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*). Description of project activities follow.

Restoration activities at Tepee Creek Phase 3 focused on restoring floodplain connectivity to increase shallow aquifer groundwater storage to extend/augment late summer flows and reducing bank erosion, siltation, and down trailing by cattle through the construction of an exclusion fence. Rock/fill material was imported to raise the bed of the incised channel to an elevation that facilitates overbank flow at the 1.5-year return interval. Fill materials were sourced from the project watershed to mimic native conditions and reduce construction costs. Planning and design work advanced to 60% completion for the White Creek 191 Meadow Enhancement project. The project proposes to create roughened (LWD and vegetation) inset floodplain benches to reduce instream hydraulic severity, promote wetland plant establishment, increase aquatic habitat complexity and wetted area, and reduce impacts from cattle grazing.

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 turbidity from Big Muddy Creek). The purpose of these data collection efforts is to understand baseline conditions, develop insights related to land-use planning, and assist in developing new restoration projects that will be effective in improving watershed health and fisheries resources. At KWEP projects, post-project monitoring occurs on select sites to document the degree to which intended physical and biological responses occurred in order to allow for adaptive management and to refine future projects. Case studies of completed projects presented at professional meetings 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*), Pacific Lamprey (*Entosphenus tridenatus*) 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 conflicts between historic and present 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 #1995-06-35) 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.

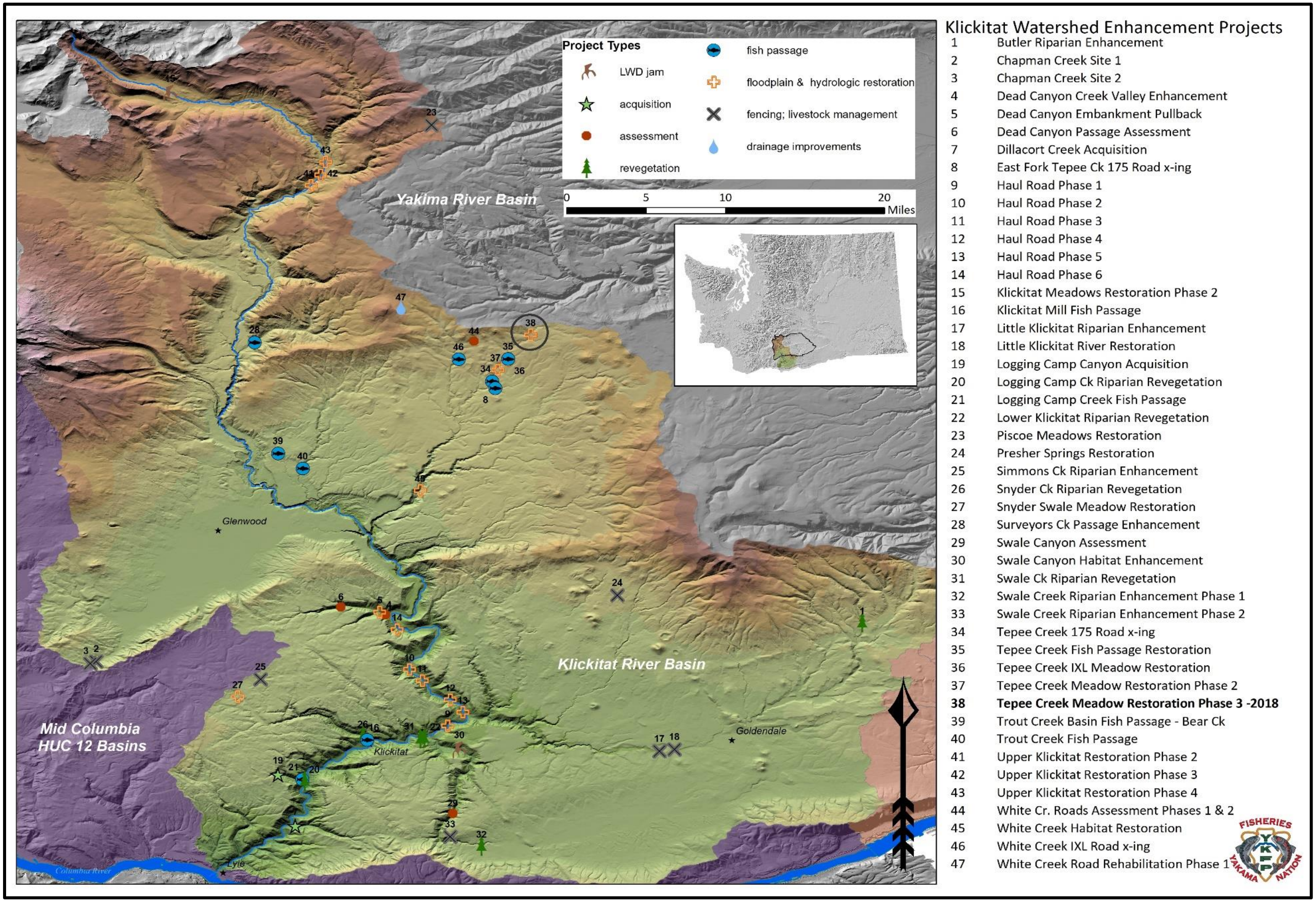


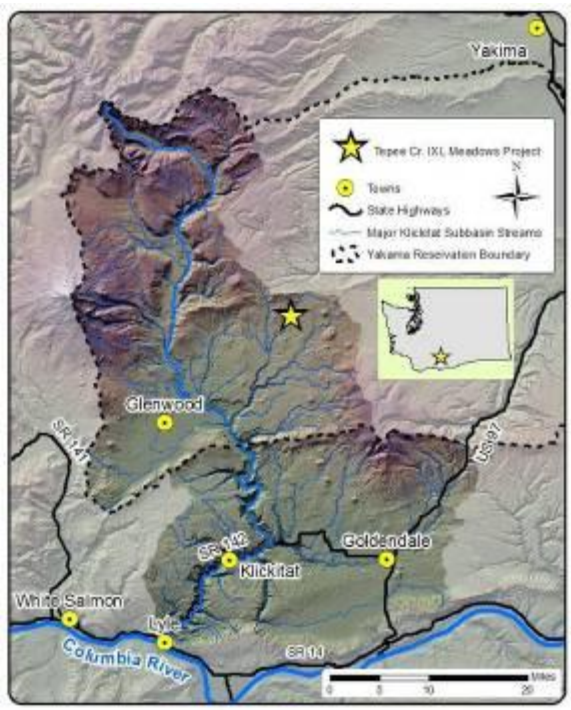
Figure 1. KWEP projects completed to-date in the Klickitat River Subbasin.

III. Work Elements/ Deliverables

Tributary Habitat Restoration and Protection

Tepee Creek Meadows Restoration - Phase 3

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 increase, and continue to degrade habitat conditions. 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.

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, which show 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 through the year.
- 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 was 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 was 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 (Figure 2), which will ultimately provide downstream benefits to Lower Tepee Creek and White Creek.

Figure 2. Pre-project conditions as observed in early-September, stream flow limited to isolated standing pools.

2018 activity: Throughout the spring of 2018, KWEP staff worked with the design team at InterFluve Inc. to refine the project design to meet conditions of BPA's Habitat Improvement Program (HIP) (Figure 3). The Design Team at InterFluve consisted of Mike McAllister, the engineer of record for the project, and Mike Brunfelt, geomorphologist. David Lindley was the project manager for the Yakama Nation and Adrianne Grimm provided technical review and a revegetation prescription. Upon completion of the environmental compliance elements of the project (HIP III, Sec 106, and YN Hydraulic Permit) and issuance of permits, on-the-ground work initiated in June 2018 with the construction of a buck-and-rail style cattle exclusion fence.

