Tucannon Fish Habitat Enhancement Project

Confederated Tribes of the Umatilla Indian Reservation

2017-2018 Annual Progress Report

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BONNEVILLE
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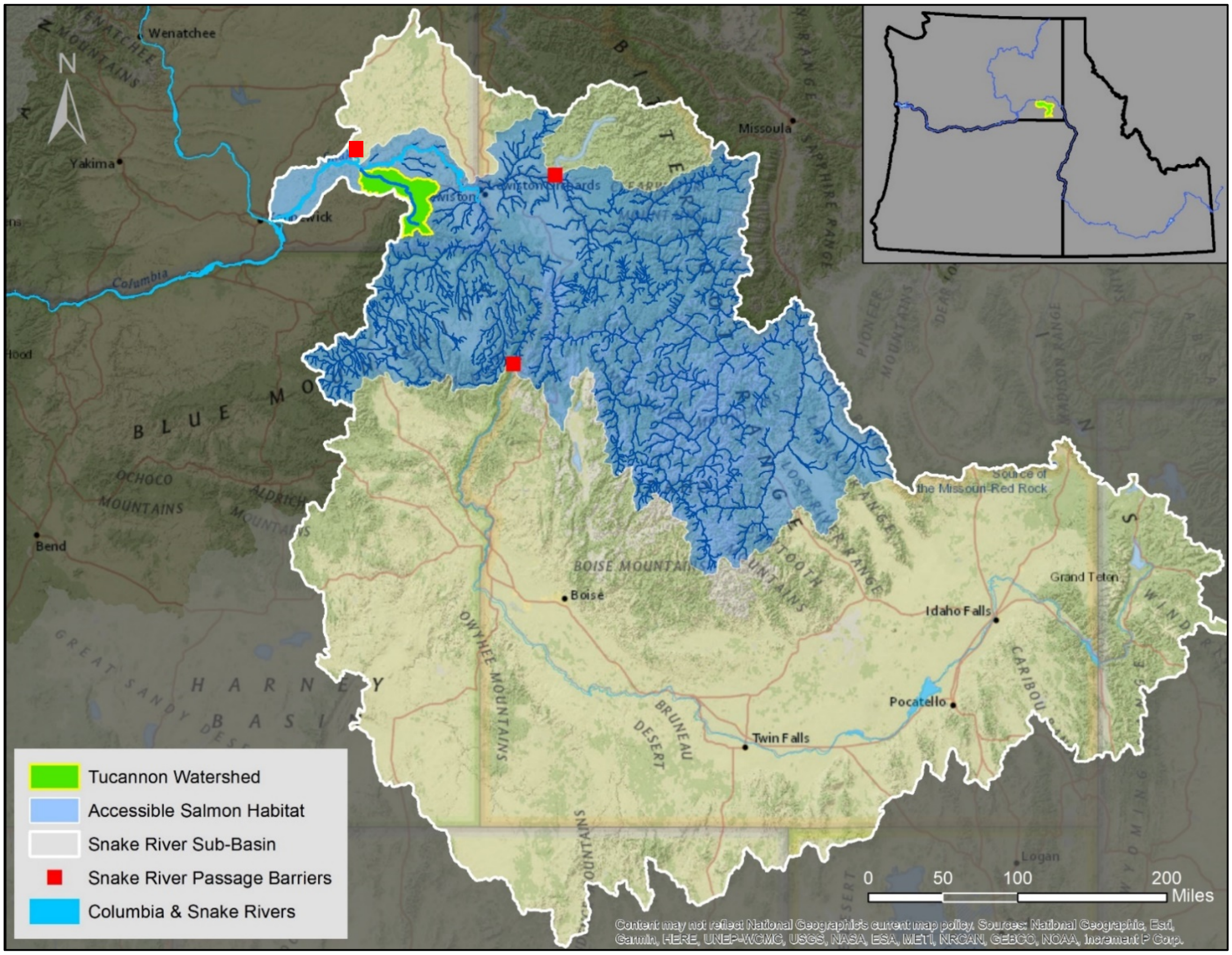
Background



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Geographic context of the Tucannon watershed and anadromous salmonid extent in the Snake River sub-basin. Much of the remaining salmonid habitat in the Snake River sub-basin is in protected wilderness. There are no significant salmon-bearing streams that occur downstream of the Tucannon River in the Snake River sub-basin.

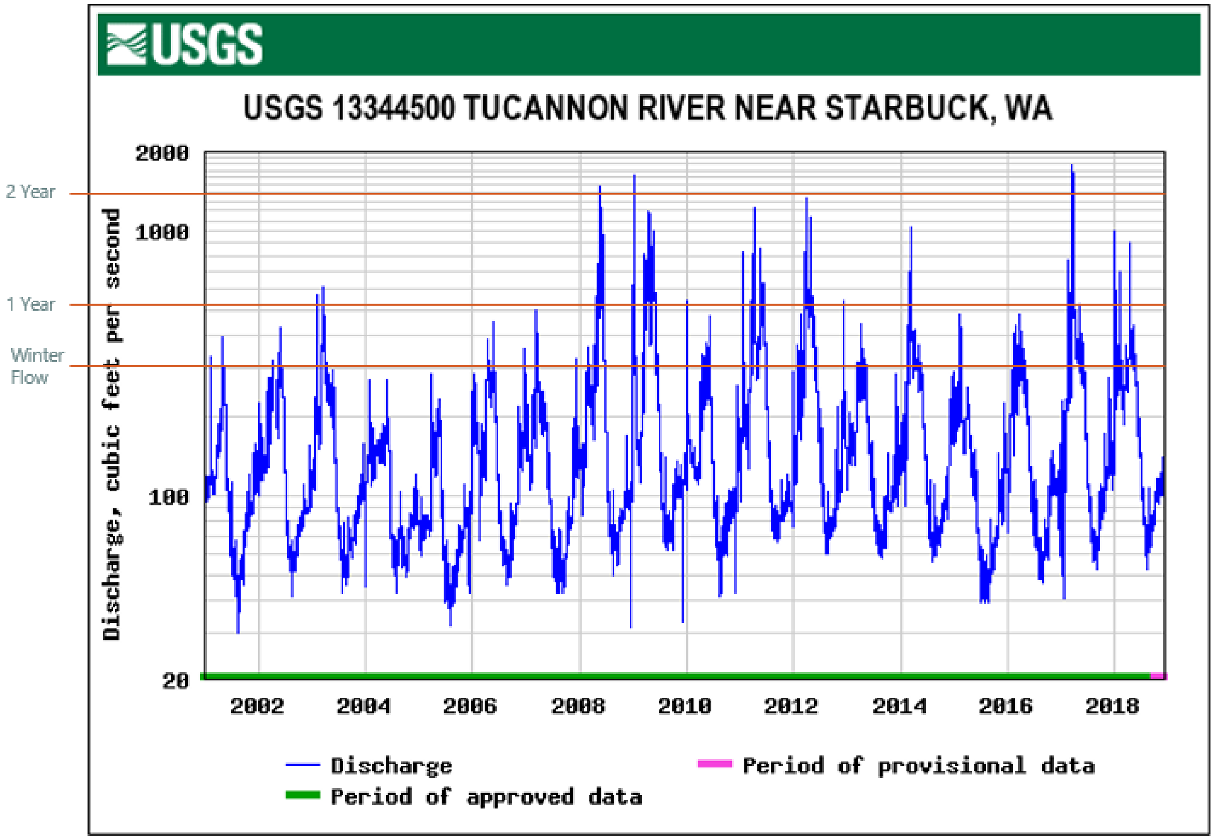
Due to the size and the amount of quality salmonid habitat remaining, the Snake River is one of the most important rivers for Chinook salmon (*Oncorhynchus tshawytscha*) in the Columbia River basin. Historically Chinook salmon runs in the Snake River totaled about 120,000 fish. But Snake River ESU Chinook populations declined throughout the 20th century and reached a critical low in the 1990s when the number of wild adults decreased to three naturally produced individuals. In April 1992, Snake River ESU spring and fall Chinook were listed as threatened under the Endangered Species Act.

The Tucannon River, in southeast Washington, is the most downstream, salmon-bearing tributary in the Snake River sub-basin. The main channel is approximately 58 miles long and drains approximately 503 square miles (m^2) from its headwaters in the Blue Mountains, to the mouth at the Snake River (CCD 2004). Several major tributaries drain into the main channel, the largest (by basin area) being Pataha Creek, which enters the main channel at RM 12.3. Pataha Creek is approximately 52 miles in length with a long, narrow watershed draining 185 mi^2. The second and third largest tributaries (by basin area) are Kellogg Creek (35 mi^2) and Willow Creek (30 mi^2).

Mean annual precipitation ranges from 10 inches at lower elevations to more than 40 inches at higher elevations. At higher elevations, much of the mean annual precipitation falls in the form of snow, with a basin mean annual snowfall of 65 inches (CCD 2004). The basin experiences multiple unique discharge peaks in a water year - one peak typically occurs as the result of a winter storm and the other the result of spring snowmelt. For the period of record, 32 of the maximum annual discharges occurred in December, January, or February, while only 18 maximum annual discharges occurred in March, April, or May. The spring peak discharge is often similar in magnitude to the winter storm peak discharge, although with a much longer duration driven by the length of the spring snowmelt.

The basin-scale hydraulic model produced in the *Tucannon River Geomorphic Assessment* (Anchor QEA, 2011a) indicates the river begins to overtop its banks at approximately 20% of the model cross-sections at the 2-year recurrence interval event. At the 5-year and 10-year events, it overtops the banks at approximately 35% and 50% of the sections, respectively. During the 50- and 100-year events, floodwater has overtopped the channel banks at over 80% of the cross-sections. During these extreme flood events, it is likely that a majority of the valley is inundated by some depth of water via bank overtopping, backwater, or flooding of side channels and tributaries.

It is believed that habitat-forming flows in the Tucannon River occur above the 2-year recurrence interval. The 2-year recurrence interval for the Tucannon River (Anchor QEA, 2011b) ranges from 1,275 cfs in the lower basin (river mile 4.8), to a low of 383 cfs and a high of 598 cfs in the upper basin (river mile 50.2). The 5-year return interval is 2,845 cfs in the lower basin (river mile 4.8), to a low of 854 cfs and a high of 1,334 cfs.



Annual hydrograph (discharge in cubic feet per second) for the lower Tucannon River at Starbuck, WA for the period of 2000-2019. The horizontal red lines indicate the average annual discharge for the winter base flow, one-year return interval (595cfs), and two-year return interval (1250cfs).

The Tucannon watershed consists primarily of Miocene-aged Columbia River Basalt (CRB) flows of the Grande Ronde, Wanapum, and Frenchman Springs members with recent Quaternary river alluvium along the valley floor. Basalt is exposed at the surface upstream of Tumalum Creek (river mile 35.5) and along the valley walls and gullies down from Tumalum Creek to river mile 18. Downstream of river mile 18, including within the Pataha and Willow Creek sub-basins, the basalt is overlain by loess deposits (fine sand and silt) of the Palouse Formation. In these areas, bedrock is only exposed in gullies and along valley slopes. The valley walls in much of the lower basin downstream of river mile 18 are composed of Quaternary flood outburst deposits consisting of stratified sand, gravel, and cobble. Alluvial fans line the valley floor at the mouths of tributaries; the fans tend to be large and wide in locations where tributaries drain loess-dominated sub-basins, and small and narrow in basins where mainly bedrock is exposed.

