Implementation of Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation

BPA Project # 1990-044-00

Report covers work performed under BPA contract #(s) 65197, 69003, 72851

Report was completed under BPA contract #(s) 72851

1/1/2015 – 5/31/2017

A. J. Vitale and S. H. Hallock

Coeur d'Alene Tribe, Plummer, ID, 83851

05 – 2017

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

This report should be cited as follows:

A. J. Vitale and S. H. Hallock. 2017. Implementation of Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation, 1/1/2015 – 12/31/2016 Annual Report, Project #1990-044-00.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PHOTOS

1.0 Project Background

Historically, the Coeur d'Alene Indian Tribe depended on runs of anadromous salmon and steelhead along the Spokane River and Hangman Creek as well as resident and adfluvial forms of trout and char in Coeur d'Alene Lake for subsistence. Dams constructed in the early 1900s on the Spokane River in the City of Spokane and at Little Falls (further downstream) were the first dams that initially cut-off the anadromous fish runs from the Coeur d'Alene Tribe. These fisheries were further eliminated following the construction of Chief Joseph and Grand Coulee Dams on the Columbia River. Together, these actions forced the Tribe to rely solely on the resident fish resources of Coeur d'Alene Lake for their subsistence needs.

The Coeur d'Alene Tribe is estimated to have historically harvested around 42,000 westslope cutthroat trout (*Oncorhynchus clarki lewisi*) per year (Scholz et al. 1985). In 1967, Mallet (1969) reported that 3,329 cutthroat trout were harvested from the St. Joe River, and a catch of 887 was reported from Coeur d'Alene Lake. This catch is far less than the 42,000 fish per year the tribe harvested historically. Today, only limited opportunities exist to harvest cutthroat trout in the Coeur d'Alene Basin. It appears that a suite of factors have contributed to the decline of cutthroat trout stocks within Coeur d'Alene Lake and its tributaries that include the construction of Post Falls Dam in 1906, changes in land cover types, impacts from agricultural activities, and introduction of exotic fish species (Mallet 1969; Scholz et al. 1985; Lillengreen et al. 1993).

The decline in native cutthroat trout populations in the Coeur d'Alene basin has been a primary focus of study by the Coeur d'Alene Tribe's Fisheries and Water Resources programs since 1990. The overarching goals for recovery have been to restore the cutthroat trout populations to levels that allow for subsistence harvest, maintain genetic diversity, and increase the probability of persistence in the face of anthropogenic influences and prospective climate change. This included recovering the lacustrine-adfluvial life history form that was historically prevalent and had served to provide resiliency to the structure of cutthroat trout populations in the Coeur d'Alene basin. To this end, the Coeur d'Alene Tribe closed Lake Creek and Benewah Creek to fishing in 1993 to initiate recovery of westslope cutthroat trout.

However, achieving sustainable cutthroat trout populations also required addressing biotic factors and habitat features in the basin that were limiting recovery. Early in the 1990s, BPA-funded surveys and inventories identified limiting factors in Tribal watersheds that would need to be remedied to restore westslope cutthroat trout populations. The limiting factors included: low-quality, low-complexity mainstem stream habitat and riparian zones; high stream temperatures in mainstem habitats; negative interactions with nonnative brook trout in stream habitats; and potential survival bottlenecks in Coeur d'Alene Lake. In 1994, the Northwest Power Planning Council adopted recommendations set forth by the Coeur d'Alene Tribe that would address these limiting factors to support the recovery of cutthroat trout populations and the re-establishment of a fishery (NWPPC Program Measures 10.8B.20). Recommended actions included, but were not limited to, the implementation of habitat restoration and enhancement measures in Alder, Benewah, Evans, and Lake Creeks (Figure 1), and the development of a monitoring program to evaluate the effectiveness of the habitat improvement projects.

Since that time, the BPA project entitled "Implementation of Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation" (#1990-044-00), which is sponsored and implemented by the Coeur d'Alene Tribe Fisheries Program, has supported the various recovery measures, which have included habitat enhancement and restoration actions, non-native biological control, and monitoring and evaluation that would inform future management decisions. This annual report summarizes previously unreported habitat enhancement activities conducted during the period January 2015 through May 2017 to fulfill the contractual obligations for the BPA project. This report is presented in a non-technical format consisting of summaries of in-stream and riparian projects implemented in the Lake and Benewah creek watersheds.

2.0 Study Area

The study area addressed by this report consists of the southern portion of Coeur d'Alene Lake and four watersheds – Alder, Benewah, Evans, and Lake - which feed the lake (Figure 1). These areas are part of the larger Coeur d'Alene sub-basin, which lies in three northern Idaho counties Shoshone, Kootenai and Benewah. The basin is approximately 9,946 square kilometers and extends from the Coeur d'Alene Lake upstream to the Bitterroot Divide along the Idaho-Montana border. Elevations range from 646 meters at the lake to over 2,130 meters along the divide. This area formed the heart of the Coeur d'Alene Tribe's aboriginal territory, and a portion of the sub-basin lies within the current boundaries of the Coeur d'Alene Indian Reservation.

Coeur d'Alene Lake is the principle water body in the sub-basin. The lake is the second largest in Idaho and is located in the northern panhandle section of the state. The lake lies in a naturally dammed river valley with the outflow currently controlled by Post Falls Dam. The lake covers 129 square kilometers at full pool with a mean depth of 22 meters and a maximum depth of 63.7 meters.

The four watersheds currently targeted by the Tribe for restoration are located mostly on the Reservation (Figure 1), but cross boundaries of ownership and jurisdiction, and have a combined basin area of 34,853 hectares that include 529 kilometers of intermittent and perennial stream channels. The climate and hydrology of the target watersheds are similar in that they are influenced by the maritime air masses from the pacific coast, which are modified by continental air masses from Canada. Summers are mild and relatively dry, while fall, winter, and spring bring abundant moisture in the form of both rain and snow. A seasonal snowpack generally covers the landscape at elevations above 1,372 meters from late November to May. Snowpack between elevations of 915 and 1,372 meters falls within the "rain-on-snow zone" and may accumulate and deplete several times during a given winter due to mild storms (US Forest Service 1998). The precipitation that often accompanies these mild storms is added directly to the runoff, since the soils are either saturated or frozen, causing significant flooding.

