding limb of the hydrograph. The data suggest that water is being stored within the project reach as groundwater, but does not persist year-round, and may not necessarily be expressed within the reach as surface flow in Tepee Creek.

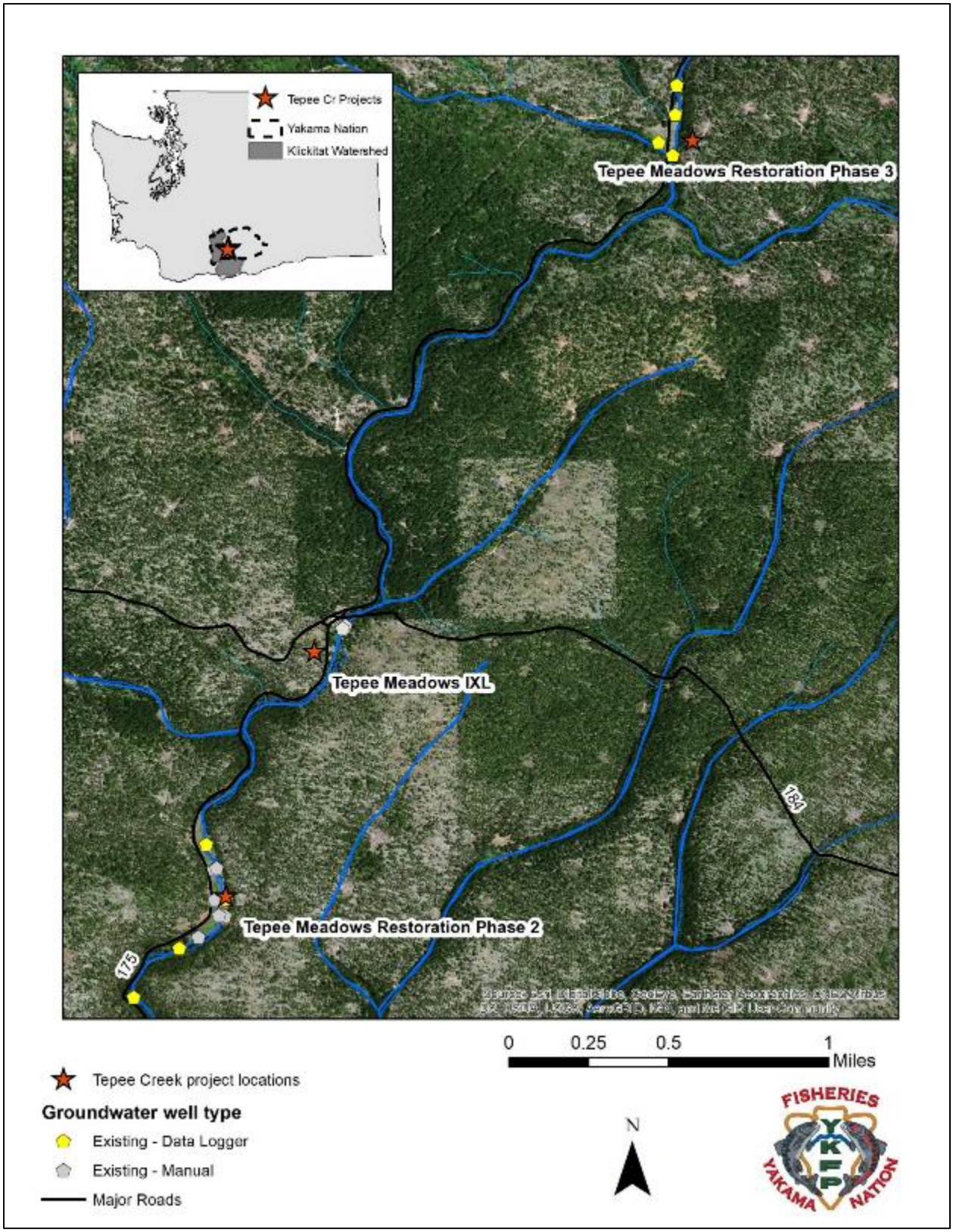


Figure 17. Locations of Tepee Creek Habitat Enhancement Projects and groundwater monitoring wells.