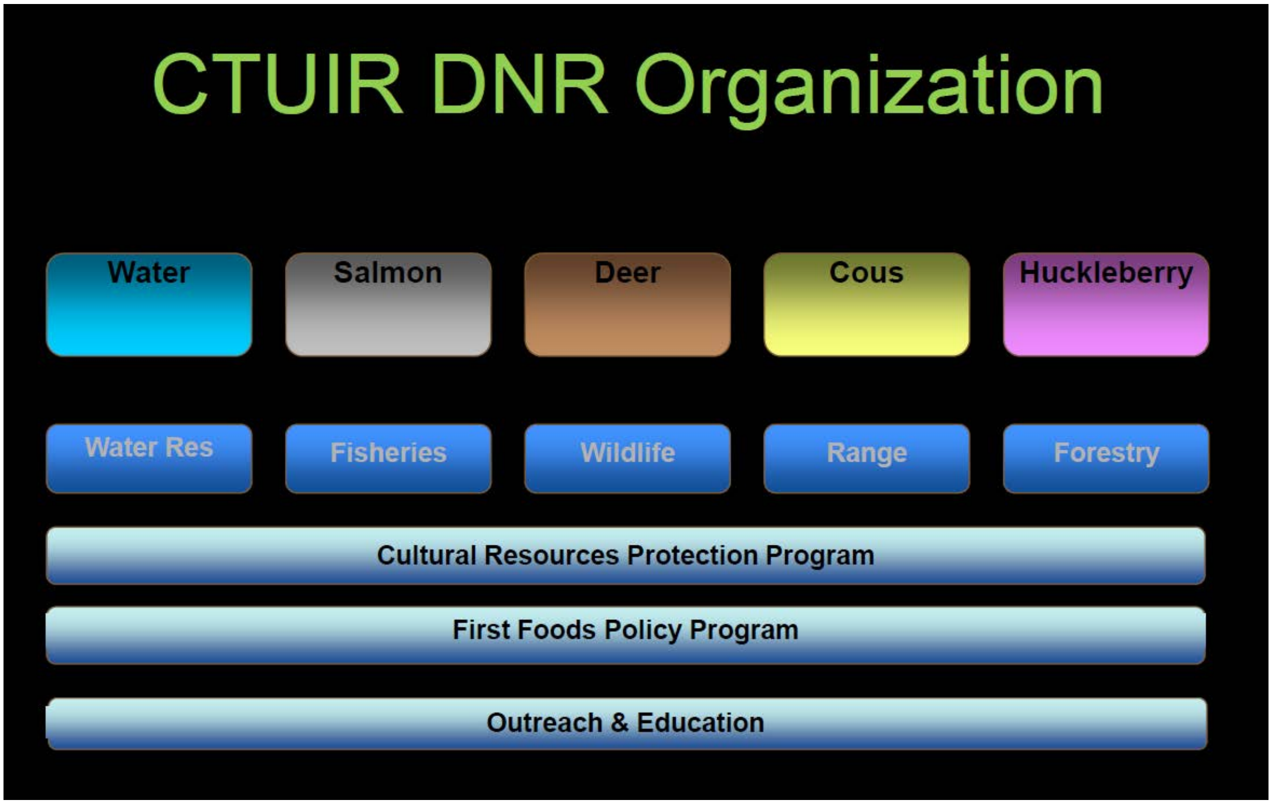
The Tucannon watershed supports the only remaining population of spring Chinook in the lower Snake River. Estimates suggest that the Tucannon once produced thousands of salmon annually. Currently the Tucannon River only produces a few hundred adult spring Chinook each year. Until recently the Tucannon River spring Chinook had been the primary focus of salmon habitat restoration efforts in the Tucannon River. In total, the Tucannon supports four populations of ESA threatened salmonid species including Snake River spring Chinook, Snake River fall Chinook, Snake River ESU summer steelhead, and the Columbia River bull trout. All reaches of the Tucannon River are utilized during one or more life history stages for all four salmonid species.

The Tucannon also provides habitat for imperiled, non-salmonid, native aquatic species which are valued by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and the Nez Perce Tribe. Some of the imperiled and tribally-valuable native aquatic species in the Tucannon River include lamprey, several varieties of freshwater mussel, mountain whitefish (*Prosopium williamsoni*), and others. Most populations of native aquatic biota in the Tucannon River have lower population abundances than would be expected under optimal habitat conditions.

Since time immemorial the CTUIR has had a vested interest in maintaining sustainable populations of salmonids in the Tucannon River. When the leaders of the Walla Walla, Cayuse, and Umatilla peoples (CTUIR) signed the Treaty of Walla Walla in 1855, they ceded 6.4 million acres (26,000 km^2) of their homeland that is now northeastern Oregon and southeastern Washington. This was done in exchange for a reservation of 250,000 acres and retained the right of CTUIR members to harvest their traditional foods, including salmon, within their “usual and accustomed” territory. The Tucannon River is located in southeast Washington State within the “usual and accustomed” or ceded territory of the CTUIR.

CTUIR Natural Resource Management Philosophy and Salmon Recovery

In 2007, the CTUIR Department of Natural Resources (DNR) established their First Foods Policy to guide and inform CTUIR's natural resource management. The First Foods are considered by the CTUIR to constitute the minimum ecological products necessary to sustain CTUIR culture. The CTUIR DNR has a mission to protect First Foods and a long-term goal of restoring related foods for the Tribal community. The mission was developed in response to long-standing and continuing community expressions of First Foods traditions, and community member requests that all First Foods be protected and restored for their respectful use now and in the future.



CTUIR DNR Organization

Water	Salmon	Deer	Cous	Huckleberry
Water Res	Fisheries	Wildlife	Range	Forestry

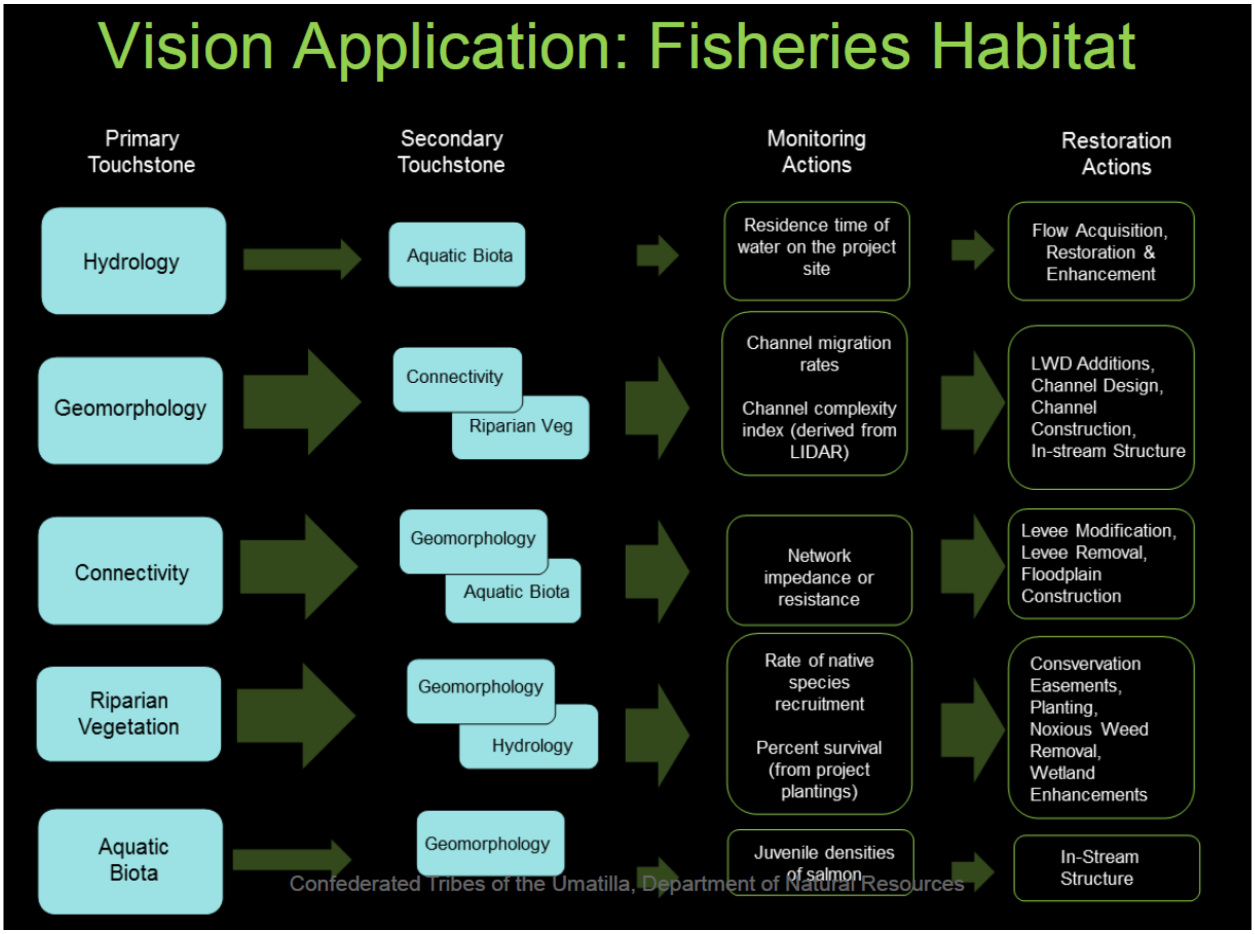
Cultural Resources Protection Program

First Foods Policy Program

Outreach & Education

First Foods Policy organizes the CTUIR Department of Natural Resources according to five categories of traditional CTUIR subsistence foods. For each of the five categories of *First Foods* a program has been developed within the CTUIR DNR. For example, the CTUIR fisheries program manages aquatic biota (salmonids and other organisms) that are important to CTUIR members.

The CTUIR First Foods Policy led to the creation of the CTUIR River Vision guidance document in 2008 (Jones et. al, 2008). River Vision identifies ecological processes and conditions necessary to sustain aquatic First Foods. CTUIR fish habitat enhancement staff use River Vision to prioritize and inform their fish habitat restoration objectives. River Vision also establishes CTUIR's interest in fish habitat enhancement throughout their "usual and accustomed" or ceded territory.



Vision Application: Fisheries Habitat

Primary Touchstone	Secondary Touchstone	Monitoring Actions	Restoration Actions
Hydrology	Aquatic Biota	Residence time of water on the project site	Flow Acquisition, Restoration & Enhancement
Geomorphology	Connectivity Riparian Veg	Channel migration rates Channel complexity index (derived from LIDAR)	LWD Additions, Channel Design, Channel Construction, In-stream Structure
Connectivity	Geomorphology Aquatic Biota	Network impedance or resistance	Levee Modification, Levee Removal, Floodplain Construction
Riparian Vegetation	Geomorphology Hydrology	Rate of native species recruitment Percent survival (from project plantings)	Conservation Easements, Planting, Noxious Weed Removal, Wetland Enhancements
Aquatic Biota	Geomorphology	Juvenile densities of salmon	In-Stream Structure

Confederated Tribes of the Umatilla, Department of Natural Resources

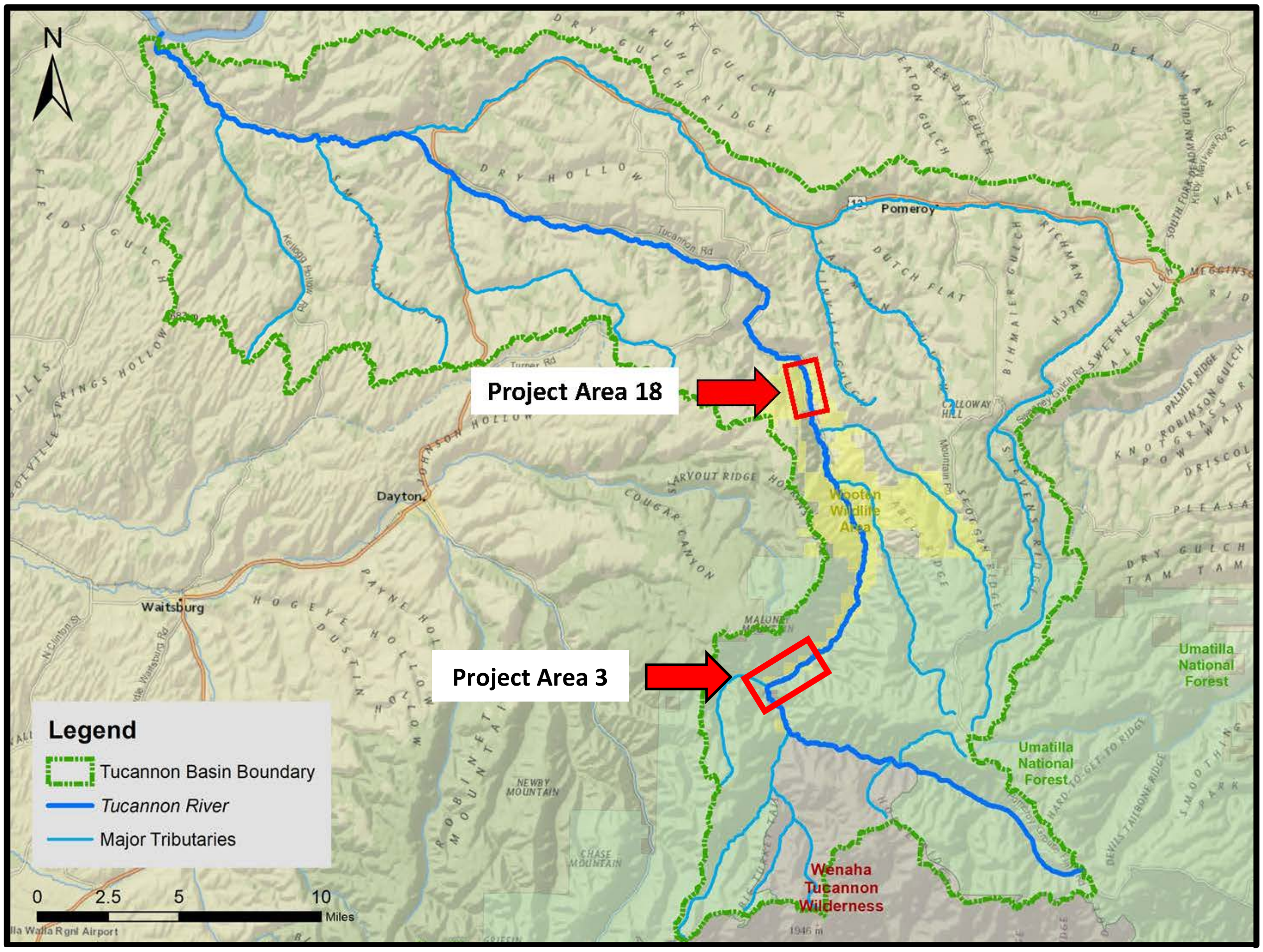
River Vision outlines five fundamental components or ecological "touchstones" of rivers that facilitate the sustained production of aquatic *First Foods*. The goal for all CTUIR fish habitat enhancement projects is to completely address all five of the *River Vision* touchstones for a given restoration treatment.