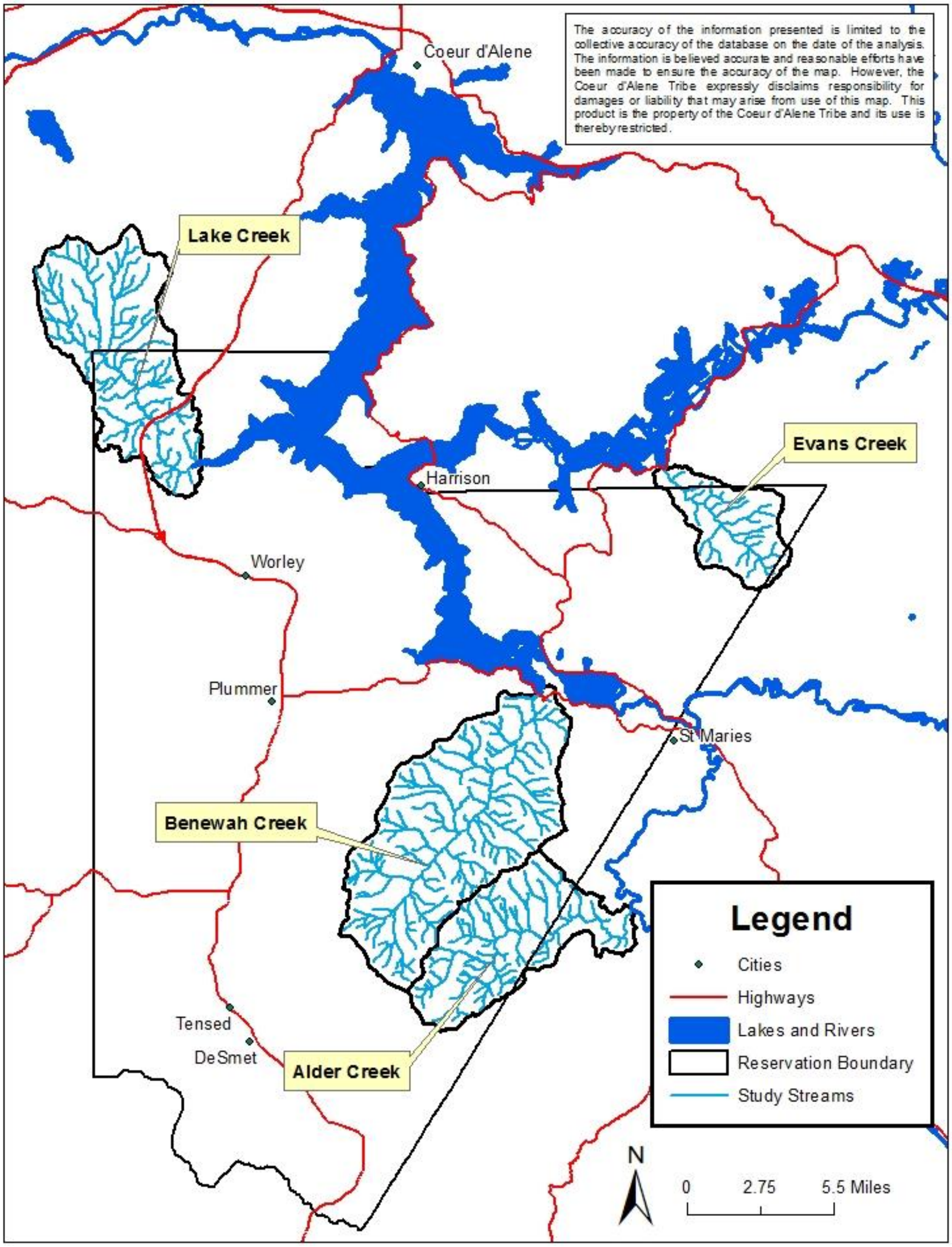

Figure 1. Locations of the four focal watersheds in the Coeur d'Alene Basin targeted by BPA project 1990-044-00.

3.0 Introduction to Habitat Enhancement Actions

This is an ongoing project designed to address the highest priority objective in the Coeur d'Alene Subbasin: to protect and restore remaining stocks of native resident westslope cutthroat trout (Oncorhynchus clarki lewisi) to ensure their continued existence in the basin and provide harvestable surpluses of naturally reproducing adfluvial adult fish in Lake Coeur d'Alene and in Lake and Benewah creeks, with stable or increasing population trends for resident life history types in Evans and Alder creeks. The project objectives are tiered to the Intermountain Province Objectives 2A1-2A4 and to the Columbia River Basin Goal 2A that addresses resident fish substitution for anadromous fish losses (Intermountain Province Subbasin Plan 2004). The management approach to habitat restoration is based on identifying and protecting core refugia and expanding restoration outward from areas of relatively intact habitats and populations, coupled with an analytical approach to prioritizing actions based on the degree of impairment to processes operating at the scale of species and ecosystems and the rarity of specific habitat types. Habitat restoration and enhancement activities employ the seven highest ranked strategies for addressing this objective within the Subbasin.

Past work products have included watershed assessments and long-term monitoring data that were used as the basis for developing and ranking future habitat projects to address watershed process impairment for sediment, flood hydrology, riparian and channel function and water quality (Firehammer et al. 2011). Prioritizing restoration actions in this way is an important part of the overall exercise to ensure that limited resources (i.e., staffing and funding) can be focused on actions that will have the greatest impact in locations that will translate into the greatest benefit. The resulting list of projects developed for the Benewah and Lake creek watersheds serves this purpose and has helped guide on-the-ground work that has been implemented since the last Resident Fish Categorical Review in 2012. The project proposal specifically identified treatments for: 1) 15 km of channel wood additions to improve habitat diversity, sediment storage, grade control, habitat cover, and connectivity with floodplains; 2) 12.7 km of riparian projects to restore and/or conserve stream adjacent forests to provide natural recruitment of coarse woody debris over time; 3) 19 km of forest road BMPs to reduce sediment delivery to important spawning and rearing habitats; and 4) 28 fish passage projects to improve access to 28.3 km of stream habitats. These collective projects support recovery of resident and migratory westslope cutthroat trout through restoration and enhancement of landscape processes that form and sustain riverine habitat diversity and provide access for fish to these restored habitats. The locations of identified and completed projects are shown in Figure 2 and Figure 3.