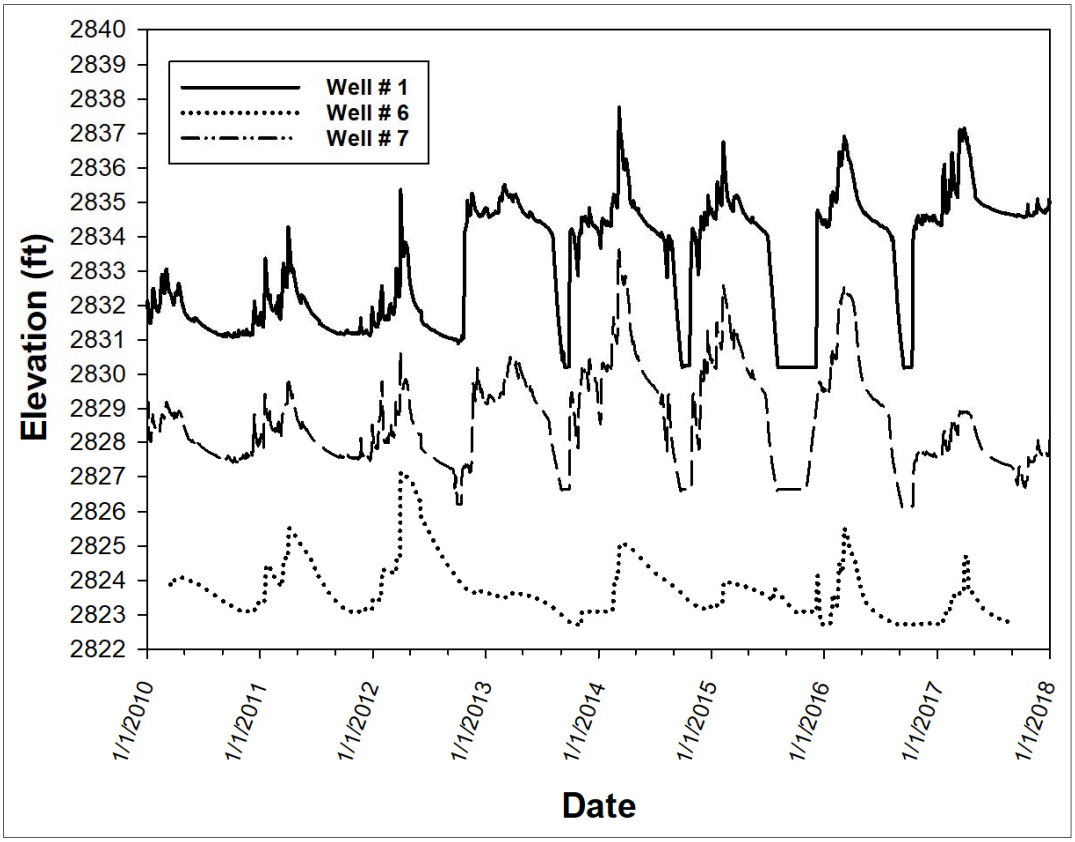


Figure 18. Groundwater well data at Tepee Creek 2 wells.

Collect Water Surface Elevation Data - Klickitat/Columbia River Confluence (Klickitat Delta Assessment)

YKFP fisheries biologists have expressed concern about altered conditions inhibiting adult fish passage at the mouth of the Klickitat River. KWEP staff initiated sampling water surface elevations (August 2009) to provide data for evaluation of depth-frequency with cost-share funds provided by a grant received from Columbia River Inter-Tribal Fish Commission (CRITFC). Data document inundation frequency of deltaic landforms and evaluate potential factors limiting salmonid production. The initial phase of the project consisted of: 1) collection of water-level and water temperature data at four locations distributed around the delta fan and 2) compilation of historic information. Data will facilitate subsequent assessments of water temperature, growth of aquatic vegetation, juvenile and adult fish passage, and predation.

The Yakama Nation and USGS recently collaborated on a grant proposal that sought funding to estimate migration survival for juvenile *O. mykiss* through the 1.3-mile reach of the Klickitat River influenced hydrologically by the Columbia River. The proposal received funding via CRITFC in 2017; the first year of sampling will begin spring 2018. Additionally, the EPA is conducting a multi-year effort to identify, characterize, and quantify cold-water inputs/refuges along the mainstem Columbia River. The Klickitat River has been identified as a critical cold-water refuge due to having water temperatures that are 4 degrees Celsius or more colder than the mainstem Columbia River during key salmon migratory time

periods. This research has renewed interest in Columbia tributary confluences and the quantification of habitat availability.

During the 2017 reporting period, the sensor array installed in August of 2009 operated continuously. Data collection monitored via a File Transfer Protocol (FTP) site provides KWEP staff with remote access from the Klickitat Field Office. KWEP staff occasionally observed discrepancies, errors, data gaps, or non-reporting that dictated site visits for troubleshooting purposes. Additional site visits enable the collection of staff gage observations during a range of water elevations to establish stage reference points. These reference points are used to quality-control data collected by deployed sensors. The configuration of landforms at the confluence changed significantly during 2017 (Fig. 19).

KWEP staff conducted several site visits to the East Delta site during 2017 to swap out the 12-volt marine battery. The configuration of three solar panels is unable to maintain a voltage in excess of 11 volts in winter. Encroaching vegetation and low light exacerbated this situation.

Figure 19. Aerial view of Klickitat River Delta under low Bonneville Pool conditions as observed on August 22, 2017.