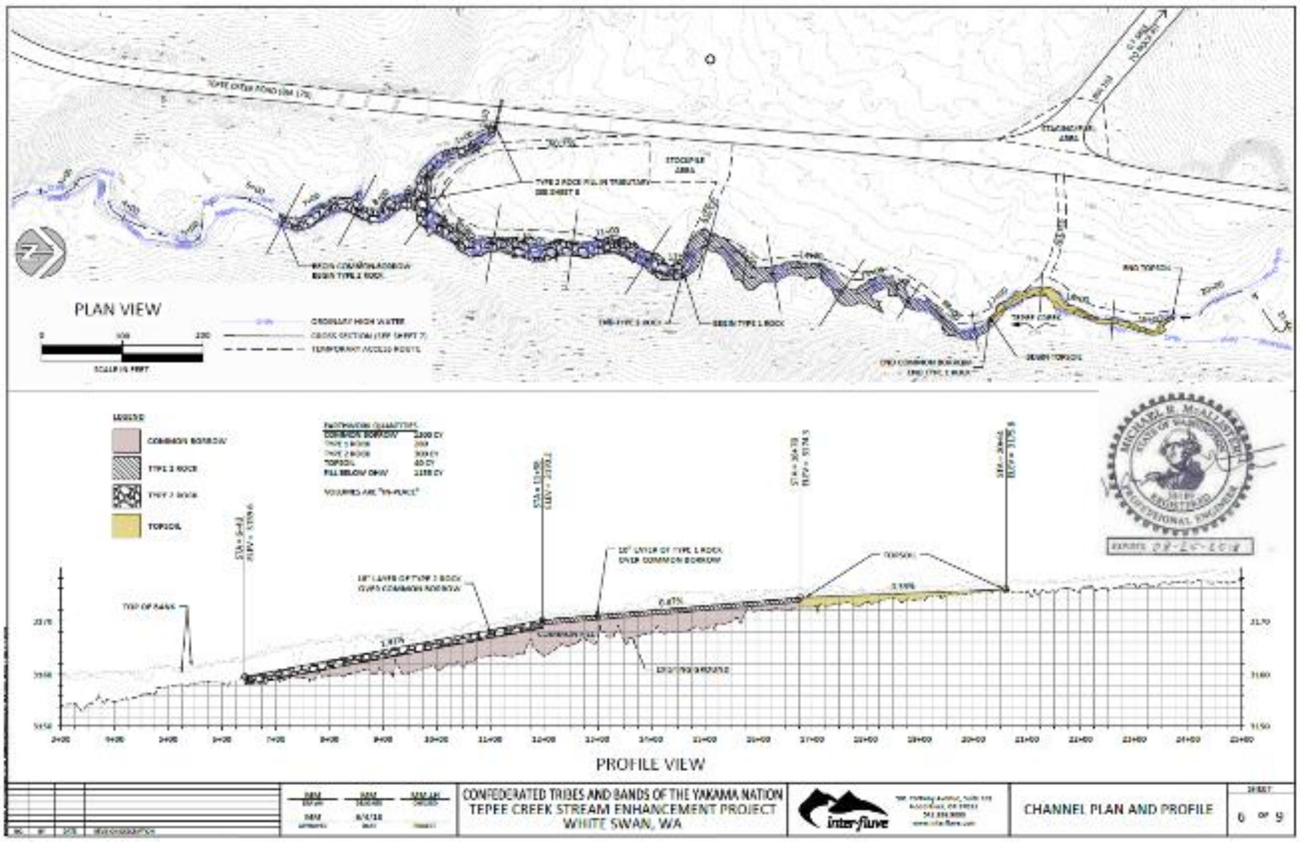


Figure 3. Final plan set Channel Plan and Profile view.

As availability permitted, a four-person Yakama Nation crew constructed the fence around three sides of the project (Figure 4), leaving the downstream section and gates along the road open to facilitate construction activities. Completion of the fence occurred in October 2018 when work requiring heavy machinery access had terminated.

Figure 4. Cattle exclusion fence around perimeter of Tepee Creek Phase 3 Project.

TMS Native Companies LLC of Toppenish, WA was selected via a competitive bidding process in June 2018 to produce, truck, and haul native fill soils and specified rock products to the project site. The reach was intermittent by mid-September with isolated pools. Prior to ground disturbing activities beginning the reach was isolated from migrating fish by placing sets of block nets at the upstream and downstream project extents. YN personnel from the Klickitat Monitoring and Evaluation Project conducted a fish salvage effort using standard electro-fishing methods. Work commenced on September 24, 2018 and proceeded in the downstream direction with native fill material placed first. Native fill and rock were hauled from two Yakama Nation source locations within the Reservation. The native soil and Type 2 rock came from a borrow pit less than a mile from the project site, while the Type 1 rock source was a pit 4 miles away. Following the native fill, type 1 rock (smaller of the two rock sizes) went in, and lastly the type 2 grade control rock was placed at the downstream terminus of the project (Figure 5). Final work elements entailed installing topsoil from station 1700 to 2000, refine channel grading to ensure design grade was met, and raking the work areas with the excavator bucket to decompact meadow soils (Figure 6 and Figure 7) and prep the site for riparian plantings . Heavy machinery work ended in early October with revegetation occurring throughout the month of October, and early November. YN personnel assisted TMS Native crew members with applying native seed mix and weed-free straw on all disturbed soils, and planted 150 containerized plants. Additional planting will occur in spring 2019.

Figure 5. Channel conditions following placement of common borrow fill (left) and type 2 rock (right).

Figure 6. Channel conditions after Type 2 rock fill (left) and post de-compaction (right).

Figure 7. Topsoil placement upstream of station 1700 and aerial view of meadow post-construction.

White Creek 191 Meadow Enhancement Design

Introduction: The White Creek 191 Meadow Enhancement 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 White Creek watershed.

Site and Watershed Description: The forested portion of the White 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 3 feet of channel incision has occurred; tall, unvegetated streambanks are evidence of the extent of down-cutting. Lateral erosion occurs as the tall steep banks collapse and slough fine sediments into the stream channel. Due to the dimensions 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 are expected to continue to increase and degrade habitat conditions. The elevation of the channel bed is several feet below the floodplain, which results in the channel functioning as a drain on the meadow, decreasing groundwater elevations and the duration of groundwater inputs into the stream.

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 (Figure 8). Anecdotal evidence, along with watershed size, elevation, and precipitation, suggest that more reaches historically had perennial flow.

Figure 8. Pre-project photos of the overall project reach (left) and lateral channel migration occurring.

Project Goal: Promote the establishment/expansion of wetland/riparian vegetation, provide high flow refugia and increase habitat quality of *O. mykiss*.

Project Objectives:

- Upon completion of the project, create inset floodplain benches inundated at a 2-year or less recurrence interval.
- Utilize LWD to create hydraulic shadows promoting the establishment of wetland/riparian vegetation.
- 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).

2018 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 excavation and large wood quantities, access routes, fill disposal, a revegetation plan and a cost estimate.

The proposed design seeks to increase riparian wetland and instream habitat by placing imported large wood log jams within excavated lowered banks at existing eroding meander bends and inflections. Channels and former meadows that have lost channel length, such as the 191 Meadow, become incised and lose contact with former floodplain surfaces during more frequent annual discharges. The abandonment of the valley bottom to more frequent discharges has dried much of the former valley bottom 191 Meadow surface. Areas that were once likely sedge and willow are now grass and pine or white fir. The abandonment and incision places greater pressure on channel banks, which over time, laterally erode and re-develop new flood-prone surfaces at lower elevations that are inset within the now-abandoned former valley bottom. These processes are occurring at the 191 Meadow and were viewed in the field during surveys and confirmed through hydraulic inundation modeling.

In some instances, incised channels can be filled and raised up to former floodplain surfaces. The 191 Meadow is not a good candidate for this strategy because it has already experienced significant lateral migration and would require a large fill volume to raise the channel bed. Further, there is no easy location downstream to establish a grade control to step down a lifted, restored creek-segment to the incised channel downstream of the project reach. Thus, the proposed design creates new flood-prone surfaces consistent with the elevation of those occurring naturally. This will increase wetland habitat and enhance instream fish habitat at the same time. The design improves future riparian floodplain by selectively excavating 0.77 acres of new floodplain surfaces that will become inundated during 2-year discharge estimate. The new surfaces will support willow (in gravel substrate) and sedge (in silt/clay substrate) vegetation depending on the substrate encountered at the new floodplain surface. Based on the variability in bank substrate, we expect the same variability in areas excavated that are adjacent to current banks. Imported trees and logs will be used to construct log jams at bend inflections and pool areas and extend back into newly excavated floodplain surfaces. The frequency of large flood inundation upon the perched floodplain will not change significantly from current conditions. However, the extent of inundation of new floodplain surfaces will be markedly increased for smaller and more frequent floods (<5yr) because of the project. Improvements in floodplain inundation are evident in the comparison of existing to proposed conditions models of the 2-year flood (Figure 9).