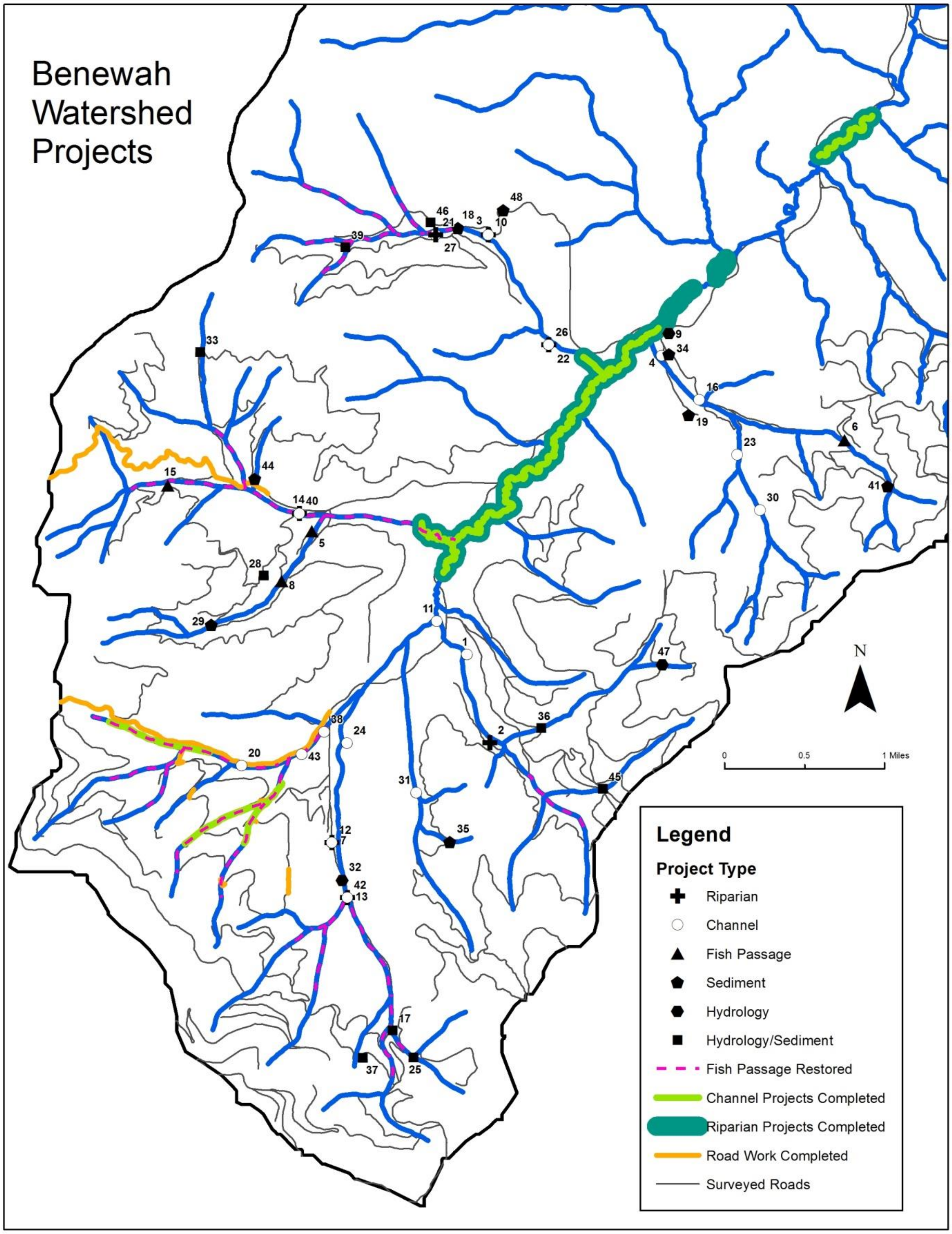

Figure 2. Locations of identified and completed projects in the Benewah Creek watershed. Project numbers are cross-referenced to the descriptive list of projects found in Appendix E.