The CTUIR's Tucannon Fish Habitat Enhancement Project (TFHP) was initiated by CTUIR in August of 2009. The goal of the CTUIR TFHP is to collaborate with federal, state and local agencies, using the River Vision guidance framework to design and implement salmon habitat restoration projects in the Tucannon River. It is expected that improved habitat conditions in the Tucannon River will lead to an increased abundance of ESA-listed salmonids returning to the Tucannon River.

Aquatic habitat restoration on the Tucannon River, conducted as part of the broader salmon recovery effort in the Columbia River basin, has been guided by several documents. Habitat limiting factors for Tucannon River salmonids were first identified in the Tucannon Sub-basin Plan (CCD 2004) and the Snake River Salmon Recovery Plan (SRSRB 2011). A Geomorphic Assessment of the entire Tucannon watershed was conducted in 2011 (Anchor QEA 2011a). The understanding of physical conditions and geomorphic processes that was gained from the Geomorphic Assessment, combined with the habitat-limiting factors, was then used to identify and prioritize habitat restoration opportunities within a Conceptual Restoration Plan (Anchor QEA 2011b) for the entire mainstem Tucannon River.

Aquatic habitat restoration efforts on the Tucannon River focus primarily on addressing two habitat-limiting factors: (1) limited floodplain connectivity, and (2) limited channel complexity. Both of these limiting factors are the consequence of human manipulations of the river channel, floodplain, and riparian vegetation. Past land use practices including logging, livestock grazing, irrigated agriculture, and construction of the Tucannon Lakes (recreational fishing ponds with annually planted hatchery trout) have resulted in an over-simplified stream channel and drastically reduced habitat capacity for adult and juvenile salmonids.

Between 2017 and 2019 the TFHP successfully implemented two aquatic habitat restoration treatments on the Tucannon River. In 2017, TFHP added ~765 pieces of large wood, removed a channel confining push-up berm, and reconnected three side-channels over 1.2 miles of the Tucannon River in a river reach designated as Project Area 18. In 2018 TFHP added 720 pieces of wood over 1.5 miles of the Project Area 3 reach in an effort to facilitate reconnection of historic side channels within the reach. River restoration activities were conducted by TFHP on the Tucannon River under BPA Project Number 2008-202-00, intergovernmental agreements 73982 REL 15 and 73982 REL 41.



Locations of restoration projects completed by CTUIR Tucannon Fish Habitat Enhancement Project between 2017 and 2018.

Methods

Project Area 18 Treatment Reach – Tucannon River, miles 33.1-34.3

Project Area 18 of the Tucannon River, was originally settled as a homestead in the early 1900's. Eventually WDFW purchased the land surrounding the reach as part of the W.T. Wooten Wildlife Area. Within PA18 the river channel had been pushed to the east hill slope, straightened and leveed in place to allow for agriculture production. Once the river was confined on the east side of the valley, the river straightened, water velocities increased, habitat simplified and the river dug itself into a trench (incised) removing all the small gravel from the reach. This removed all the gravel that formed pools for adult holding and gravel bars for spawning, limiting aquatic habitat diversity.

Goal: CTUIR sought to enhance the Primary Touchstones of River Vision within PA18, to the maximum extent possible. The goals of the Southeast Washington Salmon Recovery Plan included instream wood replenishment, increasing channel complexity, and reconnecting the river to its floodplain.

Objectives:

1) Replenish instream wood to two key pieces of wood per channel width.

2) Design large wood structures to:

- Raise the bed elevation, reconnecting the river and floodplain
- Decrease stream velocities and increase sediment deposition throughout the reach
- Increase connectivity using old side-channels throughout the reach
- Increase the local water table through hyporheic exchange with the alluvial aquifer

3) Replenish the floodplain forest with native tree plantings.

Large Wood

"Two key pieces of wood per channel width" is the wood loading target for the Tucannon River (SRSRB 2011). The minimum number of key pieces of wood necessary to achieve the target quantity for PA18 is ~255. Approximately 415 key pieces of wood were placed in PA18 as part of this restoration treatment. For each key log a corresponding "tree top" log was placed upstream of log structures to provide racking for constructed log structures. Key pieces of wood are defined as logs >6m long and 0.3m diameter (*CHaMP 2014*). The diameter of wood was measured at breast height for rootwad logs and at center for poles.

The large wood structures that were constructed in PA18 were designed to address the two primary habitat-limiting factors of the Tucannon River in the following ways:

1) Increase floodplain connectivity
    a) Engineered log jams provide hard points on the stream bank that maintain bifurcation of flows between the main channel and side-channels.
    b) Channel spanning log structures reduce stream velocities and allow for sediment aggradation, raising the stream bed elevation closer to the floodplain elevation.
    c) Large wood increases water displacement in the main channel, reducing the discharge necessary for achieving bank full water surface elevation.

2) Increase channel complexity
    a) Large wood breaks up stream flow which sorts gravel and increases bedform heterogeneity and spawning habitat quantity.
    b) Large wood distributed throughout the reach increases stream velocity refuge for all salmonid life history stages.
    c) Large wood facilitates the formation of pool and/or adult holding habitat by increasing scour around structures and individual pieces of wood.

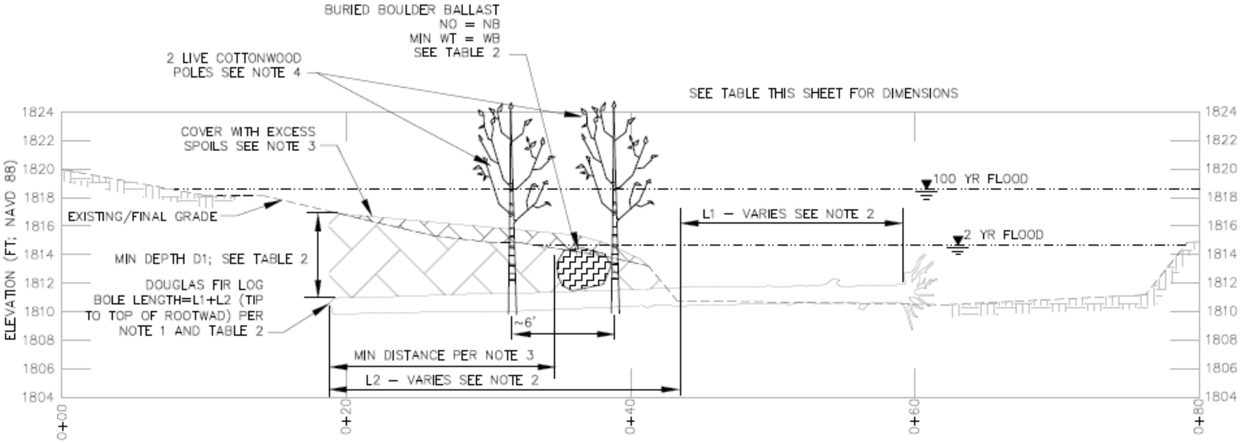
The restoration treatment in PA18 included several different types of large wood structures, which were designed for a variety of purposes and functions:

Embedded Logs

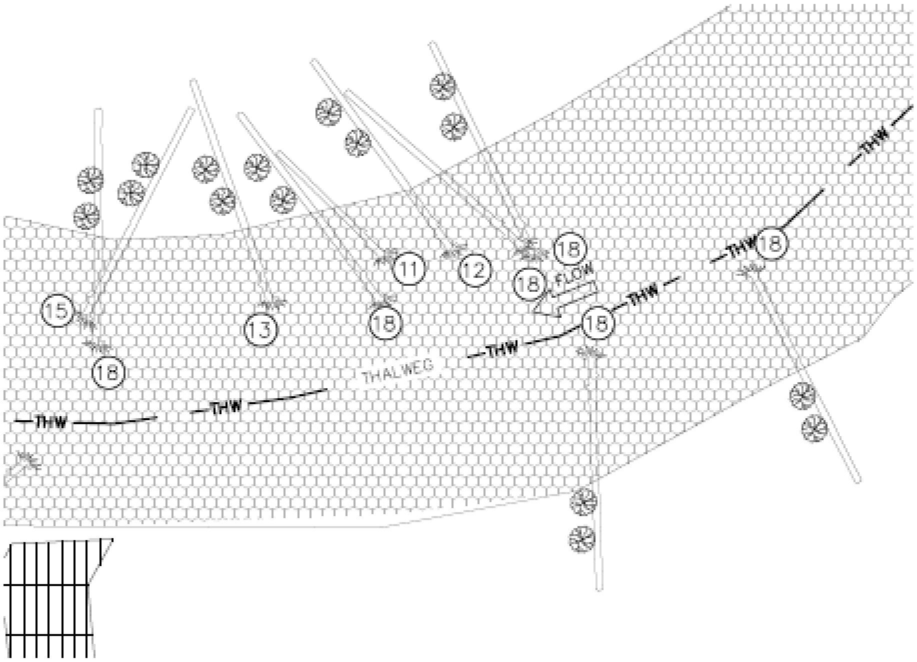
Trenches were excavated into the stream bank toe and floodplain. Individual logs (DBH 12”-24”) were placed in the excavated trenches with rootwads lying on the streambed surface. Logs were installed with varied lengths projecting into the stream channel. Boulders were placed on top of the logs to provide ballast and stability. Logs and ballast boulders were backfilled with excavated substrate to anchor them in place.

Embedded logs were distributed throughout the reach to provide instream habitat and gravel sorting functions. Some structures were set along one bank to create scour pools in the stream sediment and to provide hiding cover for juvenile salmonids. In other locations, embedded logs were placed on opposing banks to concentrate the stream current and scour out a deeper channel while also providing instream velocity refuge and overhead cover for adult and juvenile salmonids.

Embedded logs were set in locations where the channel was relatively straight with low banks, decreasing the probability of scouring and erosion that could result in the early loss of logs. These structures were constructed consistent with a general criterion for wood placement in plane bed streams with bankfull widths of around 50 feet and slopes less than 2% (e.g., ODF/ODFW 1995; NRCS 2001, 2007).



Example schematic of embedded bank log structures that were installed on PA18 of the Tucannon River



Plan view schematic of embedded bank log structures that were installed on PA18 of the Tucannon River. The "THW" line indicates the river thalweg. The circles with numbers indicate the length of protrusion for each log.

Floating Log Jams

Floating log jams are more natural in appearance and are free to shift position or become entrained by the river during flooding, moving to downstream locations that are potentially more stable. Logs for these structures were specified to be 1.5 times longer than the bankfull width of the Tucannon River. This design criterion increases the stability of log accumulations (WDFW, 2012).

Helicopters were used to place floating log jams in segments of the project reach where use of heavy equipment would result in substantial disturbance of riparian vegetation or the river bottom. Using helicopters to place anchor boulders and logs minimized riparian disturbance. Large, galvanized eye bolts were set into anchor boulders with epoxy to aid log attachment. Logs were lashed to anchor points, such as boulders, and trees in the floodplain, using biodegradable hemp rope. Log jams were arranged in an interlocking array such that flood drag forces would push rootwads together in place. Additional stabilizing forces were facilitated by placing logs in a pile with enough weight (from logs and/or boulders) to create a static load that could hold the structures in place under most conditions.