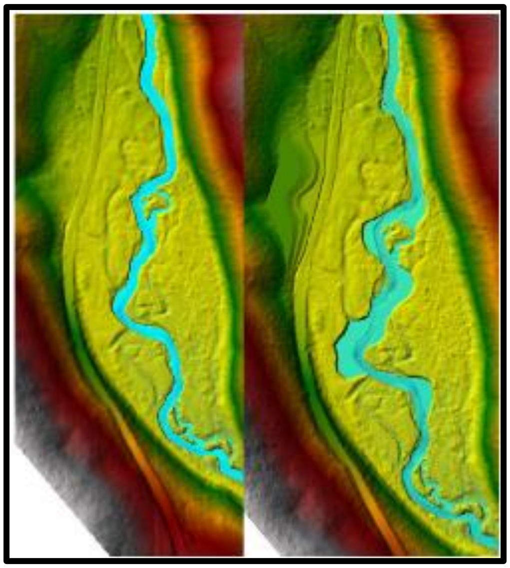


Figure 9. Inundation map of modelled existing conditions (left) and design conditions (right) during the 2-year return discharge. A total of 0.77 acres of new wetland inundation will be created during the 2-year discharge.

To enhance habitat further, existing pool areas will be excavated in areas associated with bank and valley-bottom excavation sites. Large wood will be placed to provide cover habitat over existing enhanced pools and within lowered segments of valley bottom to provide resiliency and roughness until wetland vegetation can become fully established (Figures 10, 11 and 12).

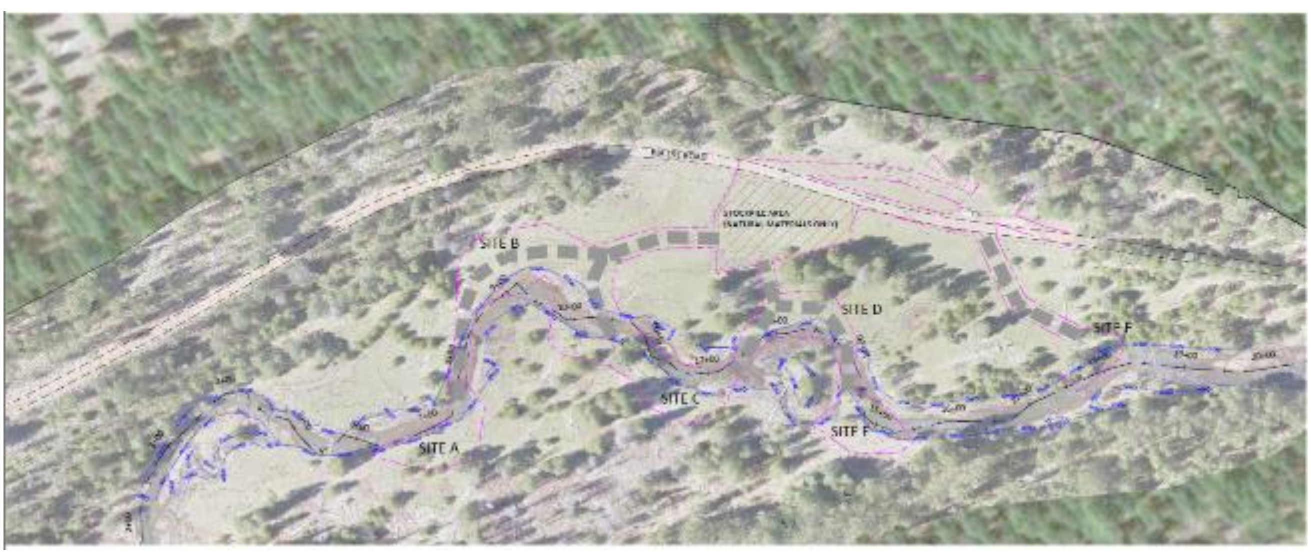


Figure 10. Aerial view of existing conditions and site access.

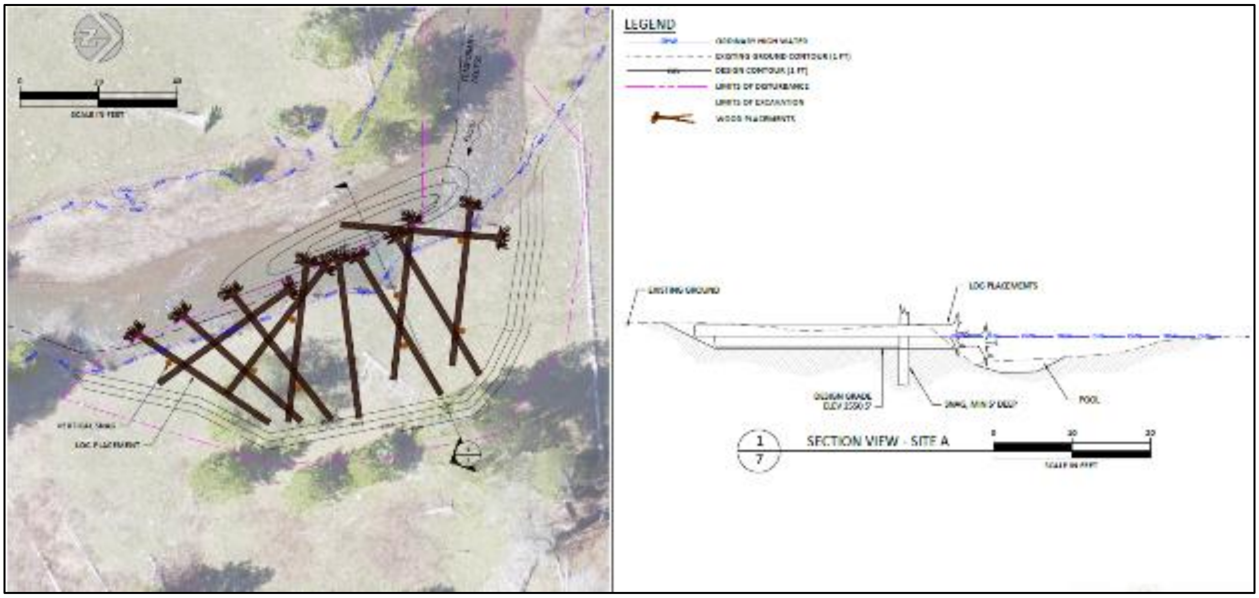


Figure 11. Plan view of Site A depicting log configuration, excavated pool and floodplain terrace.

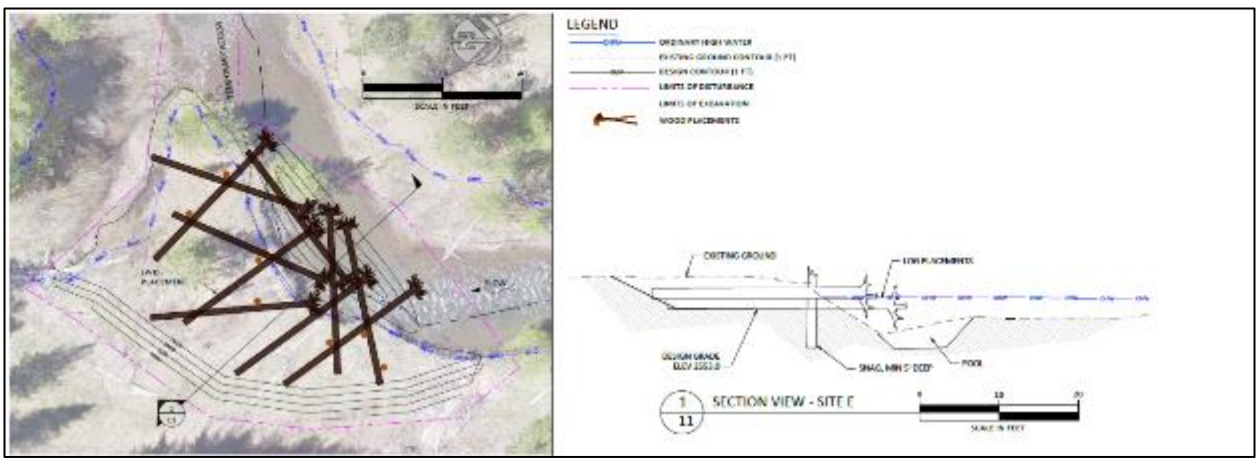


Figure 12. Plan view of Site E depicting log configuration, excavated pool and floodplain terrace.

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 2018, KWEP grew approximately 1,500 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 (primarily spiraea and rose) purchased from the Washington Association of Conservation Districts Plant Material Center. KWEP staff planted 150 of the plants grown at the KFO Nursery at the Tepee 3 project site in the fall of 2018.

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 2018 in order to evaluate the establishment of native plants and manage invasive species. Treatment of invasive plants 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 utilizes hand-removal methods.

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. Figure 2 and Figures 5-7 show examples of comparisons of pre- and post-project photo monitoring in the first section of this report, entitled the "Tributary Habitat Restoration and Protection". Photos (Figure 13) from a recent visit at Upper Klickitat Phase 3 document 2018 conditions.