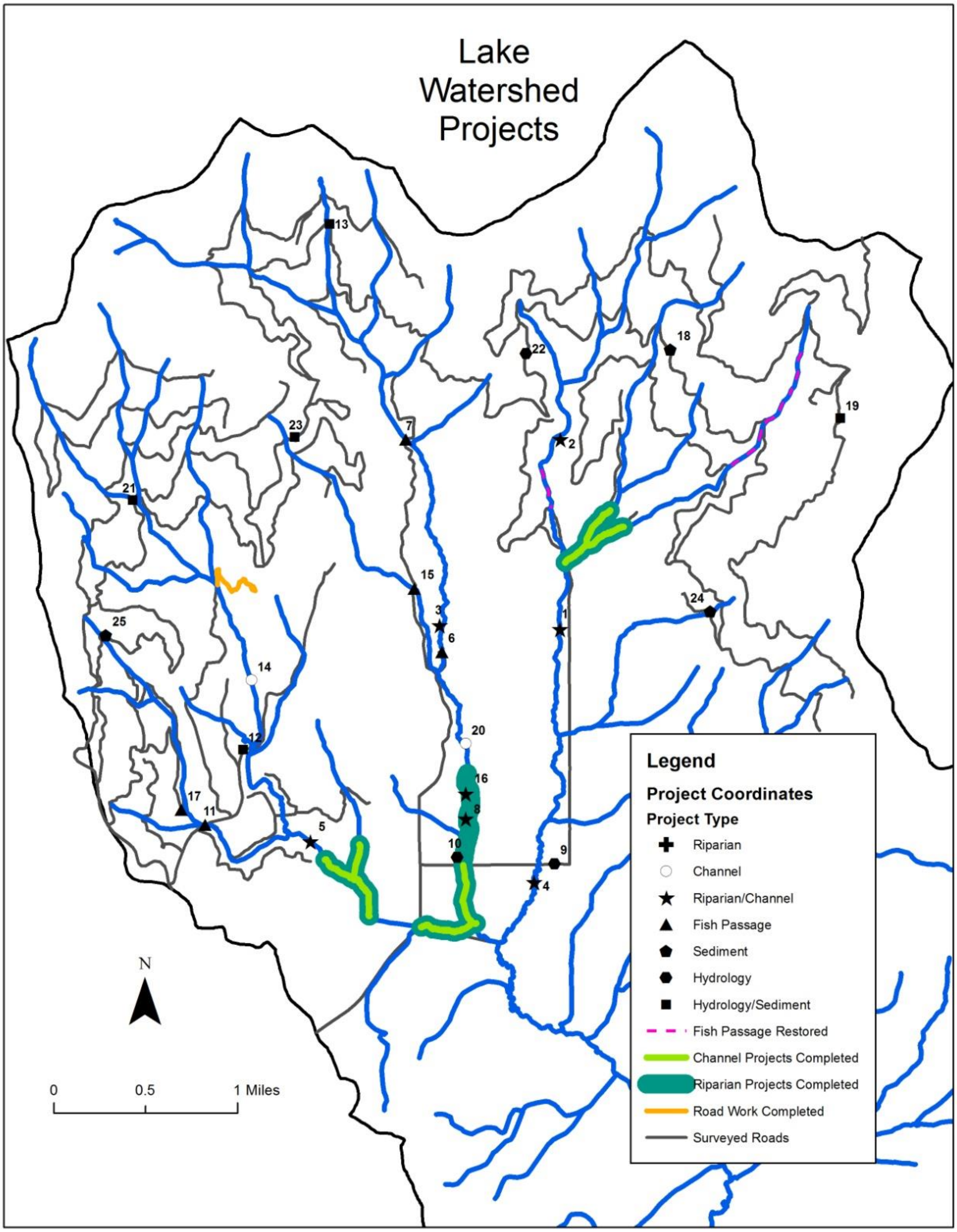

Figure 3. Locations of identified and completed projects in the Lake Creek watershed. Project numbers are cross-referenced to the descriptive list of projects found in Appendix E.

4.0 Summary of Implemented Actions

Implementation of restoration and enhancement activities occurred in the Benewah and Lake creek watersheds during 2015 and 2016. All activities completed during this period are summarized below in a format that provides a detailed site characterization, description of limiting factors (problem statement), project objectives, summary of activities and relationship to the contracted scope of work.

A brief explanation of the project ID that is used in the summary table and in the detailed descriptions is warranted here. The project ID is an alphanumeric code that corresponds to the location of individual treatments in relation to the river-mile of the drainage network for the watersheds of interest. The first digit of the code signifies the watershed that the treatment is located in, using the first letter in the watershed name (e.g., B=Benewah Creek, L=Lake Creek, etc.). The series of numbers that follow correspond to the position in the river network (in kilometers) at the downstream end of treatment sites. River kilometer is tabulated in an upstream direction from mouth to headwaters and treatments that are located in tributary systems have river kilometer designations separated by a forward slash (/). For example, the downstream end of project L_8.2/0.7 is located in the Lake Creek watershed 0.7 kilometers up a tributary that has its confluence with the mainstem 8.2 kilometers from the mouth. This nomenclature is intended to indicate the spatial relationship of treatments to the mainstem and tributary aquatic habitats having significance to the target species. Furthermore, it readily conveys information about the relationship of multiple treatments by indicating the distance to common points in the drainage network.

Project L_13.1/5.4 – Upland/Road: Reduce sediment delivery to WF Lake Creek

Project Location:

Watershed: Lake Creek	Legal: T24N R45E S25 NW NW
Sub Basin: WF Lake (5.4 rkm)	Lat: 47.549884N Long: -117.064219W

Site Characteristics:

Slope/gradient: >10%	Aspect: NW	Elevations: 963 – 1000 m
Valley/Channel type: II/B3	Proximity to water: hydrologically connected roads	

Other: Hydrologically connected road segments totaling 527 meters were treated to decrease sediment delivery to the West Fork Lake Creek subwatershed.

Problem Description: The WF Lake Creek is an important spawning and rearing stream for resident and adfluvial westslope cutthroat trout. A Forest Road and Fish Passage Assessment completed in 2008 identified road segments in the Lake watershed that directly contribute sediment to these streams (Duck Creek Associates 2009). A prioritization process subsequently completed by the Fisheries program identified areas where additional drainage improvements and road resurfacing was needed (Firehammer et al. 2011). This work is part of the on-going effort by the tribe to improve fish habitat and water quality by managing roads and stream crossings in watersheds that encompass priority streams.

Description of Treatment: This project involved improvements to hydrologically connected roads contributing sediment directly to the WF Lake Creek subwatershed. From the 2008 study, sediment production for this road segment was predicted to be 2.02 mean tons/annually. By changing the road surface from a native surfaced road to a gravel road, the sediment production was predicted to drop to 1.49 mean tons/annually, a reduction of 26 percent (Duck Creek Associates 2009). In addition, improving drainage on the road will further reduce sediment transport to WF Lake Creek. This reduction in sediment production was the focus of work for this project. Previous work in this subwatershed included construction and reconnection of 922 meters of stream channel and floodplain in lower WF Lake Creek and in 305 meters of an unnamed tributary. These projects benefit from reduced sediment input following road rehabilitation in the upper reaches of the watershed.

The following work was completed in summer 2015:

A total of 527 meters of native surface road was graded and ditched using a Bobcat T-320 tracked skidsteer. Two types of rock were used to resurface the road; a base of courser 6” minus rock was placed first, followed by a surface cover of ¾” minus rock. A total of six 12” diameter culverts and two rolling dips were installed using a Cat 303 mini-excavator to cross drain the resurfaced road segments and prevent water accumulation in roadside ditches. Road improvements were completed for a total of 527 meters of native surface road. Runoff generated from an adjacent 100 meters of native surface road is intercepted by the improved road segments with the runoff safely redirected to a vegetated hillslope which provides sediment filtration over a distance of more than 67 meters before it reaches the WF Lake Creek. This additional realized sediment reduction was not estimated or included in the predicted results reported above.