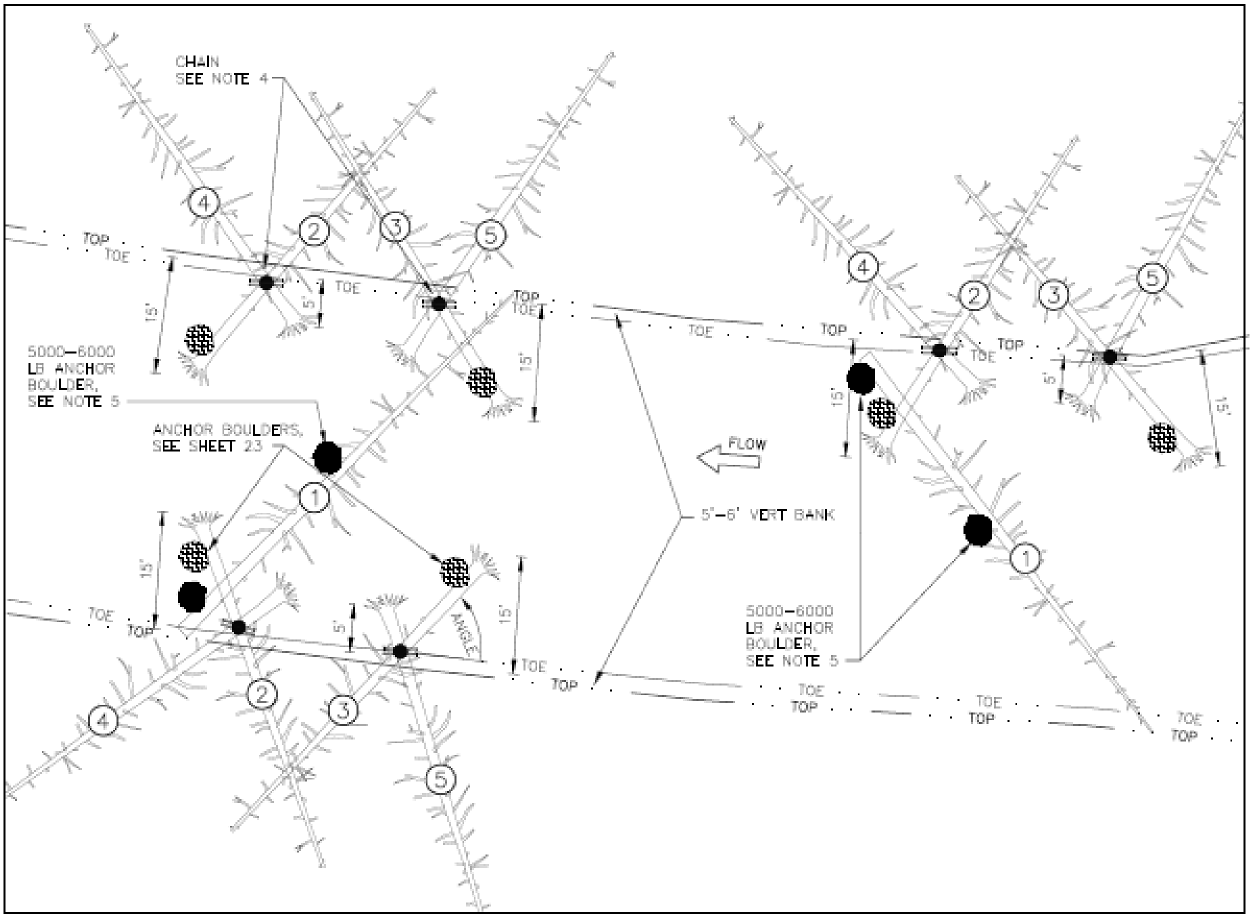
Floating log jams were placed in a variety of different configurations:

(i) Single logs with rootwads sticking out into the channel

(ii) Multiple logs arranged in a triangle apex pointing into the channel

(iii) Channel spanning logs across the stream bed

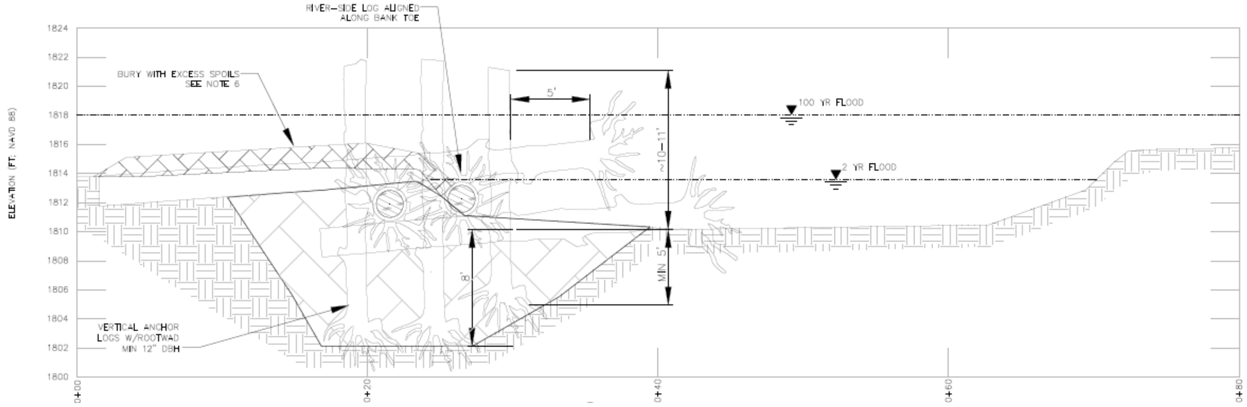
(iv) Apex log jams on the upstream side of gravel bars



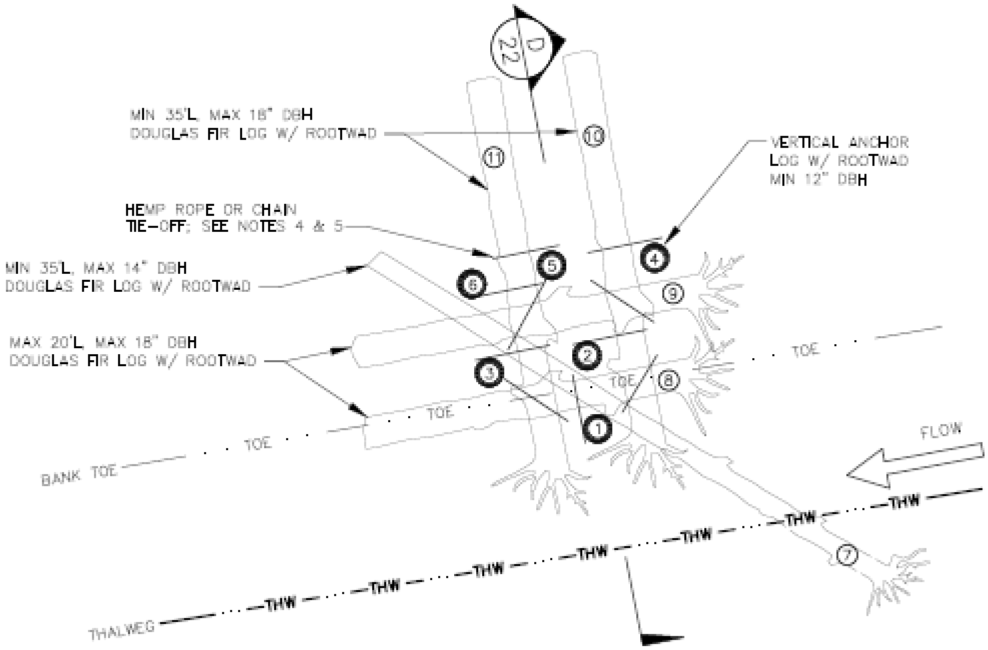
Example floating log jams with anchor boulders placed by helicopter. Black dots where logs overlap indicate points where logs were lashed together with biodegradable hemp rope.

Engineered Log Jams (ELJs)

ELJs were sited and designed to split the flow of the main channel into side channels and/or excavated pilot channels. Several logs were placed horizontally in an excavated hole, stacked and crisscrossed at perpendicular angles with adjacent logs. Horizontal logs were oriented with rootwads protruding into the stream channel. Additional Logs with rootwads were placed vertically in the hole and lashed to the horizontal logs with hemp rope. The horizontal logs and rootwads of vertical logs were buried with a mound of excavated substrate.



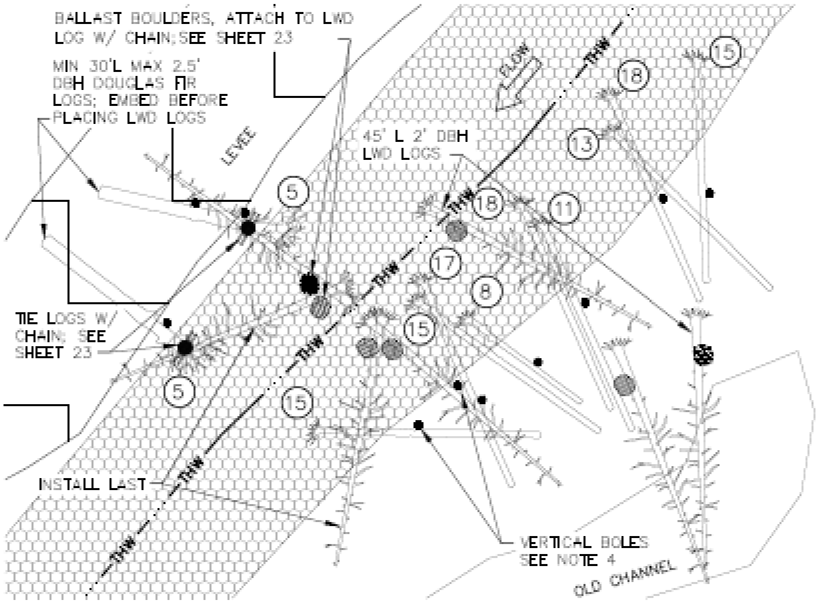
Example schematic of the engineered log jams that were built on PA18 of the Tucannon River



Plan view schematic of the engineered log jams that were built on PA18 of the Tucannon River

The "Catcher's Mitt"

A large, heavily anchored structure was constructed at the most downstream location in the PA18 reach. Several large logs with rootwads were embedded into opposing stream banks and buried with ballast rock and excavated substrate. The portion of logs that protruded into the channel were also lashed to instream anchor boulders with galvanized chain, providing additional stability. The heavily fortified structure is designed to intercept debris that gets swept away from upstream structures, protecting downstream infrastructure.



"Catcher's Mitt" structure constructed at furthest downstream extent of PA18

Habitat Boulders

Two boulder clusters (one cluster of nine, and one cluster of 6) were installed within the PA18 project reach. Boulder clusters were established to increase instream habitat diversity for steelhead and other salmonid species (e.g., > 2 ft wide boulders, Ward and Slaney 1979). Boulders were designed to remain stable and provide suitable refuge from the stream current (for fish) over a wide range of flows. Habitat boulders were placed in runs and the lower half of riffles on gradients between about 1-3% (Mooney et al. 2007). Habitat boulder siting and design specification was informed by existing in-stream boulders throughout the reach. Boulder cluster analogs are located where the river abuts the valley toe-slope and exposes basaltic bedrock, contributing to boulder accumulations in the stream channel.

Pilot Channels

Pilot Channels were excavated at the upstream junction of historic side channels that are not connected to the Tucannon River at most flows. Large wood structures were designed and constructed downstream of pilot channels. Large wood – pilot channel complexes were designed to collect sediment and water on the upstream side of the large wood structures and divert a portion of the main channel flow into the side channel.

Push-up Berm Removal

In the 1960's bulldozers were used to dredge the Tucannon River bed, straightening the channel. Stream flows within the main channel of the Tucannon River became confined by mounds of river alluvium that had been piled on the stream banks. Much of the channel confinement on the Tucannon River today is a legacy of these historic actions to control the Tucannon River. Whenever possible, restoration treatments on the Tucannon River attempt to remove legacy push-up berms, and return the historic alluvium back to the Tucannon River. One such push-up berm was returned to the Tucannon River as a part of the PA18 restoration treatment.

Project Area 3 Treatment Reach – Tucannon River, miles 46.7-48.2

In the summer of 2014 large wood was placed in PA3 to aggrade the channel bed and increase in-stream habitat complexity. Rapid Habitat Surveys (RHS) were conducted before and after implementation of the 2014 restoration treatment, and once more in 2017. RHS data revealed wood loading for PA3 had decreased below the target and was used to inform adaptive management decisions for the reach in 2018.

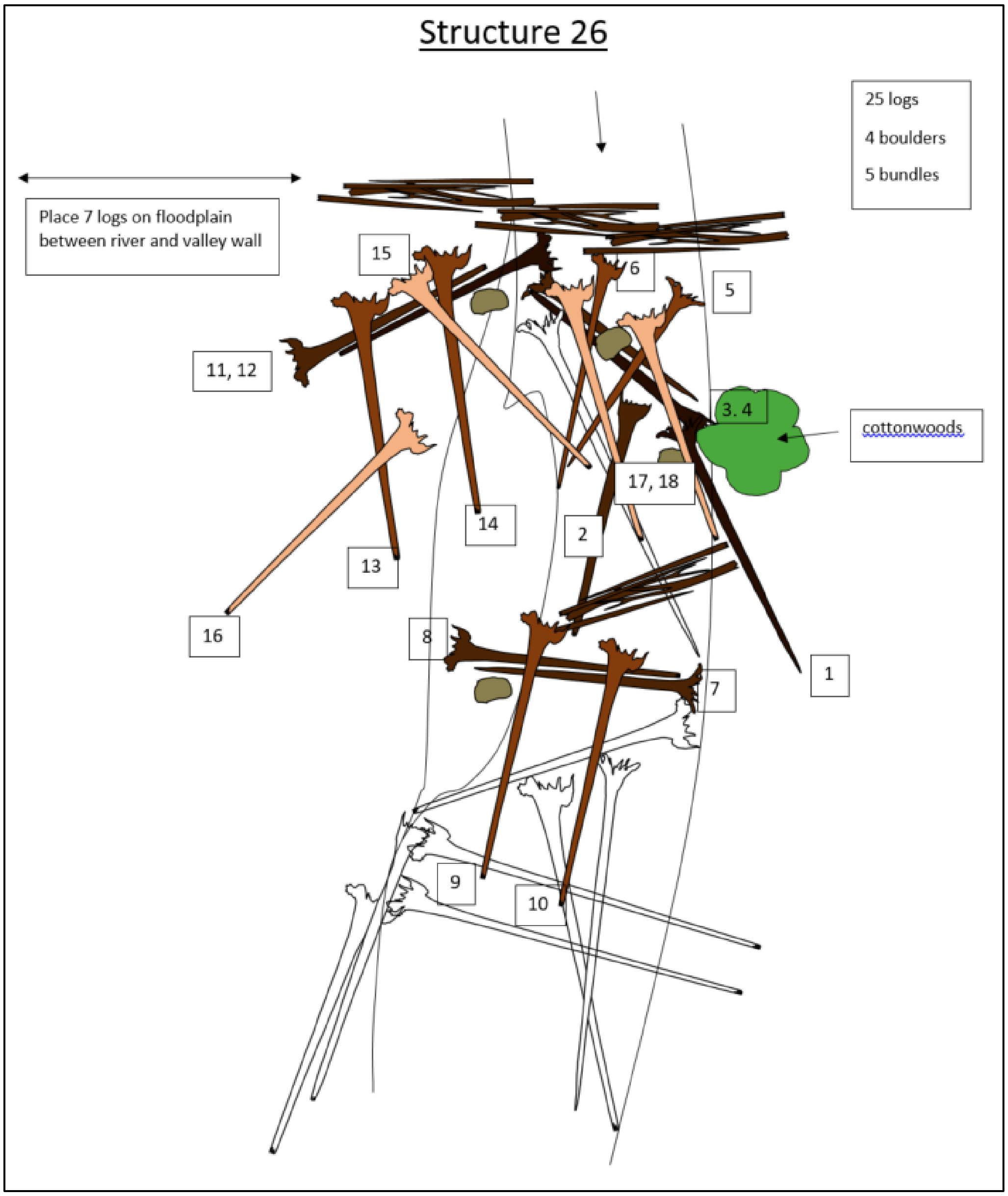
LiDAR data for PA3 was used to identify opportunities for increased floodplain connectivity and habitat complexity. The LiDAR data revealed three to four paleochannels that could be reconnected with the main channel of the Tucannon River. River Complexity Index (Brown, 2002) was used to model potential improvements in floodplain connectivity and habitat complexity through reconnection between the main channel and floodplain paleochannels.