Figure 13. Upper Klickitat Phase 3 site conditions as observed May (left photo looking downstream) and August (right photo looking upstream) during 2018 monitoring visits.

Streamflow Monitoring

KWEP staff, cooperatively with Klickitat M&E and the YN Water Program (YNWP), monitor stream flows throughout the Klickitat sub-basin using eleven 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.

During the reporting period, staff made 55 visits to eleven sites with data loggers for maintenance, data downloads, and field calibration of loggers. Activities conducted at eleven sites are summarized in Table 1.

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 2018 cooperative activities included discharge measurements at Summit Creek, White Creek, Swale Creek, Tepee Creek above IXL, and Tepee Creek above 175 Rd (Table 2). Instantaneous discharge measurements were taken more frequently in 2018 than in 2017 and logger battery changes were due on many of the loggers, requiring more maintenance visits than in recent years. Graphs of 15-minute-increment stage data for Water Years (WY) 2012 through 2018 at stream gaging sites are presented in Figure 14 through 25. Many of these charts show the entire period of record for the given stream gage, but a few show only water year 2018 due to data gaps or other anomalies that are under review.

Table 1. Services performed by KWEP and YNWP at 11 stream-gaging sites in the Klickitat River subbasin in WY 2018.

Site	Elev. (ft)	Q	Staff Read	Download	Maintenance	Total Visits
Dillacort Creek	292	1	3	3	-	3
Klickitat River blw Summit Ck	940	-	2	2	-	2
Klickitat River @ Wahkiacus	526	-	4	4	-	4
Logging Camp Creek	363	1	3	3	2	3
Snyder Creek	595	2	6	6	2	6
Summit Creek nr mouth	1067	4	7	6	3	7
Swale Creek nr mouth	564	4	7	7	2	7
Tepee Creek abv. 175 Rd	2924	2	6	4	-	6
Tepee Creek abv. IXL Rd	3030	3	7	4	-	7
Wheeler Creek	448	1	3	3	1	3
White Creek nr mouth	1276	3	7	6	2	7
Total		**21**	**55**	**48**	**12**	**55**

Table 2. WY 2018 discharge data collected at sites where KWEP operates continuous dataloggers.

Site	Date	Stage	Discharge (cfs)
Dillacort Creek	04/18/18	2.47	2.94
Logging Camp Creek	04/06/18	1.83	1.59
Snyder Creek	04/10/18	5.22	29.48
Snyder Creek	04/26/18	4.8	12.2
Summit Creek nr mouth	03/21/18	5.41	53.3
Summit Creek nr mouth	05/09/18	5.38	41.0
Summit Creek nr mouth	07/18/18	4.83	17.2
Summit Creek nr mouth	08/21/18	4.77	12.2
Swale Creek nr mouth	02/13/18	3.06	27.3
Swale Creek nr mouth	03/14/18	3.33	46.5
Swale Creek nr mouth	04/06/18	2.79	16.3
Swale Creek nr mouth	05/29/18	2.19	1.8
Tepee Creek abv 175 Road	4/25/2018	1.12	6.845
Tepee Creek abv 175 Road	5/8/2018	0.98	4.371
Tepee Creek abv IXL Road	10/24/2018	3.95	0.293
Tepee Creek abv IXL Road	4/24/2018	4.2	6.643
Tepee Creek abv IXL Road	7/17/2018	3.88	0.242
Wheeler Creek	04/18/18	1.2	3.03
White Creek nr mouth	03/21/18	2.32	68.5
White Creek nr mouth	05/09/18	1.89	30.5
White Creek nr mouth	08/08/18	0.86	0.407

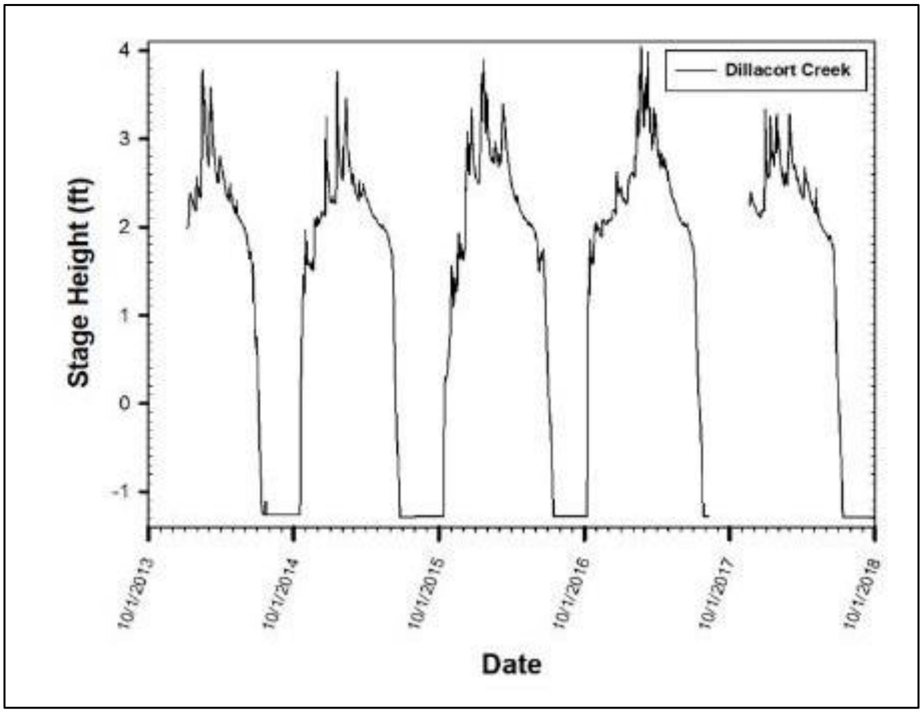


Figure 14. Dillacort Creek stage at the gaging site near the confluence with the Klickitat River for water years 2012 through 2018.

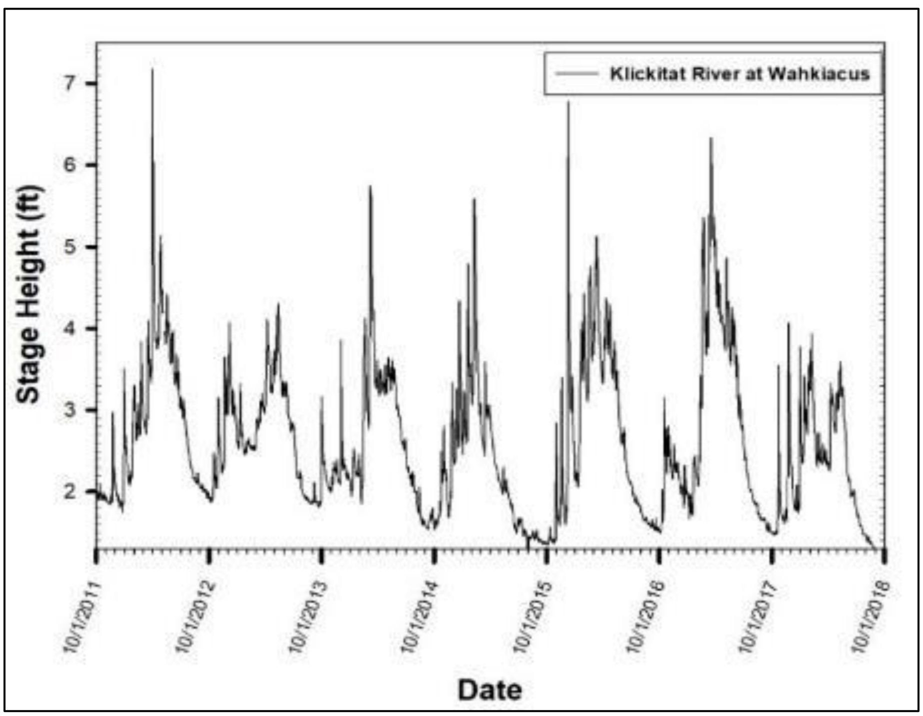


Figure 15. Klickitat River stage at the gaging site at the Klickitat Field Office near the town of Klickitat, WA for water years 2012 through 2018.