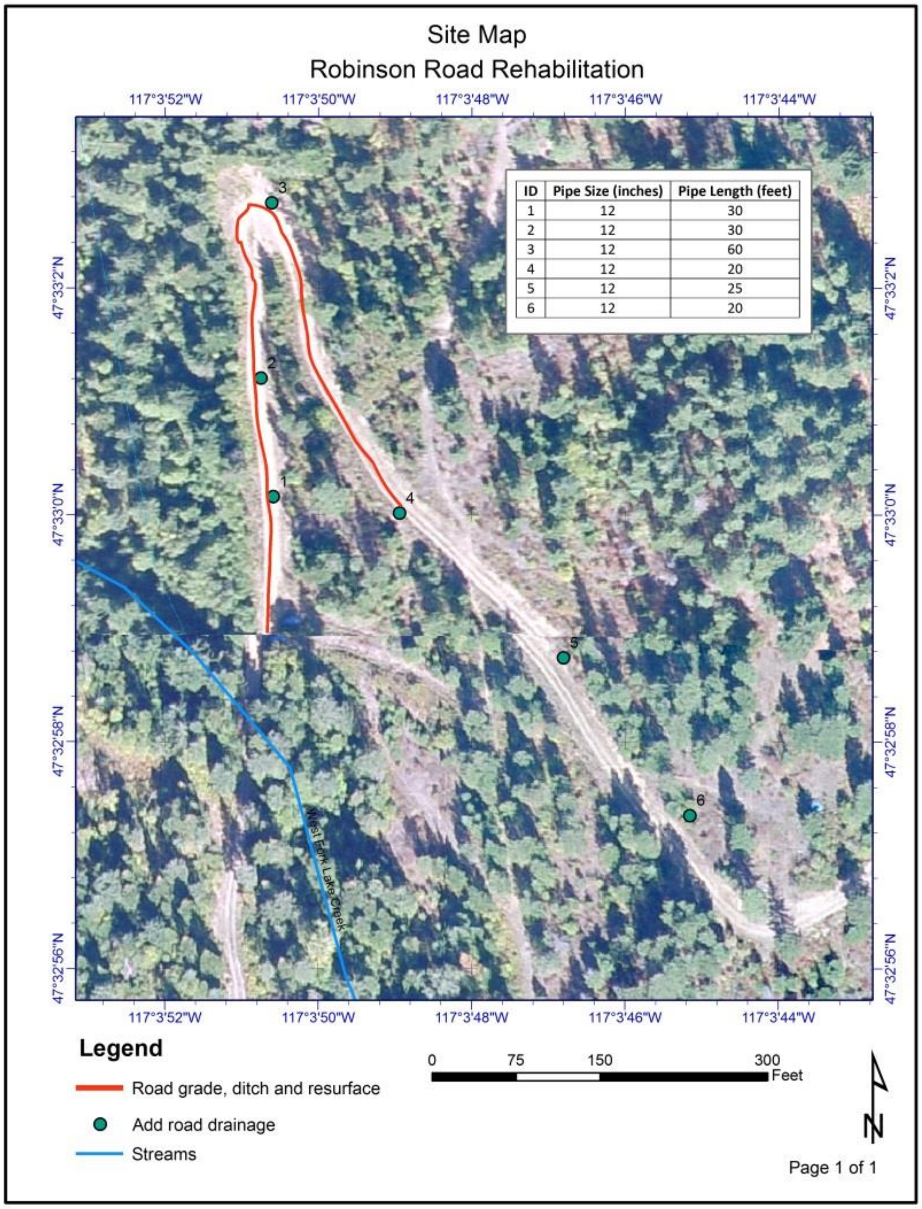

Figure 4. Approximately 527m of high gradient native surface road in the West Fork Lake Creek watershed was graded, ditched, drained and resurfaced in 2015.

Project Timeline: NEPA compliance documentation and landowner agreement were completed in 2015. Construction for the project was completed in July 2015.

Project Goals & Objectives: Reduce sediment delivery and improve drainage along road segments that are hydrologically connected and delivering sediment to important spawning and rearing streams.

Relationship to Scope of Work: This work fulfills the Program commitments for WE G in the 2016 Scope of Work and Budget Request (Contract #69003) for the contract period June 1, 2015 - May 31, 2016.

Project L_13.1/5.4 – Upland/Road: Replace bridge on WF Lake Creek

Project Location:

Watershed: Lake Creek	Legal: T24N R45E S25 NW NW
Sub Basin: WF Lake (5.4 rkm)	Lat: 47.549756N Long: -117.063098W

Site Characteristics:

Slope/gradient: 4%	Aspect: NW/SE	Elevations: 902 m
Valley/Channel type: B3	Proximity to water: hydrologically connected roads	

Other: A 30-foot wide bridge was replaced to decrease sediment delivery to the West Fork Lake Creek subwatershed.

Problem Description: The WF Lake Creek is an important spawning and rearing stream for resident and adfluvial westslope cutthroat trout. A Forest Road and Fish Passage Assessment completed in 2008 identified road segments in the Lake watershed that directly contribute sediment to these streams (Duck Creek Associates 2009). A prioritization process subsequently completed by the Fisheries program identified areas where additional drainage improvements and road resurfacing was needed (Firehammer et al. 2011). This work is part of the on-going effort by the tribe to improve fish habitat and water quality by managing roads and stream crossings in watersheds that encompass priority streams.

At this site a bridge with a 30-foot span was used to provide local access across the stream. A treated beam that was laid directly on the ground without a solid abutment or footing served as the only substructure supporting the girders and bridge deck. Surface water runoff directed and concentrated along the road approaches had eroded the soil under the bridge substructure, caused slumping of the natural slope leading to the stream, and resulted in annual contributions of sediment directly to the stream. The entire bridge had become increasingly unstable as runoff continued to exasperate this condition. Some past attempts at stabilizing the toe of the natural slope under the bridge using interlocking concrete blocks had been unsuccessful (Photo 1).

Description of Treatment: This project involved replacing a decrepit bridge crossing West Fork Lake Creek. Previous road work in this area included grading and surfacing 527 meters of hydrologically connected native surface road and installation of 6 cross drains in proximity to the bridge.

The bridge replacement was completed during two weeks in September. Two large Cat 320 excavators were used to remove the existing bridge, including the old footings, the failed erosion protection, and loose fill underneath the bridge. The greatest amount of time was spent preparing the new foundation for the bridge. Trenches were dug on both sides of the creek, lined with filter fabric, and then backfilled with a one foot deep layer of ¾" crushed rock to form the footing for the abutments. The backfilled rock was compacted with a Wacker RT82C trench roller and hand compactor. The bridge footing was leveled and adjusted to the correct elevation to meet the design specifications. Once this was completed, 40 E-Blocks - each weighing between 1900 – 3850 lbs. - were placed one by one in an interlocking configuration to form six foot high retaining walls. At each corner of the structure, steel braces were fabricated and anchored to the concrete blocks to provide additional support. Given that groundwater was encountered during construction, 3 inch diameter perforated drainage pipe was placed at each footing to help divert water around the bridge foundation.

The existing treated beams that served as bridge girders were reused by setting them on top of the E-Block foundation. The beams were secured to the blocks with steel brackets and long ¾" diameter threaded rods that connected all the beams together to form a single platform to support the bridge decking. Rock rip-rap was placed underneath the new bridge and adjacent to the new footings for erosion control. Finally, the road was regraded to ensure all water would be diverted off the roadway before reaching the bridge. All disturbed areas were seeded with native grasses at a rate of 40 lbs/acre (18 kg/ha).