The proposed adaptive management action would use helicopters to add 360 new rootwad trees and 47 ballast boulders to the reach. Large wood additions would occur in strategic areas within the reach that would facilitate decreased stream velocities, aggradation of bedload, and movement of surface water into existing paleochannels. This project would ultimately serve to meet the objective of wood loading for the reach and improve habitat conditions for all life history stages of ESA-listed salmonids in the Tucannon River.

This restoration treatment had four objectives: 1) establish two key pieces (> 6m long, > 0.3m diameter) of large wood per channel width, (2) aggrade the channel, (3) reconnect the floodplain, and (4) increase channel complexity.

Large Wood Structures

As with PA18 “two key pieces of wood per channel width” is the wood loading target for PA3 (SRSRB 2011). The minimum number of key pieces of wood necessary to achieve the target quantity for PA3 is ~330. Approximately 360 large trees with rootwads and 47 ballast boulders were used to construct 55 large wood structures in PA3. For each key log a corresponding “tree top” log was placed upstream of log structures to provide racking for constructed log structures. The resulting total number of key pieces of wood added to the reach was 720. All logs and ballast boulders for this project were placed by helicopter in order to minimize disturbance of the mature riparian forest throughout the reach.



Example schematic from designs used to construct large wood structures on PA3. Pictured here is one of the channel spanning log jams built for reconnection of paleochannels.

Results

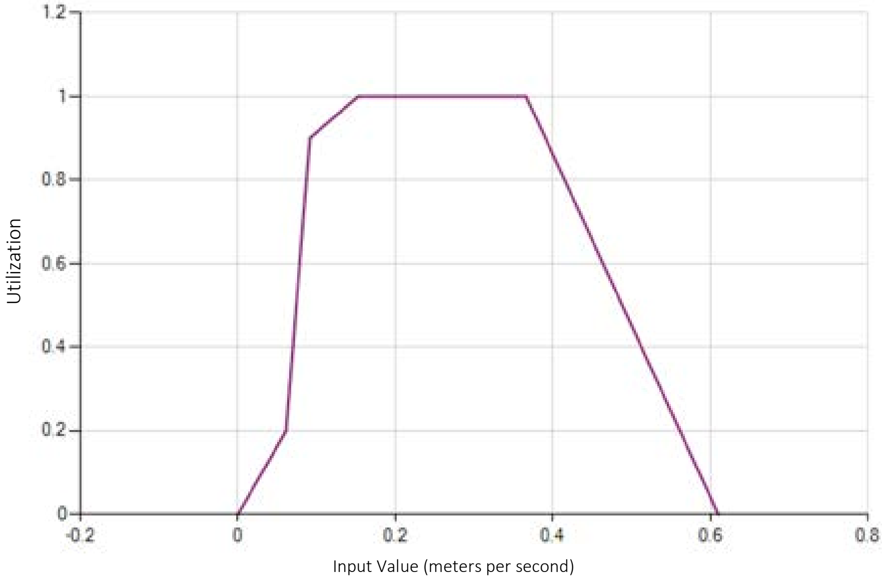
PA18 CHaMP and AEM Metrics

A Survey site (CBW05583-079743) operated under BPA's Columbia Habitat Monitoring Program (CHaMP) and Action Effectiveness Monitoring (AEM) was located in the center of the PA18 reach. CBW05583-079743 was part of rotating panel 3 for CHaMP, meaning it was surveyed in 2013, 2016, and 2017 for CHaMP, and in 2017 and 2018 for AEM. These monitoring protocols collect topographic survey data coupled with measurements of physical and biological attributes within the survey site. The data from CHaMP and AEM surveys were analyzed by the CTUIR Biomonitoring Project in order to determine the effects of river restoration treatments on salmonid habitat conditions. The analysis conducted by the CTUIR Biomonitoring Project compared changes in stream velocity, stream depths, and Habitat Suitability Index (HSI) for target species of salmon, before and after the PA18 restoration treatment.

Stream Velocity

Low velocity areas are important physical conditions for optimizing energetics of foraging juveniles and migrating adult salmon. The optimum stream velocity for juvenile steelhead is between 1.5-3.5 meters per second (Figure 1). Figure 2 provides a spatial comparison of pre-treatment and post-treatment stream velocities within the CBW05583-079743 survey site. A qualitative observation of the pre-treatment and post-treatment spatial comparison of modeled velocities (Figure 2) suggests that the post-treatment condition has greater spatial heterogeneity in stream velocity. The 2016 pre-treatment velocity condition appears to have high velocity segments that are contiguous over longer stretches of space. There appear to be more frequent low velocity breaks interspersed throughout the survey area in the 2018 post-treatment condition which, if true, would improve habitat conditions for salmonids.

Figure 1: Juvenile Steelhead Water Velocity Preference (m/s)



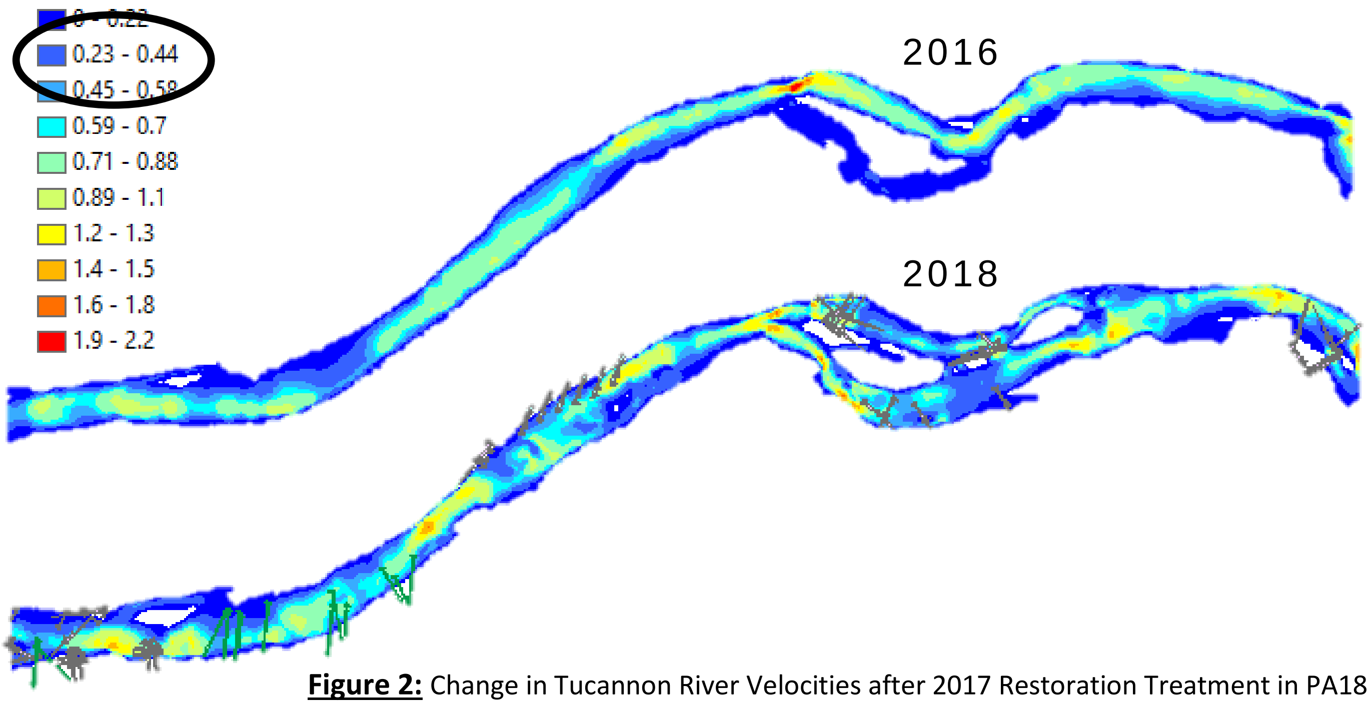
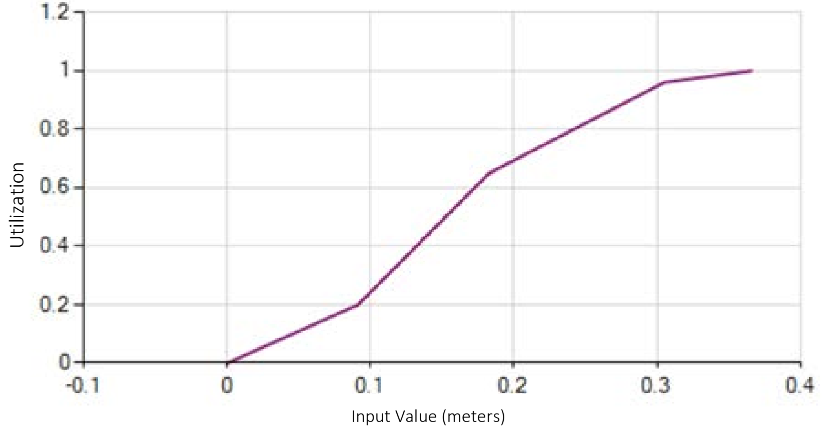


Figure 2: Change in Tucannon River Velocities after 2017 Restoration Treatment in PA18. Velocities 0.23 – 0.44 m/s are the ideal range for salmon.

Stream Depth

Deep water provides refuge from aerial predators for salmon. The optimum stream depth for juvenile steelhead is between 0.3 and 3 meters (Figure 3). Figure 4 provides a spatial comparison of pre-treatment and post-treatment stream depths within the CBW05583-079743 survey site. A qualitative assessment of the pre-treatment and post-treatment spatial comparison of surveyed stream depths (Figure 4) suggests that the post-treatment condition has an increased frequency of deep water conditions and a reduction in the amount of stream area that falls within the shallowest depth range. Water depths falling within the optimum range for juvenile steelhead, between 0.3 and 3 meters, appears to have improved.