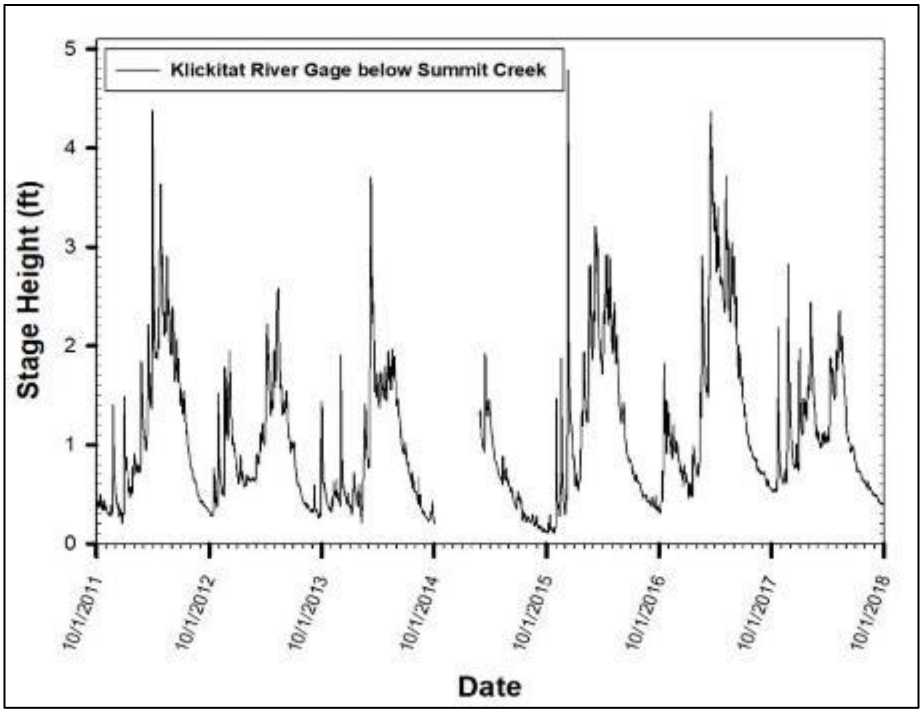


Figure 16. Klickitat River stage at the gaging site downstream of the mouth of Summit Creek for water years 2012 through 2018.

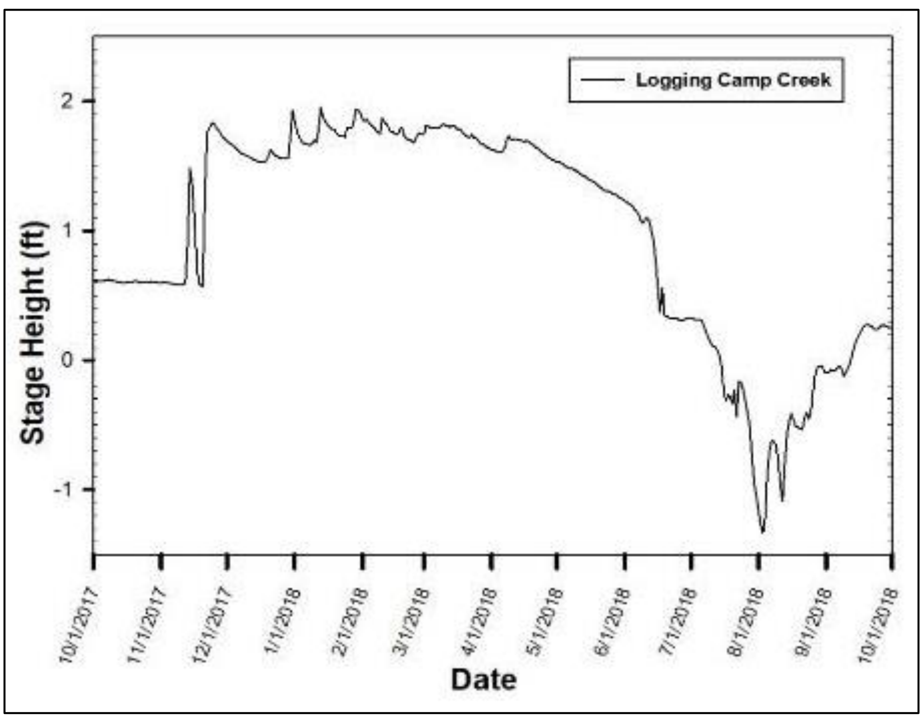


Figure 17. Logging Camp Creek stage at the gaging site near the confluence with the Klickitat River for water year 2018.

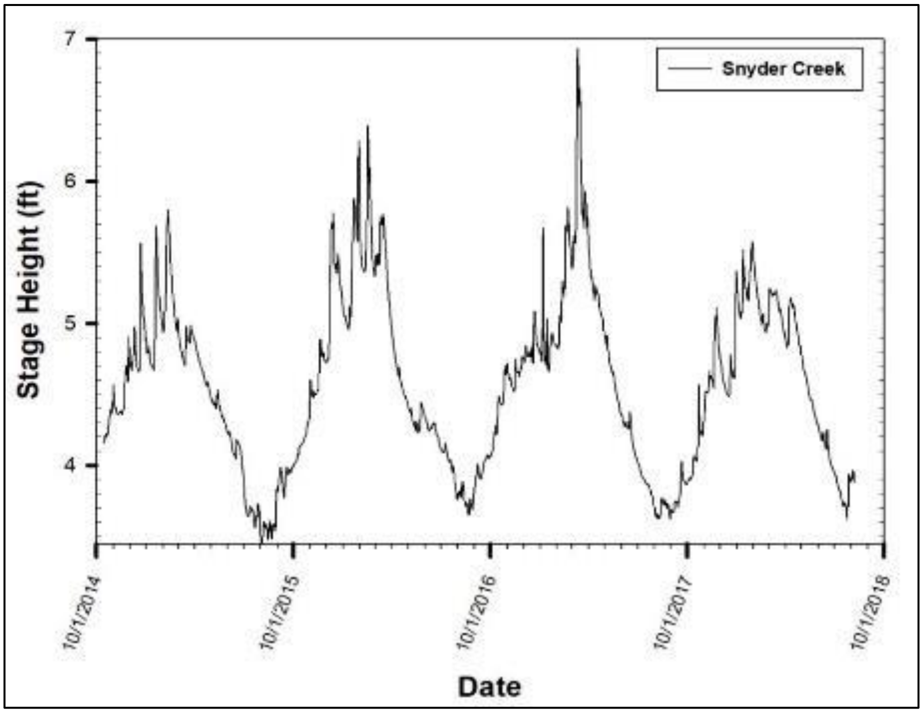


Figure 18. Snyder Creek stage at the gaging site near the confluence with the Klickitat River for water years 2015 through 2018.

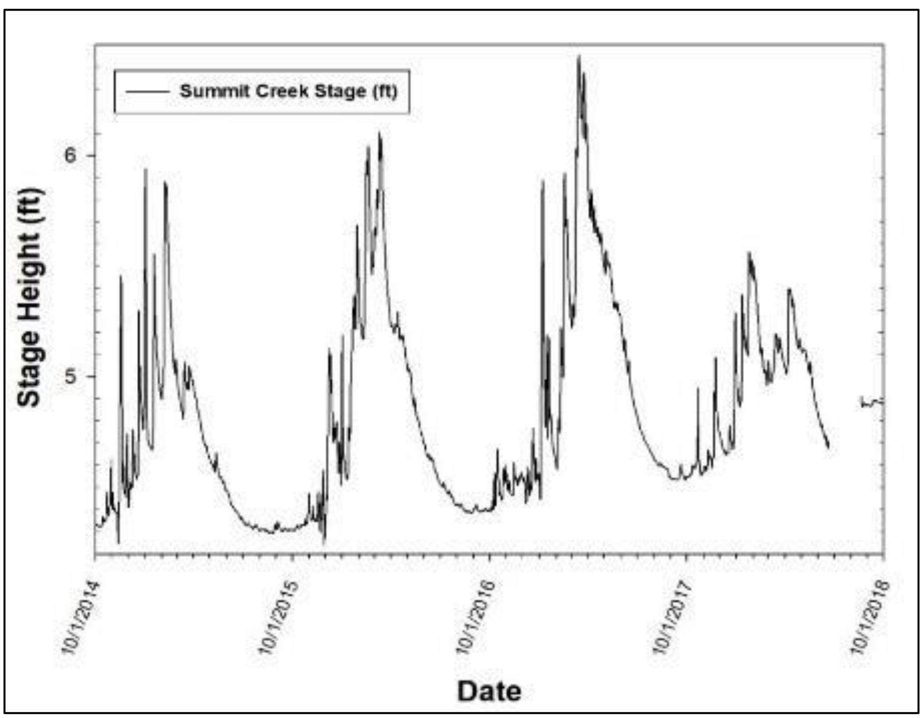


Figure 19. Summit Creek stage at the gaging site near the confluence with the Klickitat River for water years 2015 through 2018.