Photo 1. (Left) The former bridge over Lake Creek had deteriorated to the point where using it was a hazard and sediment was delivered directly to the stream during frequent, low magnitude runoff events. (Right) The new bridge provides a stable stream crossing, eliminates sediment delivery to the channel and safely passes the largest flood.

Project Timeline: A landowner agreement was completed in 2015. Permitting and NEPA compliance paperwork was completed by early August 2016. Bridge construction and planting was completed in September 2016.

Project Goals & Objectives: Reduce sediment delivery and improve drainage along road segments that are hydrologically connected and delivering sediment to important spawning and rearing streams.

Relationship to Scope of Work: This work fulfills the Program commitments for WE I in the 2016 Scope of Work and Budget Request (Contract #72851) for the contract period June 1, 2016 - May 31, 2017.

Project L_13.1/0.0 - Instream/Channel Enhancement: WF Lake Creek wood additions

Project Location:

Watershed: Lake Creek	Legal: T48N R6W S12 NW1/4
Sub Basin: WF Lake (0.0 rkm)	Lat: 47.522331 N Long: -117.035937 W

Site Characteristics:

Slope/gradient: <0.5%	Aspect: S/SE	Elevations: 780 m
Valley/Channel type: C4/C5	Proximity to water: Instream	

Other: Large wood was placed along 1100 meters of channel in 2015 to create fish habitat and increase connectivity with the adjacent floodplain.

Problem Description: Historically, frequent engagement of flood flows on the valley floor in this reach was most likely in response to both (i) blockage effects of large wood pieces falling into the channel and aggregating smaller wood, and (ii) beaver dams, with local gravel and fine sediment accumulations upstream. Whenever the channel did avulse in response to blockages, it likely did so through rapid down-cutting through the easily eroded loess layer, reaching a base gravel layer in the valley relatively quickly and then remaining at the grade defined by that layer. Following a more recent history of intensive logging, forest clearing, beaver trapping, agriculture and grazing, the hydraulic influence of local beaver dam/sediment accumulation was reduced or removed. The stream banks were more susceptible to unraveling and channel widening, leading to the state seen at some locations where a new, lower elevation alluvial floodplain appears to have established between the upper bank surfaces defined by the valley floor. Hydraulic analysis of representative channel cross-sections show the overall level of channel incision/entrenchment is approximately equivalent to the capacity of a 5-year return interval peak flow event. By comparison, less disturbed channels would typically access their floodplain at the 1.5-2 year return interval flow.

The significantly reduced access of flood flows to the former floodplain and broader valley bottom has affected wetland habitats on a large scale and accelerated streambank erosion. It appears that shallow groundwater tables have been lowered and recharge of wetlands by overbank flows has been greatly reduced. Many of the remaining wetland areas are only marginal in size and dominated by non-native, invasive species.

A wood recruitment study conducted in 2007 and 2008 found significant wood related habitat function (i.e., pool formation, sediment accumulation, grade control, habitat cover, etc.) associated with wood loading rates that exceeded 6 m^3/100 m (Duck Creek Associates 2008). The project reach, however, currently has measured instream wood loading rates of <3 m^3/100 m and was therefore prioritized for channel wood additions. Moreover, the riparian area is comprised primarily of alder and young conifers that were planted during previous restoration efforts, and thus lacks the ability to provide naturally recruited large wood to the channel over a period of 25-50 years in the future.

This stream reach is located in a portion of the watershed that historically provided important summer and winter rearing habitats for westslope cutthroat trout. Recent single pass density indices for age 1+ cutthroat trout ranged from 1.6 – 6.6 fish/100 m and few young of the year were found (Firehammer et al. 2016). Lack of habitat diversity, reduced infiltration of water from adjacent wetlands, and slightly elevated water temperatures are all factors that limit the productivity of these reaches.

Description of Treatment: Approximately 37 cubic meters (16 MBF) of wood was used to create single and multiple log structures in the project reach to better approximate historic wood loading rates in the channel. A total of eleven in-channel wood structures were constructed to emulate flow obstruction effects of natural wood jams and beaver dams.

Five of these structures were intended to provide improved bank stabilization in WF Lake Creek and Upper Lake Creek and utilized a passive approach by placing 2-4 large logs in the channel, with key pieces anchored in the bed and banks, to provide a key framework that beavers could use in dam construction and which serves as a natural analog that approximates historical, wood recruitment processes. This approach was based on observations from other watersheds that the most persistent, existing dams throughout the stream corridor are built with mountain alder integrated with remnant in-channel large wood.

The remaining six structures were engineered "flow choke structures" in which the concept was to create increased backwater effects during floods such that the valley floor would become connected annually. The structures affect approximately 650 m of habitats in WF Lake Creek and an additional 105 m of Upper Lake Creek by increasing residual pool depth and volume at base flow conditions. Each of the structures consisted of a horizontal log spanning the channel to form a simple weir and several horizontal bank logs to constrict high flows, with sufficient depth to permit passage of floating debris at the bankfull level (Photo 2).

To implement the design concept, construction involved:

1. Placement of a horizontal cross-log that acts as a control weir at flood flows. The bottom elevation of the orifice was designed to emulate general low flow control elevations formed by numerous beaver dams present in the reach, where median depths were 0.36 m at the riffle crest and 0.97 m below the floodplain; these served as natural process-based design criteria for situating the orifice control elevation and the depth of impounded gravel upstream. An additional horizontal log was buried beneath the weir at a depth that exceeded the estimated scour depth for each site.
2. A series of horizontal cross-logs protruding from each stream bank that project a blocked area in the downstream direction leaving a central orifice area for lower flows to pass through.
3. A pad of rock placed at the downstream end of the structure as a scour countermeasure, to protect the integrity of the structure.
4. A deposit of finer gravel, sized to be comparable to stones occurring naturally in the river banks and bed, placed on the bed of the upstream side of the structure to facilitate smoother streamlines and potentially provided trout spawning habitat.
5. Laid back stream banks within the upstream and downstream footprints of the structure to prevent saturated bank collapse, avulsion, and loss of structure integrity. A maximum graded slope of 1.5H:1V was specified here as an initial approximation to reduce the amount of excavation on either side of the structure while maintaining a saturated slope

stability safety factor above 3. The laid back banks were re-vegetated with herbaceous plants.

The cumulative effect of these treatments have enhanced approximately 1,100 m of tributary habitats and improved rearing conditions for native trout by increasing habitat diversity (i.e., instream cover, mean residual depth, pool frequency and volume) and reducing bank erosion typically associated with channel incision/entrenchment. Furthermore, the more persistent channel obstructions that have been constructed will facilitate stream bed aggradation over time across the larger reach.