Figure 3: Juvenile Steelhead Water Depth Preference (m)



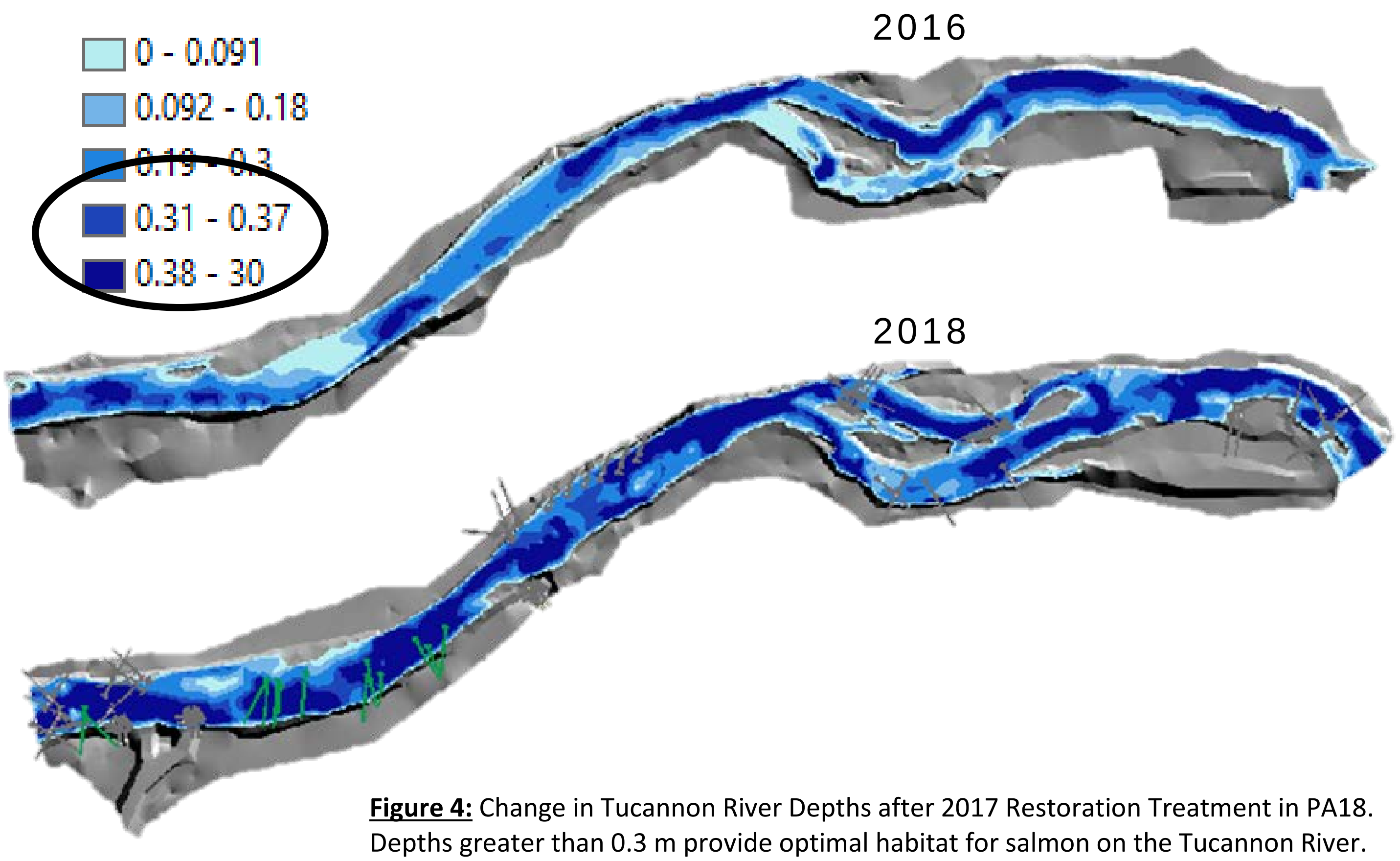


Figure 4: Change in Tucannon River Depths after 2017 Restoration Treatment in PA18. Depths greater than 0.3 m provide optimal habitat for salmon on the Tucannon River.

Habitat Suitability Index (HSI)
An HSI is a numerical index that represents the capacity of a given habitat to support a selected species. This HSI describes the suitability of pre-treatment and post-treatment salmonid habitat by combining the interactions of velocity and depth on a species' vital rates and survival. The HSI model used for CBW05583-079743 rates salmonid habitat quality on a scale of 0-1. Figure 5 provides a spatial comparison of pre-treatment and post-treatment HSI within the CBW05583-079743 survey site. Usable area (suitable salmonid habitat) increased after the 2017 restoration treatment was completed in PA18 (Figure 7 and 8).

Pools
The number of observed pools within the CBW05583-079743 survey site increased from four in the 2016 pre-treatment condition to six in the 2018 post-treatment condition (Figure 6).

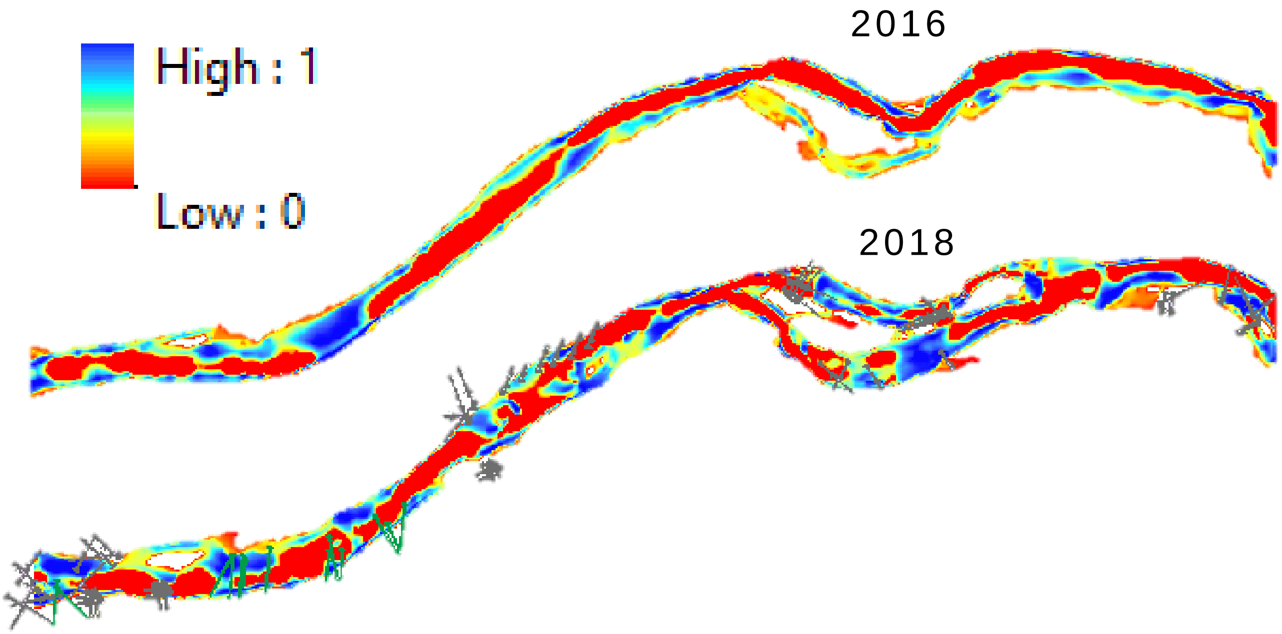


Figure 5: Change in Habitat Suitability Index within PA18 after 2017 Restoration Treatment. Areas that provide the most suitable salmon habitat, according to the model, are blue on the map. Areas that are least suitable are red on the map.

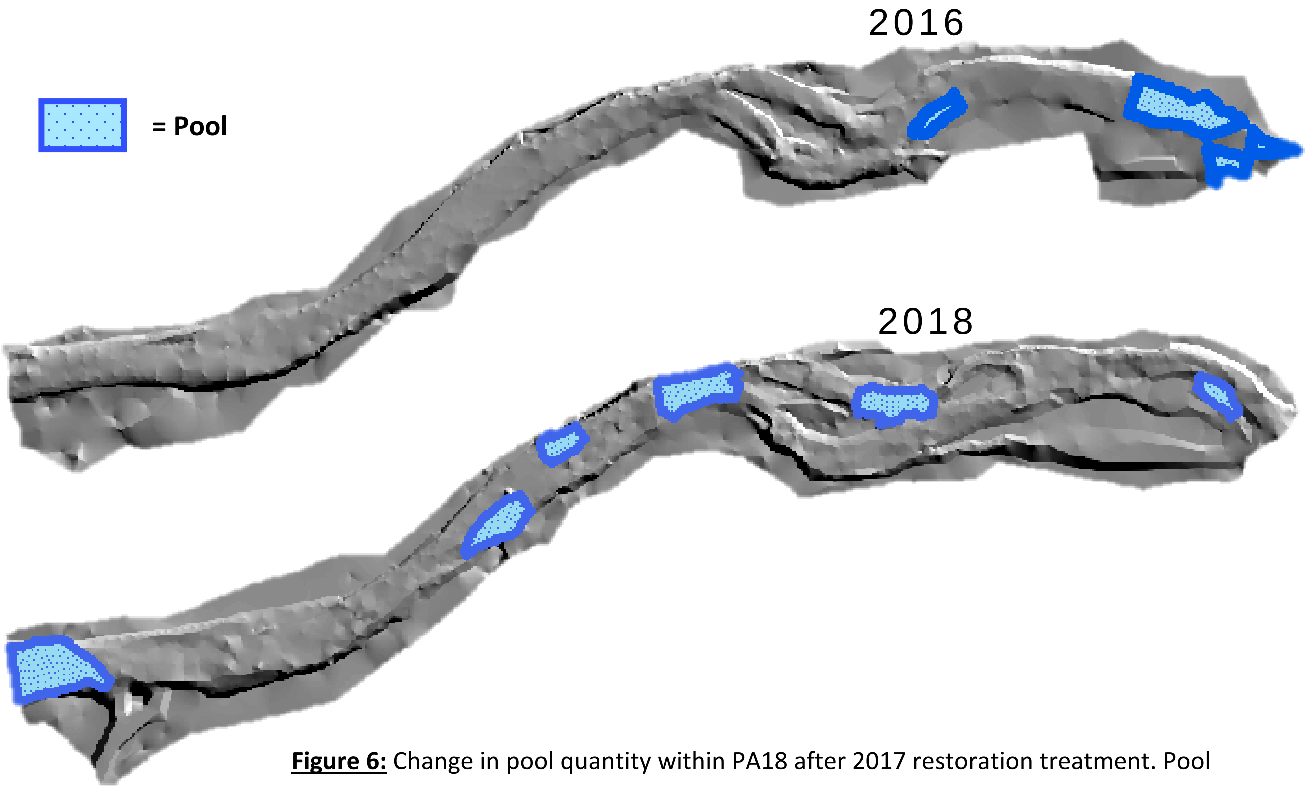


Figure 6: Change in pool quantity within PA18 after 2017 restoration treatment. Pool quantity and distribution increased in the analysis area after the 2017 restoration treatment.