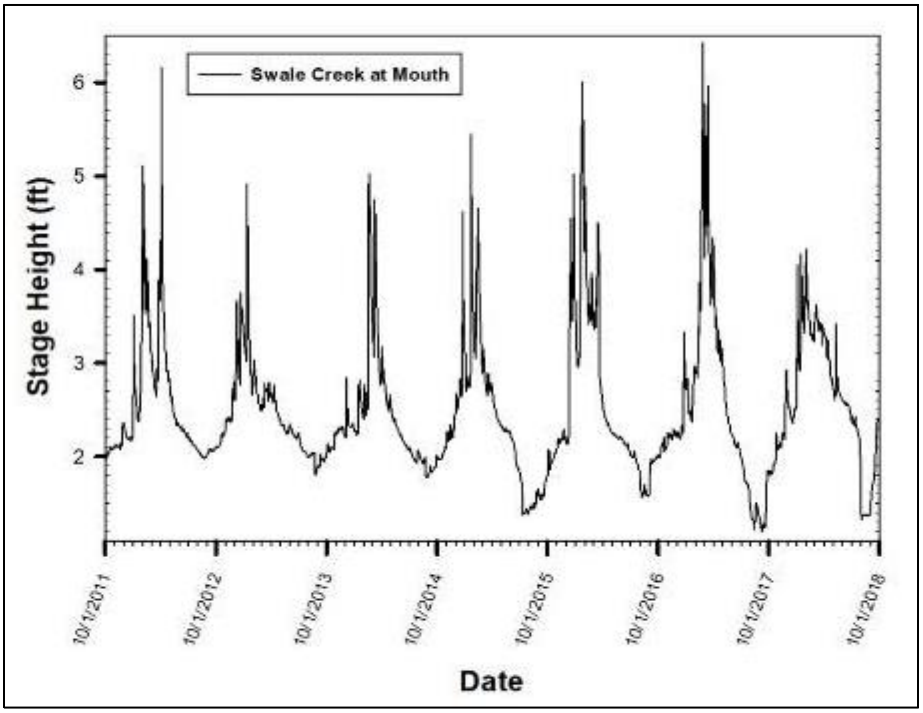


Figure 20. Swale Creek stage at the gaging site near the confluence with the Klickitat River for water years 2012 through 2018.

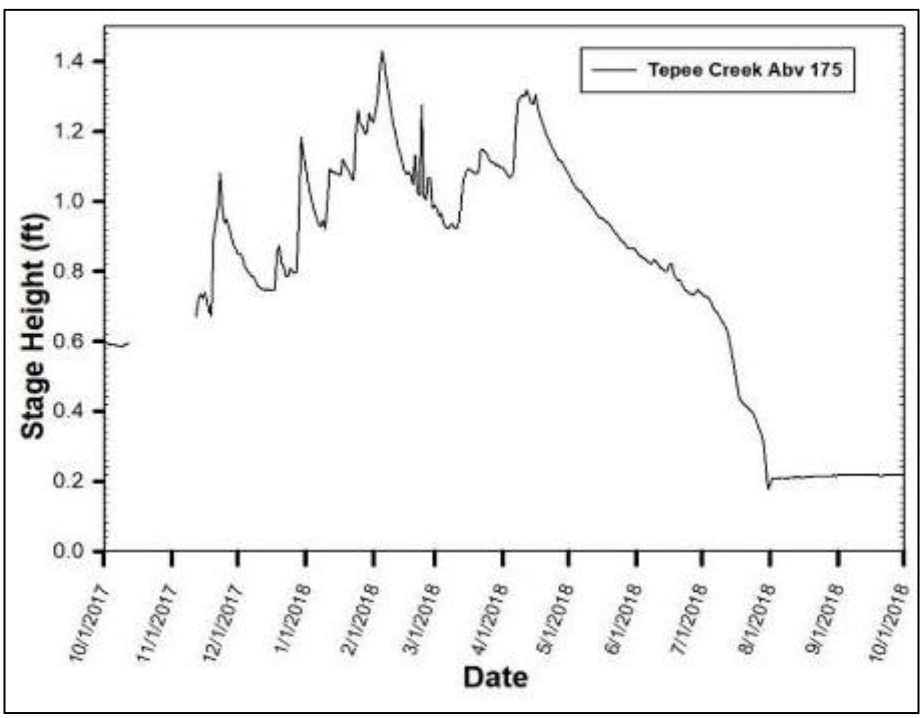


Figure 21. Tepee Creek stage at the gaging site above the 175 Road for water year 2018.

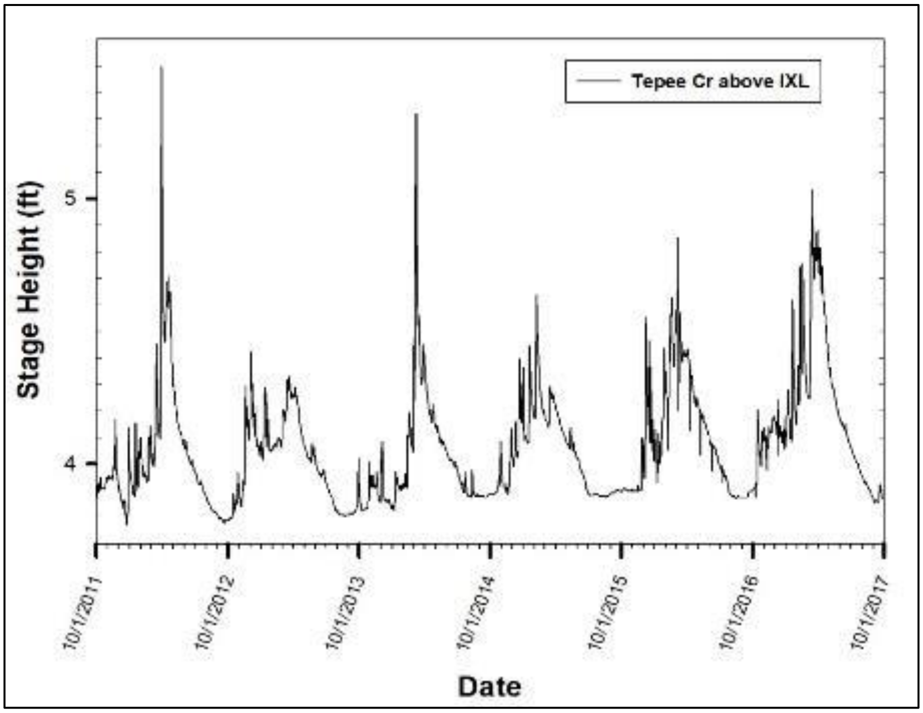


Figure 22. Tepee Creek stage at the gaging site above the IXL intersection for water ears 2012 through 2017.

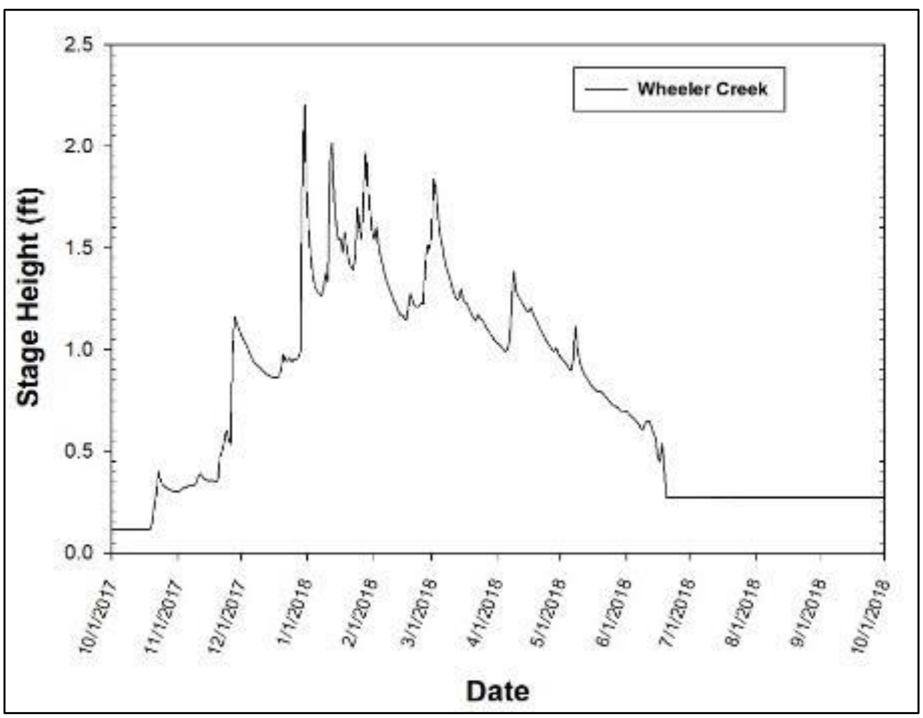


Figure 23. Wheeler Creek stage at the gaging site near the confluence with the Klickitat River for water year 2018.