Photo 2. Engineered "flow choke structures" constructed in Lake Creek use a combination of weir flow over a horizontal cross-log and lateral constriction by bank logs to provide desired water surface elevation controls.

Project Timeline: NEPA compliance documentation and landowner agreement were completed in early 2015. Construction for the project was completed in September and planting occurred in October.

Project Goals & Objectives: Provide for stream channel/floodplain connectivity at the 1.5-2 year return interval flow. Increase instream wood quantities and associated wood related habitat function to meet a wood loading target of 6 m^3/100 m. Improvements are anticipated for pool frequency and quality, gravel sorting and spawning gravel retention, hiding cover for fish, bed and bank stability, and stream/floodplain connectivity.

Relationship to Scope of Work: This work fulfills the Program commitments for WE I in the 2015 Scope of Work and Budget Request (Contract #69003) for the contract period June 1, 2015 - May 31, 2016.

Project L_13.6/0.0 – Upland/Planting: Lake Creek afforestation of former cropland

Project Location:

Watershed: Lake Creek	Legal: T48N R6W S12 NW; T48N R6W S1 SW
Sub Basin: Upper Lake (13.6 rkm)	Lat: 47.525564 N Long: -117.036149 W

Site Characteristics:

Slope/gradient: 3-25%	Aspect: Various	Elevations: 780 m
Valley/Channel type: VIII/E5	Proximity to water: Upland	

Other: Project treats approximately 18.9 ha (46.7 acres) of previously farmed uplands with highly erodible soils adjacent to 1447 m of streams in the upper watershed.

Problem Description: The project site consists of 18.9 hectares of uplands that variously drain to the mainstem of Lake Creek between river km 13.6 and 14.4 and to WF Lake Creek between river km 13.6/0.0 and 13.6/0.6. The forest was cleared from this area beginning in the 1920's and had a history of cropping and grazing up until the late 1990s. Soils in 33% of the area are classified as highly erodible. Sheet and rill erosion from these areas generated an estimated 15.1 tons/acre (total 262 tons/yr) of sediment annually with a delivery rate to streams of 10% under the historical cropping scenarios (US EPA 2005). Soils in the remaining 67% of the area are classified as moderately erodible due to their lower gradient. The single pass density index for age 1+ cutthroat trout in this area is quite variable based on the history of channel disturbance and lower than in adjacent upriver reaches. An index site within the more disturbed part of the project area supported trout densities in the range of 1.6-6.6 trout/100m, while a less disturbed site had densities of 9.8-34.1 trout/100m. Abatement of sediment from upland sources is an important factor in maintaining the productivity of aquatic resources within this reach.

Previous work conducted on the project site consisted of 450m of stream wood additions to Lake Creek and a series of riparian planting projects completed between 1998 and 2001 (Vitale et al 2003). The established stream buffer was subsequently enrolled in the Conservation Reserve Program offered by the NRCS. The Coeur d'Alene Tribe ultimately facilitated purchase of the properties encompassing the project site to mitigate for wetlands impacts associated with construction of US Hwy 95. In 2012, the Idaho Transportation Department deeded the property to the Tribe and a conservation agreement protects the wetlands and other natural resources values in perpetuity. The next series of planting occurred afterwards in April 2014 where 15,915 conifers were planted on 21.4 hectares. In 2015, large wood choke structures were placed on the West Fork of Lake Creek and main-stem Lake Creek on the new Tribal property to help aggrade the stream channel. Additional large wood was also placed to create fish habitat.

Description of Treatment: In May 2017, a total of 9,800 conifers (ponderosa pine, western white pine, and lodgepole pine) were planted. This included inter planting 16.6 hectares that were previously planted in 2013. An additional 2.3 hectares was planted at a density of 300 trees per acre on former cropland. Herbicide was also applied as a shielded spot spray using Atrazine 4L and glyphosate to control the grass and weeds in a 1.5m diameter circle around each seedling. In wetter portions of the planting area, Polaris SP replaced the Atrazine in the tank mix to protect ground water. A soil scalp adequate to prevent sprayed vegetation from brushing against seedlings was completed before planting. Vexar tree tubes were placed around a portion of the trees to provide shade and decrease browsing.

Project Timeline: Initial site preparation occurred in April and trees were planted in May 2017, followed by the herbicide treatment.

Project Goals & Objectives: Restore prior converted agricultural lands back to a native forest community. Reduce sheet and rill erosion and increase water retention on site. Improve wetland function and values associated with sediment/nutrient/toxicant retention and removal, wildlife usage, uniqueness and cultural value. Achieve a minimum stocking rate after 5 years of 200 trees/acre on at least 70% of the planted areas. Survival surveys will monitor stocking in first, second and fifth years after planting. Further replanting would be scheduled where survival surveys indicate that the minimum acceptable stocking rate is not achieved.

Relationship to Scope of Work: This project fulfills the Program commitments for WE K in the 2016 Scope of Work and Budget Request (Contract #72851) for the contract periods dating June 1, 2016 through May 31, 2017.

Project B_15.6 – Increase Habitat Complexity: Benewah Creek Beaver Dam Analogs

Project Location:

Watershed: Benewah Creek	Legal: T45N R4W S13 and S24
Sub Basin: Upper Benewah (15.6 rkm)	Lat: 47.237607N Long: -116.777158W

Site Characteristics:

Slope/gradient: 0.7%	Aspect: N	Elevations: 830 m
Valley/Channel type: B2/C4	Proximity to water: Instream and adjacent floodplain	

Other: BDAs installed at 36 locations in Benewah Creek between rkm 15.6 and 20.3 affecting 3360 m of channel. Planted 2340 native riparian plants within 3 acres of fenced floodplain habitats.

Problem Description: In Benewah Creek, we postulated that a positive feedback cycle may exist where historic beaver trapping and removal of trees and shrubs used by beaver resulted in local extirpation or significant reductions in beaver population size (Firehammer et al. 2013). In this event, neither beaver populations nor beaver-generated fish habitat will fully recover until riparian vegetation is restored (Pollock et al. 2004). Recovery of beaver-generated floodplain wetlands and their wet meadow, scrub–shrub, and forested plant communities is dependent upon the restoration of lost hydraulic linkages between the channel and its floodplain through annual flood pulses and a locally high water table (Westbrook et al. 2006). However, water availability may not be sufficient in environments like Benewah Creek to support riparian plant establishment and growth. In such circumstances, beaver were likely the historic mechanism that supplied riparian vegetation with sufficient water to establish and maintain trees and shrubs. Importantly, successful beaver recolonization and riparian vegetation restoration may require long periods of time when the positive feedback mechanism described above has been activated.