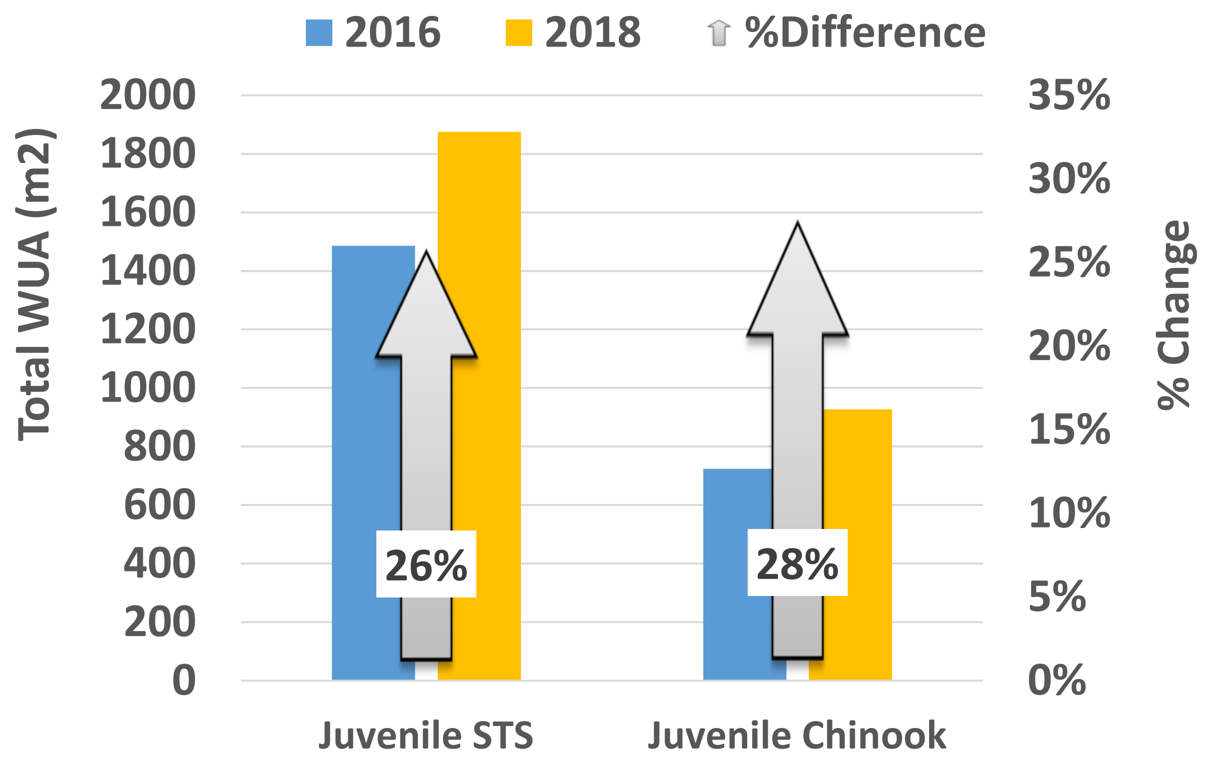


Figure 7: *Weighted Usable Area*

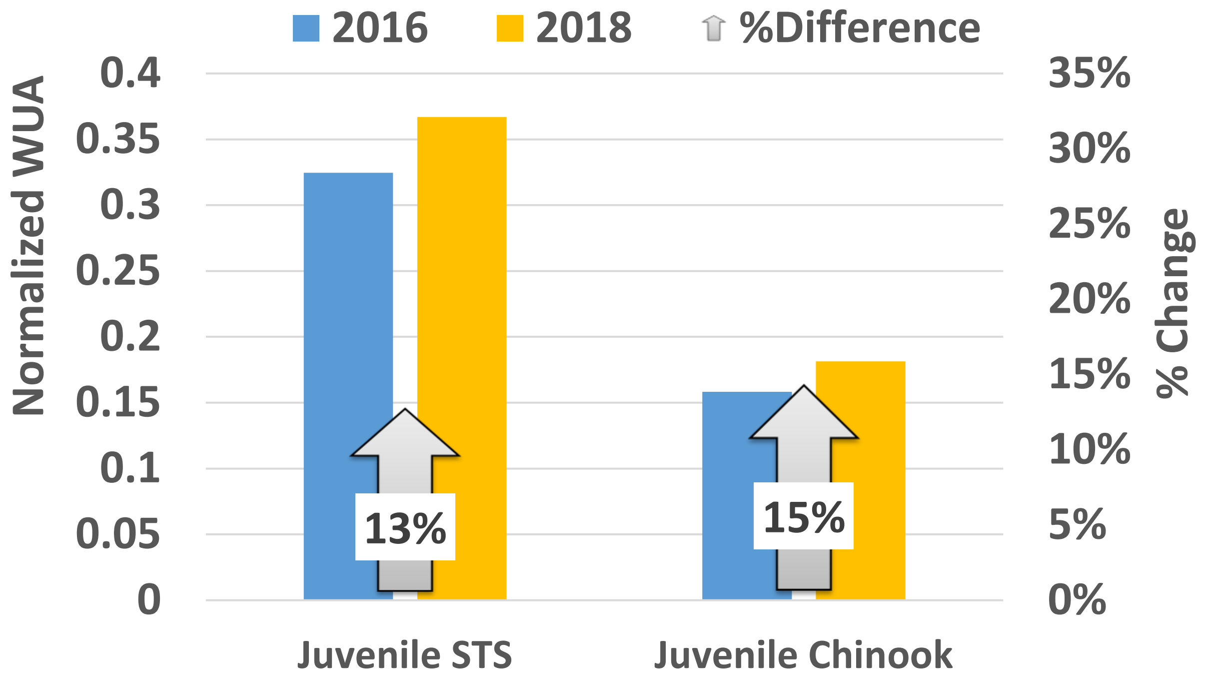


Figure 8: *Normalized Weighted Usable Area*

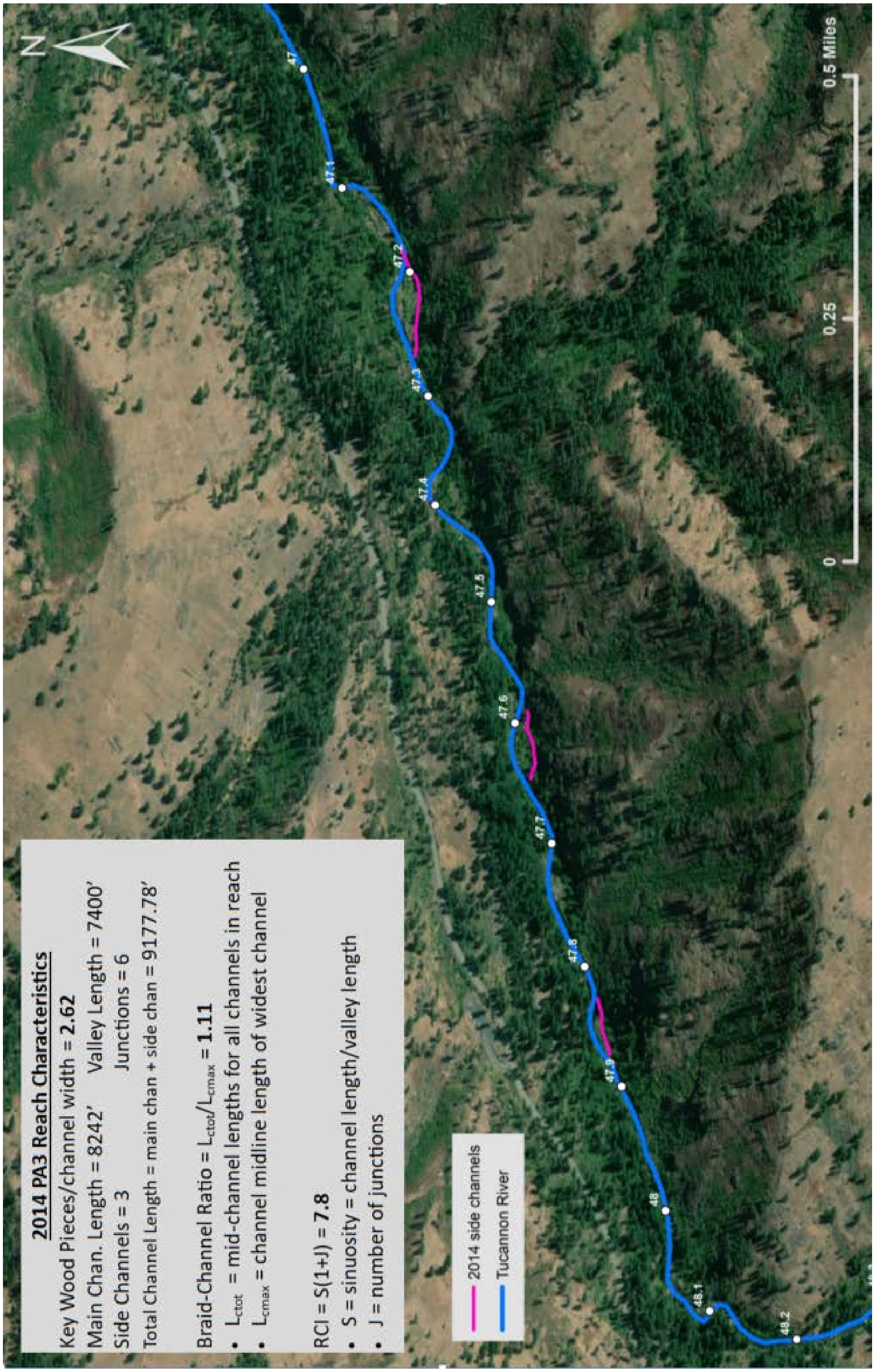
PA3 Rapid Habitat Surveys

Rapid Habitat Surveys (RHS) were conducted before and after implementation of the river restoration project in 2014 (Figure 9), and once more in 2017 (Figure 10). Prior to 2014, channel bed incision was an issue of primary concern in PA3. The RHS data revealed that between 2014 and 2017, key pieces of large wood had decreased. The number of pools in the reach also decreased between 2014 and 2017. Conversely, the number of side channels increased between 2014 and 2017. The increase in number of side channels suggests that bed aggradation has occurred since the 2014 large wood project.

The bed aggradation which resulted from the 2014 restoration treatment in PA3 increased the potential for side channel connection in the reach. River Complexity Index (Brown, 2002) was used to model potential improvements in floodplain connectivity and habitat complexity that could result from reconnecting the observed paleochannels.

The adaptive management actions taken in 2018 added 720 key pieces of wood and 47 ballast boulders to the reach. Channel spanning large wood structures were strategically placed below the upstream opening to observed paleochannels in order to facilitate a backwatering effect and move surface water into the paleochannels (Figure 11). The number of key pieces of wood per channel width in the 2017 pre-treatment condition was 1.59. The 2018 restoration treatment in PA3 increased wood loading for the reach to 3.79 key pieces per channel width.

Pre-treatment RCI was measured to be 18.93 (Figure 10). Post-treatment RCI modeling scenarios suggest potential increases in RCI as high as 27.84, a 47% increase above existing conditions (Figure 12).



2014 PA3 Reach Characteristics

Key Wood Pieces/channel width = **2.62**

Main Chan. Length = 8242' Valley Length = 7400'

Side Channels = 3 Junctions = 6

Total Channel Length = main chan + side chan = 9177.78'

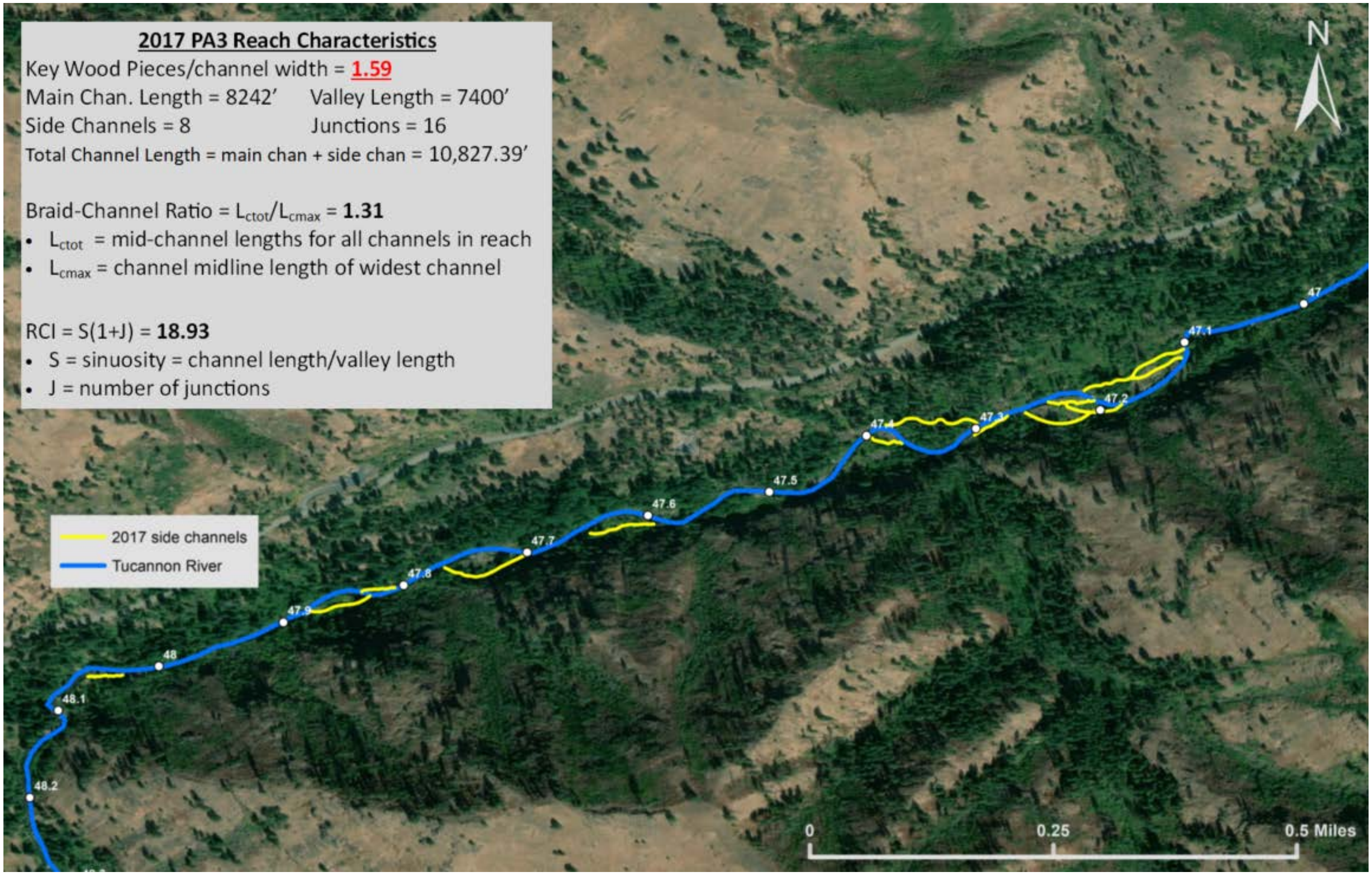
Braid-Channel Ratio = L_{ctot}/L_{cmax} = **1.11**

- L_{ctot} = mid-channel lengths for all channels in reach
- L_{cmax} = channel midline length of widest channel

RCI = S(1+J) = **7.8**

- S = sinuosity = channel length/valley length
- J = number of junctions

Figure 9: Physical habitat parameters of the PA3 reach after 2014 restoration. Physical habitat characterization was conducted using the Rapid Habitat Survey methodology.



2017 PA3 Reach Characteristics

Key Wood Pieces/channel width = **1.59**

Main Chan. Length = 8242′ Valley Length = 7400′

Side Channels = 8 Junctions = 16

Total Channel Length = main chan + side chan = 10,827.39′

Braid-Channel Ratio = L_{ctot}/L_{cmax} = **1.31**

- L_{ctot} = mid-channel lengths for all channels in reach
- L_{cmax} = channel midline length of widest channel

RCI = S(1+J) = **18.93**

- S = sinuosity = channel length/valley length
- J = number of junctions

Figure 10: Physical habitat parameters of the PA3 reach after 2014 restoration. Physical habitat characterization was conducted using the Rapid Habitat Survey methodology.