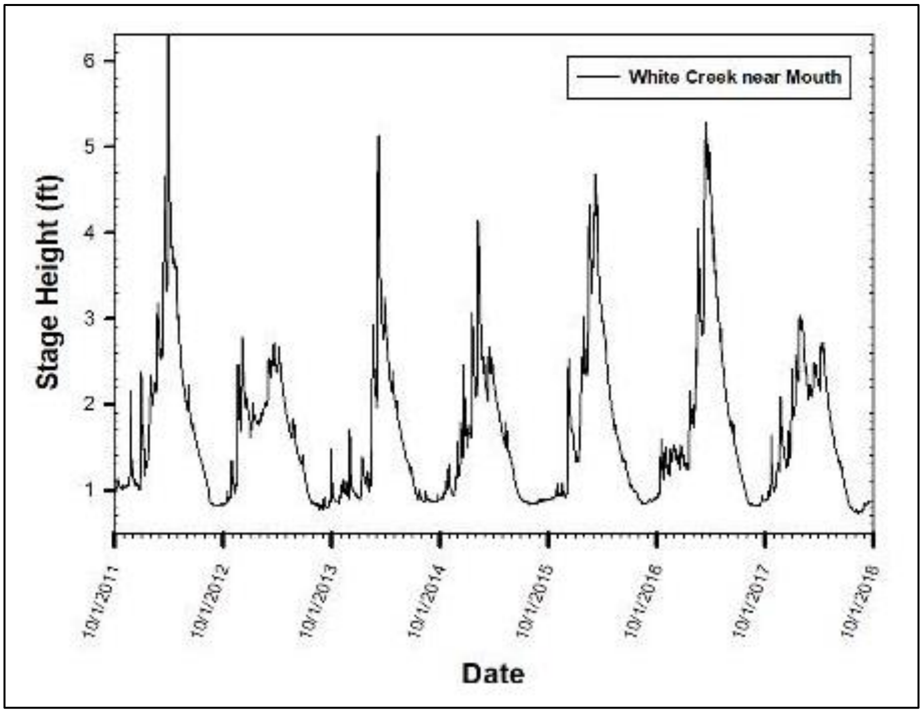


Figure 24. White Creek stage at the gaging site near the confluence with the Klickitat River for water years 2012 through 2018.

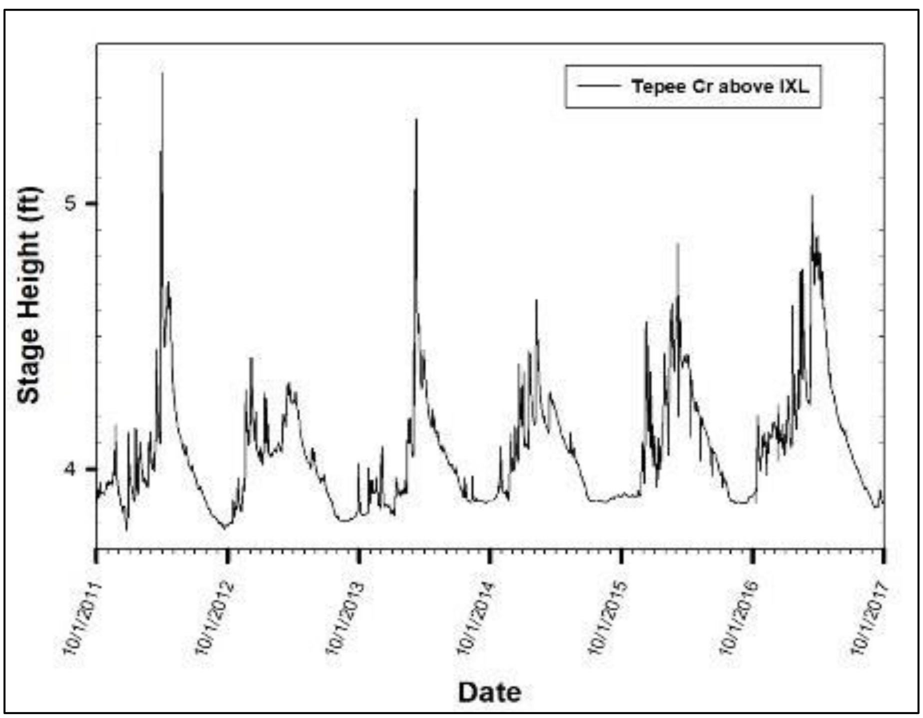


Figure 25. Tepee Creek stage at the gaging site near the intersection of the IXL and 175 roads for water wears 2012 through 2017.

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 2018, fish abundance surveys and groundwater monitoring was conducted. KWEP staff monitored groundwater elevations throughout 2017 via physical measurements and continuously deployed dataloggers (Figure 26Figure 27). Klickitat M&E personnel led fish abundance surveys conducted in June 2018. ***Results presented in Klickitat M&E annual reports.***

Invertebrate prey availability

To compare invertebrate prey availability between pre-and-post treatment conditions, estimates of invertebrate abundance, biomass, and composition from benthic, drift, and allochthonous sources were obtained seasonally during the study in treatment and control sub reaches. Benthic invertebrates are collected with a 500-µm net Surber sampler (0.09 m^2 area) at 3 random locations in riffle habitat in each sub reach sample section. Invertebrate drift is estimated by placing a 500-µm drift net (0.45 m x 0.20 m) in the thalweg of riffle habitat at the upstream and downstream end of each sub reach sample section. Drift nets were set for 20 minute intervals at dawn and afternoon. Staff positioned drift nets to intercept the total water column to ensure capture of invertebrates floating on the surface. Surber and drift samples were sieved (500-µm), large organic material removed, and organisms preserved in a 95% ethanol alcohol solution prior to processing.

During each sampling event, allochthonous invertebrate inputs were estimated from samples collected in pan traps (0.071 m^2) for 7 days. Nine pan traps were suspended 1 m above the water surface from rebar in each sub sample reach section. Pan traps were filled with approximately 3 cm of water with 2-3 drops of soap surfactant to help retain captured invertebrates. The wetted width of the stream reaches was divided longitudinally into three subsections (left, center, and right) and three pan traps are randomly placed in each subsection. During each sampling event, the random placement of pan traps was repeated in each sub reach sample section. Pan traps were sieved (500-µm) at the end of each 7-day sample period and preserved in a 95% ethanol alcohol solution prior to processing.

Resident rainbow trout and juvenile steelhead diet

During each sampling period, resident rainbow trout and juvenile steelhead were collected in each sub reach section to sample for stomach contents. Fish are collected 24 hours after instream invertebrate sampling to allow fish to return to natural foraging behavior. A variable waveform backpack electroshocker (Smith Root Inc., Vancouver, Washington) was used to collect fish. Electroshocking was conducted from the downstream end of each sub reach sample section to the upstream. Every effort was made to collect a minimum of 20 fish (≥ 70 mm fork length). Captured fish were placed in 5 gallon buckets with aerators. Sampling occured between 10:00 and 16:00 to include stomach contents of prey from aquatic and terrestrial derived sources.

Captured fish were anesthetized in a solution of water and MS-222 (Tricane methanesulfonate). Stomach contents were removed by a flushing procedure using a narrow pipetted bottle, strained into coffee filters, and placed into small plastic bags with 95% ethanol alcohol. For each fish, time and date of capture, length (nearest mm FL), and weight (to the nearest 0.1 g) are recorded. Each sampled fish receives a 12 mm Passive Interrogator Transponder Tag (Destron Fearing, South St. Paul, Minnesota). All fish were returned to their original location after fully recovering from anesthesia.

Invertebrate Identification

Invertebrates collected from the benthos, drift, pan traps, and fish stomachs were sorted under a dissecting microscope, taxonomically identified (primarily to the family level), enumerated, and measured to the nearest 0.5 mm using an eyepiece micrometer. Organisms were categorized as either aquatically or terrestrially derived based on the larval residence time in each environ. Macroinvertebrate biomass (dry mass mg•m^{-2}) is estimated using published taxon-specific length-mass regression equations. Lengths of partially digested organisms were estimated from intact individuals of the same taxon that appear to be of similar size.

The sampling of additional physical and biological attributes at the sampling sites was initiated in 2009 to document and assess pre-project baseline conditions. Elements included groundwater, low-flow refugia mapping, habitat survey/mapping, vegetation inventory, juvenile *Onchorhynkus mykiss* (Steelhead/Rainbow trout) abundance estimation, and a food web study.