Measure Turbidity Timing and Duration Associated with Big Muddy Creek

Big Muddy Creek is a Klickitat River tributary that originates on the south-eastern flank of Mt. Adams and is a known source of occasional debris flows and frequently occurring high turbidity conditions. Historically debris flows have contributed to salmonid mortality observed in the mainstem Klickitat River. Data collection initiated in 2011 documents patterns associated with runoff production and sediment generation. KWEP staff utilize data to inform decision-making regarding location and type of enhancement projects. Longer-term trends regarding the timing, duration and frequency of turbidity events will be analyzed dependent upon the duration of the data collection effort.

In 2013, KWEP staff installed telemetry equipment at two existing sites to facilitate remote data transmission (Big Muddy Ck @ 255 rd crossing and Klickitat River downstream of Summit Ck). Due to the remoteness of the sites and critical nature of having functioning equipment during episodes of increased turbidity, remote monitoring is made possible via the GOES satellite network. Data are accessed via the Web multiple times a week to ensure the station is functioning properly. Operation of the Big Muddy Creek turbidity gage was halted in 2016 until a more suitable site could be identified, but monitoring at the site below Summit Creek on the mainstem Klickitat continues. Construction and project managers utilized the turbidity-monitoring sensors below Summit Creek to monitor turbidity upstream of construction activities at the Haul Road Phase 6 during late summer and fall 2017. The long-term status-and-trend turbidity dataset that this network provides allows managers to compare the short-term, lower magnitude turbidity events resulting from Haul Road deconstruction to naturally occurring, longer-duration, higher-magnitude turbidity events flowing in from Big Muddy Creek or other upstream sources (Fig. 20). In 2017, the mainstem Klickitat River station downstream of Summit Creek functioned well, without interruption of data collection or transmission.

Figure 20. Naturally occurring late summer turbidity event on the Klickitat River, September 11, 2017, as observed from Horseshoe Bend Rd Bridge, Wahkiacus, WA (looking downstream on the left, looking upstream on the right). Air visibility conditions were a result of the Eagle Creek Fire in the Columbia Gorge.

Education and Project Outreach

Though education and outreach constitutes a minor portion of overall KWEP staff time allocation, it is a critical component of the project. KWEP staff made one presentation at conferences in 2017 and conducted multiple field tours for various audiences. These activities are oriented toward helping the public understand our mission and objectives and communicate lessons learned to improve the field of watershed and stream restoration science.

The Em2 Stream Demonstration Table purchased in 2016 assisted visualization of basic principles of river behavior, channel morphology, and sediment transport processes. The stream table was set up at local elementary schools, environmental education oriented festivals (Fig. 21), and Water Jam. These outreach events facilitated interactions with hundreds of students and adults providing a means for discussing watershed processes and concepts.

Figure 21. Stream table demonstration at Underwood Conservation District Tree Festival.

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Ian Sinks – Stewardship Manager, Columbia Land Trust (CLT)

IV. References

Conley, W. and D. Lindley. 2012. Klickitat Watershed Enhancement Project: Annual Report for January 1, 2008 to December 31, 2008. Project No. 1997-056-00. Prepared for Bonneville Power Administration, Portland, OR.

Klickitat Lead Entity (KLE). 2013. Klickitat Lead Entity Region Salmon Recovery Strategy. Available online at:

http://www.klickitatcounty.org/NaturalR/FilesHtml/SalmonHabitatRecovery/2013_klickitat_LE_strategy.pdf

LeMier, E., H. Wendler, and L. Rothfus. 1957. Stream Appraisal of Klickitat River Above Castile Falls: July 25-26, 1957. State of Washington, Department of Fisheries.

Moore, K. K. Jones, J. Dambacher, and C. Stein. 2010. Aquatic Inventories Project: Methods for Stream Habitat Surveys. Oregon Department of Fish and Wildlife, Aquatic Inventories Project, Conservation and Recovery Program, Corvallis, OR 97333.

Northwest Power and Conservation Council (NPCC). 2004a. Klickitat Subbasin Plan. http://www.nwcouncil.org/fw/subbasinplanning/klickitat/plan/.

Pleus, A.E., D. Schuett-Hames, and L. Bullchild. 1999. TFW Monitoring Program methods manual for the habitat unit survey. Prepared for the Washington State Dept. of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-00-003. DNR #105.

Romero, N. and D. Lindley 2012. Rapid Aquatic Habitat Assessment Protocol Methods for Stream Inventory Surveys. Version 1.0, February 2012.

Roper et. al 2010. A Comparison of the Performance and Compatibility of Protocols used by Seven Monitoring Groups to Measure Stream Habitat in the Pacific Northwest. North American Journal of Fisheries Management. American Fisheries Society 2010.

Schuett-Hames, D., A.E. Pleus, J. Ward, M. Fox, and J. Light. 1999. TFW Monitoring Program method manual for the large woody debris survey. Prepared for the Washington State Dept. of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-00-004. DNR #106.

Schuett-Hames, D., A.E. Pleus, and D. Smith. 1999. TFW Monitoring Program method manual for the salmonid spawning habitat availability survey. Prepared for the Washington State Dept. of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-00-007. DNR #109. November.