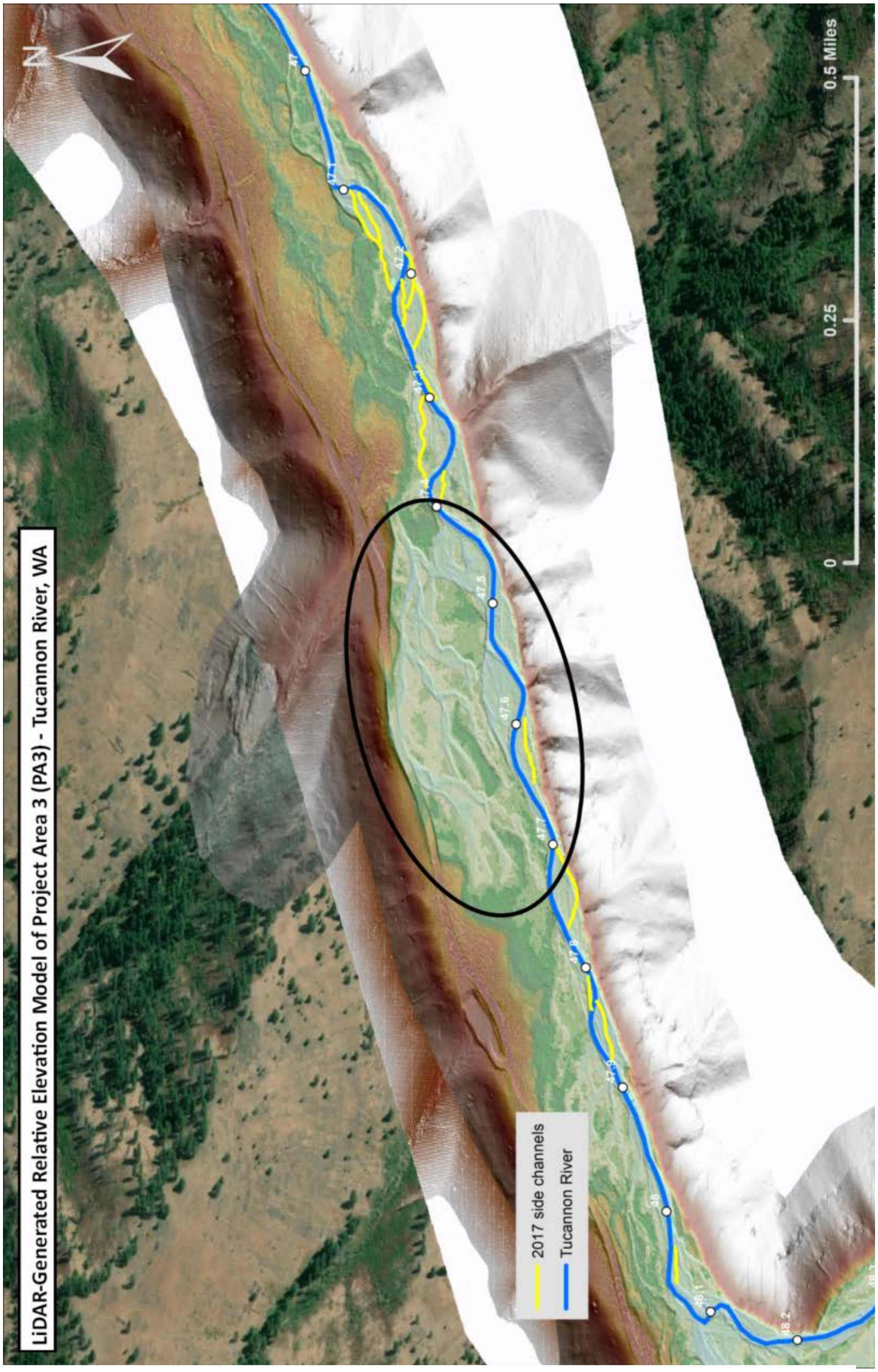


Figure 11: LiDAR generated topographic relief of the Tucannon valley bottom within the PA3 reach. The area inside the black circle is where paleochannels were observed.

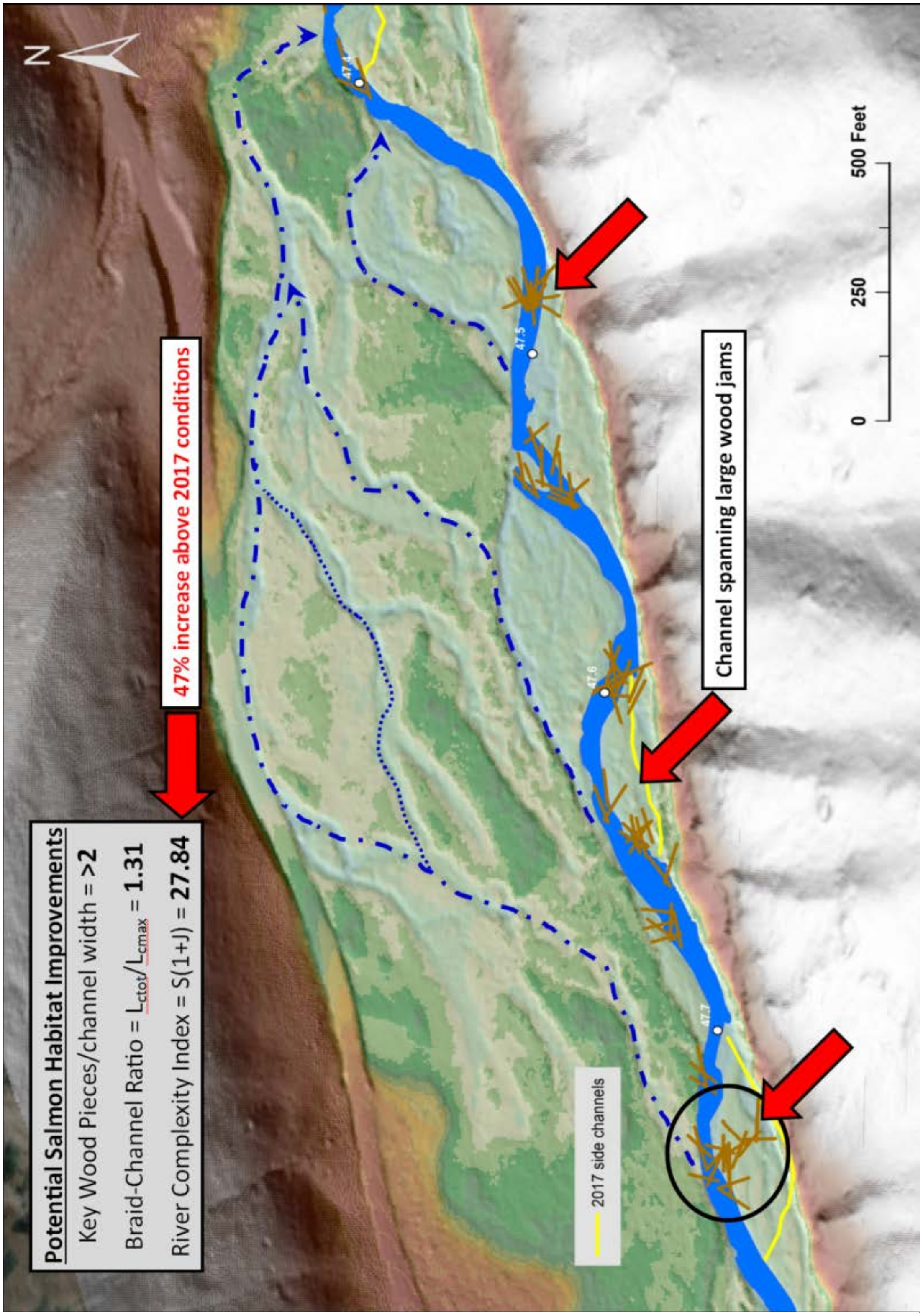


Figure 12: Model of potential physical habitat characteristics within PA3 if paleochannel reconnection is successfully facilitated by large channel spanning wood jams.

Figure 13: Pre-treatment and post-treatment conditions where a channel spanning wood structure was placed near the upstream opening to a paleochannel in PA3.

Discussion

The restoration treatments that were implemented by CTUIR TFHP in PA18 and PA3 were designed to work in concert with the physical potential of the Tucannon River. In other words, the Tucannon River has the potential to generate sufficiently large stream power to regenerate salmonid habitat when it interacts with instream wood and the floodplain. Due to the physiographic location and climatic conditions of the Tucannon River, it is uncommon for the Tucannon River to produce large stream power that regenerates salmonid habitat in a short period of time (weeks to months).

A basin-wide hydrologic analysis was conducted in 2019 as a part of the Updated Conceptual Restoration Plan (Anchor QEA unpublished, 2019). Since 2011 the Tucannon River has only achieved a two-year return interval discharge (> 1250 cfs) three times. The Tucannon River has not exceeded anything above a two-year return interval discharge since 2011, nor has it exceeded a two-year return interval discharge since the PA18 project was completed in the summer of 2017 (Figure 14).

Larger stream discharges come with increased stream power. As stream power increases on the Tucannon River, the rate at which the Tucannon River regenerates salmonid habitat as it interacts with instream wood also increases. Some modest changes/increases in salmonid habitat have been observed since completing the PA18 restoration treatment in 2017. In PA3 there has not been a sufficient amount of time, nor has there been a sufficiently large enough stream discharge within the reach for a change in physical salmonid habitat to have occurred.

Unfortunately, large, channel-altering discharges greater than or equal to the five year return interval have not occurred since large scale restoration efforts started on the Tucannon River in 2011. It is expected that larger stream discharges will bring about larger changes/increases in salmonid habitat in areas where large wood has been placed in the Tucannon River. But it will take time and patience to see large scale improvement in salmonid habitat resulting from the extensive restoration efforts on the Tucannon River. Once channel-altering discharges are finally realized, the Tucannon River will begin the process of renewal.

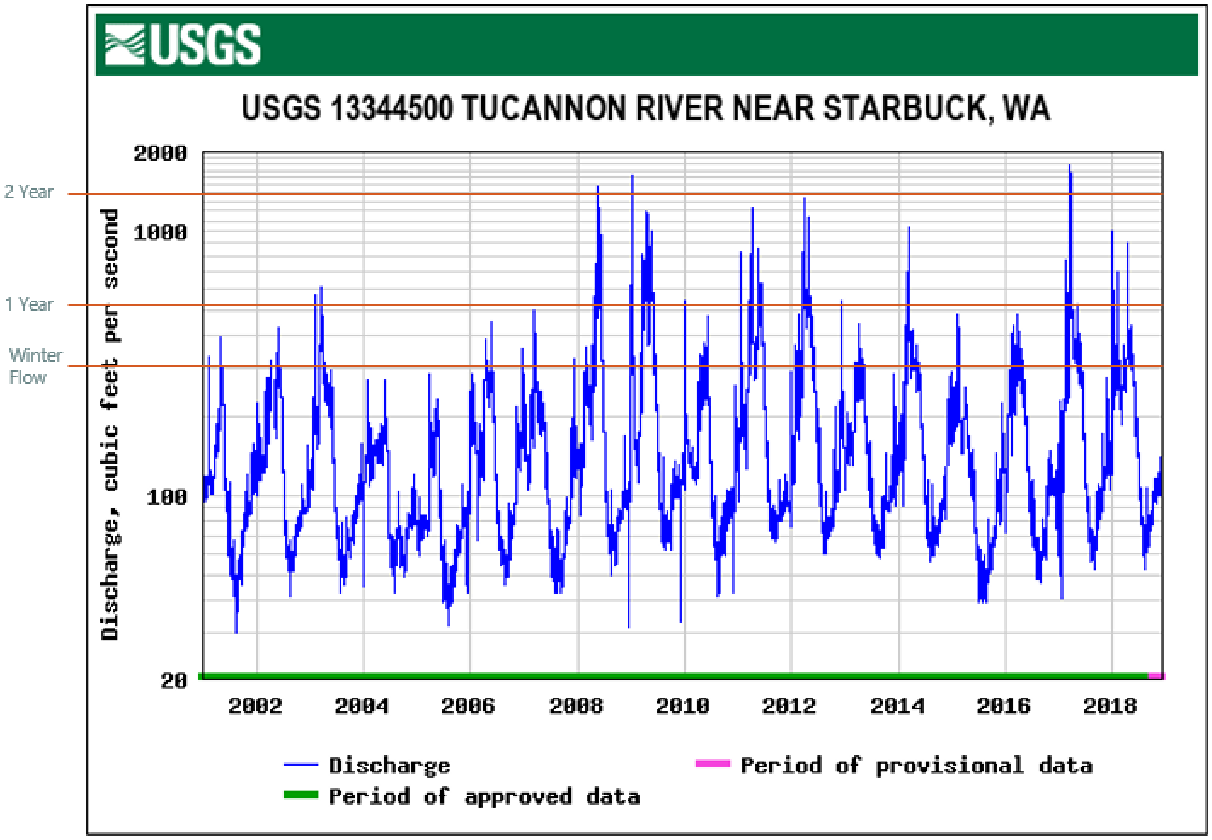


Figure 14: Annual hydrograph (discharge in cubic feet per second) for the lower Tucannon River at Starbuck, WA for the period of 2000-2019. The horizontal red lines indicate the average annual discharge for the winter base flow, one-year return interval (595cfs), and two-year return interval (1250cfs).

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