Table 3. Summary of post-treatment food web samples collected spring 2018 – fall 2018.

Stream	Sample Type	Year	Season	# Benthic Samples	# Drift Samples	# Pan Trap Samples	# Stomach Samples
Tepee Ck	Treatment	2018	Spring	15	*	*	*
		2018	Summer	15	12	39	81
		2018	Fall	*	*	43	7
		2018	**Total**	**30**	**12**	**82**	**89**
White Ck	Control	2018	Spring	12	*	*	*
		2018	Summer	12	16	35	61
		2018	Fall	*	*	35	13
		2018	**Total**	**24**	**16**	**70**	**74**

*Seasons with sample types without numeric values not collected due to insufficient flows.

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 (Figure 26). 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, less in winter due to restricted access). Data from three wells with continuous sampling are depicted in Figure 27. In-stream construction was completed in 2013. Continuous groundwater elevation data through 2018 in Wells 1 and 6 (Figure 27) 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 summer of 2017, after a particularly heavy snow year, show a full season extension of groundwater at Well 1, though seasonal drops in groundwater were observed in Wells 6 and 7. In the 2018 water year, such low precipitation was observed at the Tepee 2 sites that KWEP staff were able to make a visit and download loggers in February; a trend that is also expressed in the lower peak water levels that winter and the pronounced low flow period in the summer of 2018. The data suggest that water is being stored within the project reach as groundwater, but does not generally persist year-round (except for Well 1 and 2017), and may not necessarily be expressed within the reach as surface flow at Tepee Creek stream gages.

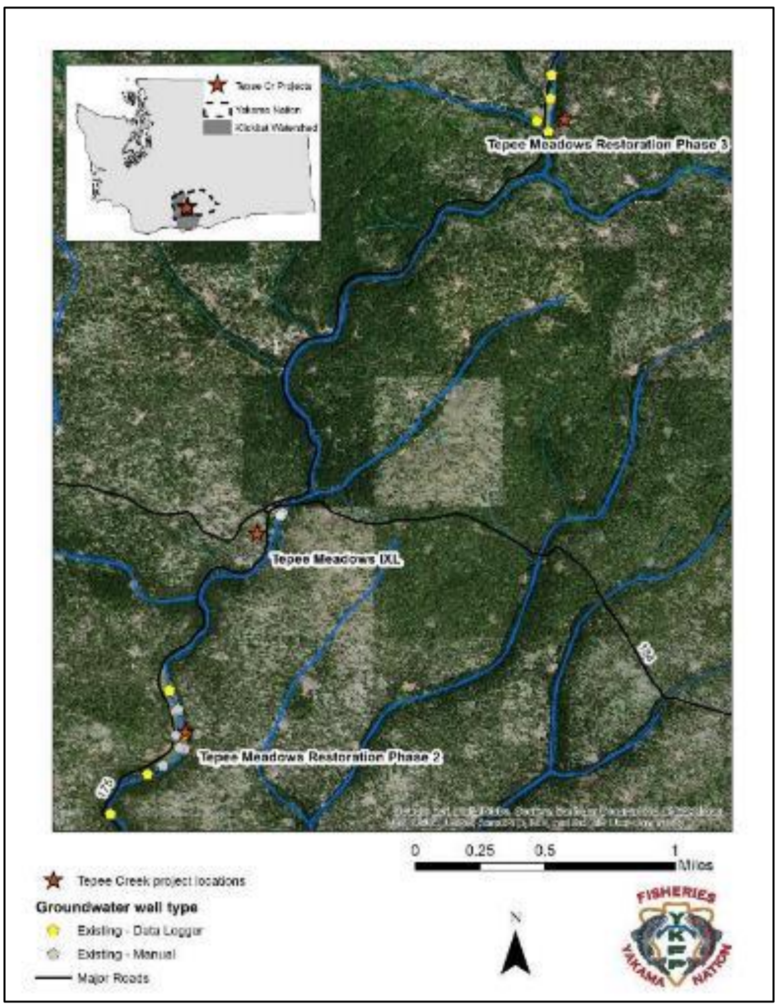


Figure 26. Locations of Tepee Creek Habitat Enhancement Projects and groundwater monitoring wells.

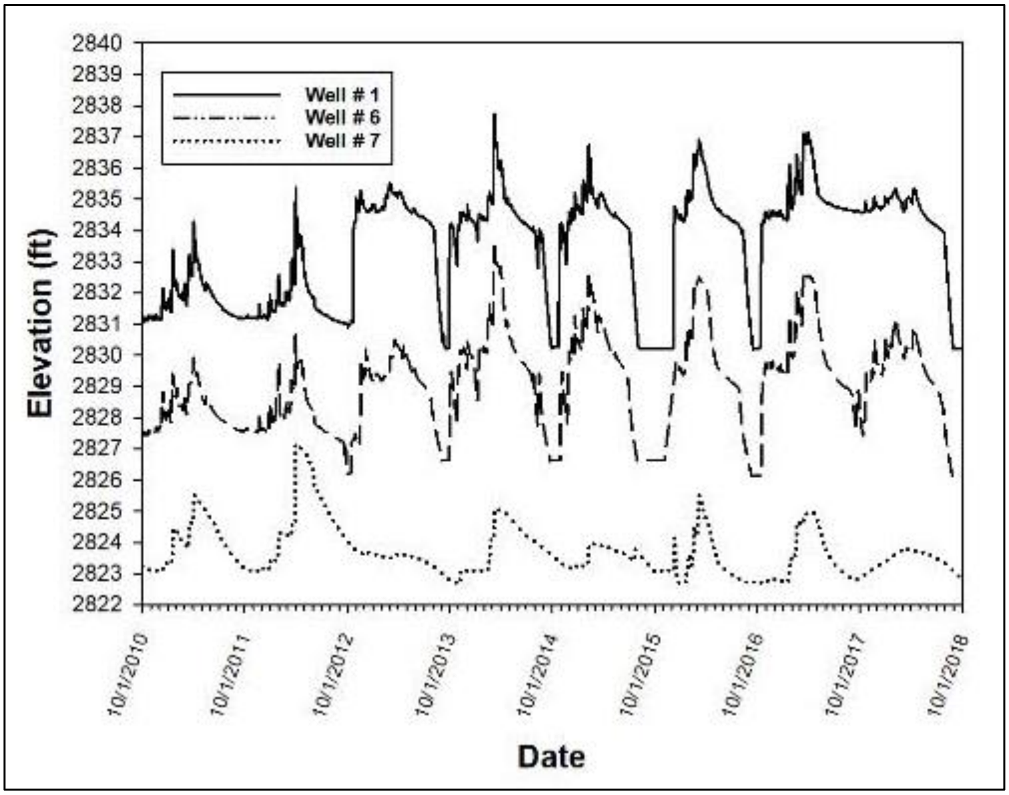


Figure 27. Groundwater well data at Tepee Creek 2 wells through Water Year 2018.

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 of 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 by CRITFC in 2017; the first year of sampling occurred in the spring 2018, sampling will continue in spring 2019. 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 quantity and availability.

During the 2018 reporting period, the sensor array installed in August of 2009 operated intermittently due to a failed sensor that occurred in the spring under high-flow conditions that prohibited safe access. 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 changes constantly because of high flows and depositional patterns (Figure 28).

KWEP staff conducted several site visits to the East Delta site during 2018 to swap out the 12-volt marine battery. Additional visits occurred to replace a faulty cell phone modem and water-level sensor that failed due to a leaky seal. The configuration of three solar panels struggles to maintain a voltage in excess of 11 volts in winter. Encroaching vegetation and low light exacerbated this situation.

Figure 28. Aerial view of Klickitat River Delta under low Bonneville Pool conditions as observed on June 19, 2018.

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. In 2018, the mainstem Klickitat River stations at Wahkiacus and downstream of Summit Creek functioned well without interruption of data collection.

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 a presentation on the White Creek LWD Project at the Columbia Gorge Fisheries and Watershed Science Conference in 2018 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 with visualization of basic principles of river behavior, channel morphology, and sediment transport processes. The stream table is central to the demonstration and educational content of curriculum presented to students from area schools. These outreach events facilitated interaction with approximately six hundred students and tens of adults via the Pathfinder Outdoor School, Camp Cowabunga and Water Jam (Figure 19). Curriculum focuses on watershed processes and their influence on aquatic fisheries habitat.

Figure 29. Stream table demonstration at Water Jam, the culminating event of the "Salmon in the Classroom" Program.

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