We developed and implemented a simple approach to restoration in this reach of mainstem Benewah Creek between rkm 15.6 and 20.3 that emulates the ecosystem engineering effects of beaver. The approach involves constructing log flow-choke structures that mimic the hydraulic function of a stable natural beaver dam during flooding (DeVries et al. 2012). By placing these structures throughout the stream reach at locations promoting increased frequency of flood connection with floodplain swales and relict channels, we set the stage to restore the riparian corridor and floodplain more quickly than could be achieved through revegetation alone. We coupled this with several more passive approaches, where 1) vertical posts were used to reinforce active dams, and 2) large wood was placed in the channel and partially buried to provide a stable framework for beaver to build on; approaches that have more recently been referred to as Beaver Dam Analogues (BDAs) (MacCracken et al. 2005; Pollock et al., 2015). Together we hoped these methods would provide an ecosystem "kick-start" that emulates the mechanisms driving natural floodplain connectivity and restoring both fish habitat and floodplain vegetation more rapidly than simply revegetating and waiting for the riparian zone to mature.

Between 2009 and 2012, treatments were applied in 30 locations affecting 57 percent of stream habitats within 3,138 m of the upper mainstem of Benewah Creek (Figure 5). From the perspective of riparian floodplain restoration, these collective efforts were achieving at least some of the intended results. However, in the same timeframe we documented a 79 percent reduction in the direct influence by beaver on aquatic habitats in the reach, which we speculated would significantly affect the overall trajectory and scale for recovery of watershed processes (Firehammer et al. 2013). This trend has worsened more recently with loss of all the remaining natural dams in the reach. Concurrent with the widespread loss of natural beaver dams we have observed less channel inundation and lower summer water tables, and by inference, less hyporheic exchange, a contraction in wetland area and an overall decrease in the complexity of the stream ecosystem. Establishing riparian plantings at a scale that can support beaver populations and shade stream channels in the future has continued to be a real challenge that still needs to be addressed if restoration actions are to reach their potential in a reasonable time frame.

Description of Treatment: The absence of beaver activity in the reach suggests several opportunities for refining the restoration approach. In fact, monitoring data reinforces the need for such an adaptive approach. For example, seasonal movements have been detected showing fish utilizing mainstem reaches during summer and fall rearing periods and moving downstream into restored sections of the upper Benewah mainstem in winter (Firehammer et al. 2016). The movements illustrate the importance of protecting or restoring seasonal habitats in the watershed.

The past mapping and monitoring of beaver dams in upper Benewah Creek identified nearly 50 specific locations where construction of BDAs may be appropriate (Figure 5). Starter dams were established in three of these locations in 2015, wherein a line of wooden posts was installed using a hydraulic post pounder, followed by weaving branches in between the posts, after Pollock et al. (2012) (Photo 3.). In all cases the posts lines remained intact across several high flow periods and several dams functioned in much the same manner as log flow-choke structures that mimic the hydraulic function of stable natural beaver dams during flooding. Post lines were installed at 22 additional locations in the reach in 2016 to allow for establishing willow weaves at a later date; willow weaves were completed at 11 of these sites.

In addition, the 17 locations where engineered flow choke structures have previously been built in Benewah Creek could also be modified to function more like natural beaver dams during a wide range of flows. Currently these structures create a constriction in the channel, which increases upstream flooding and creates temporary ponding during high flows, but during low flows they provide little functionality that is similar to a beaver dam. It was hypothesized that the weir opening in these stable structures could be “plugged” using natural materials in much the same manner as the starter dams described above. Less permeable plugs could effectively increase channel inundation and raise summer water tables thereby providing more viable planting conditions. Consistent with the original intent of this work, these refinements would be very low impact and cost effective, requiring investments primarily in manual labor. Experiments were conducted in 2016 to test this concept at 11 locations in the project reach (Photo 4). At each location movable “dam boards” were fashioned to fit within the weir opening of the engineered structures, elevating stream levels by as much as three feet. These dam boards can be quickly installed and removed to adjust stream water levels as needed to influence surrounding ground water tables during critical times of the year for riparian plantings.

Preliminary monitoring of the BDAs installed in 2016 indicated that the structures maintained a high degree of integrity during summer low flows and elevated stream water levels, and presumably ground water levels as well, through the growing season (Photo 4). A number of these same dams remained intact and functional following a 10-year return interval flood that occurred the winter after initial installation. Only relatively minor maintenance may be required to sustain these functions over a period of several seasons. These observations led to a quickly devised plan to replant areas in close proximity to these structures where previous attempts to establish native plants had failed presumably due to drier than desirable site conditions. During spring 2017, an area encompassing approximately 3 acres in proximity to the stream channel was fenced and then planted in order to test whether these treatments can indeed provide favorable site conditions for plant establishment (Figure 5). A total of 840 alder, dogwood, cottonwood and aspen were planted within fenced areas. In addition, 1500 live cuttings of drummond, mackenzie and pacific willow were planted in 30-50' long transects in areas with apparently elevated ground water. Monitoring of these treatments is ongoing and results will be described in future technical reports for this project.

The addition of BDAs in this manner should increase both the abundance and life span of natural dams if and when beaver should return, which in turn should promote reconnection of floodplain surfaces on a larger scale. Such longer lived, less transient dams should become building blocks for resilient and dynamic beaver dam complexes that support thriving colonies of beaver.

Project Timeline: Implementation of the habitat enhancement recommendations represents an ongoing process to occur across several contract years. BDAs were constructed in summer 2015 and at additional locations in summer 2016. Fencing and riparian plantings encompassing approximately 3 acres were completed in spring 2017.

Project Goals & Objectives: Goals for this project include 1) create wetland habitats and increase the hydraulic connections with the valley bottom; 2) reduce bank erosion; and 3) establish native plant communities to improve channel function and sustain beaver populations; Improvements are anticipated for pool frequency and quality, hiding cover for fish, bed and bank stability, and stream/floodplain connectivity.

Relationship to Scope of Work: This work fulfills the Program commitments for WE J in the 2016 Scope of Work and Budget Request (Contract #72851) for the contract period June 1, 2016 - May 31, 2017.

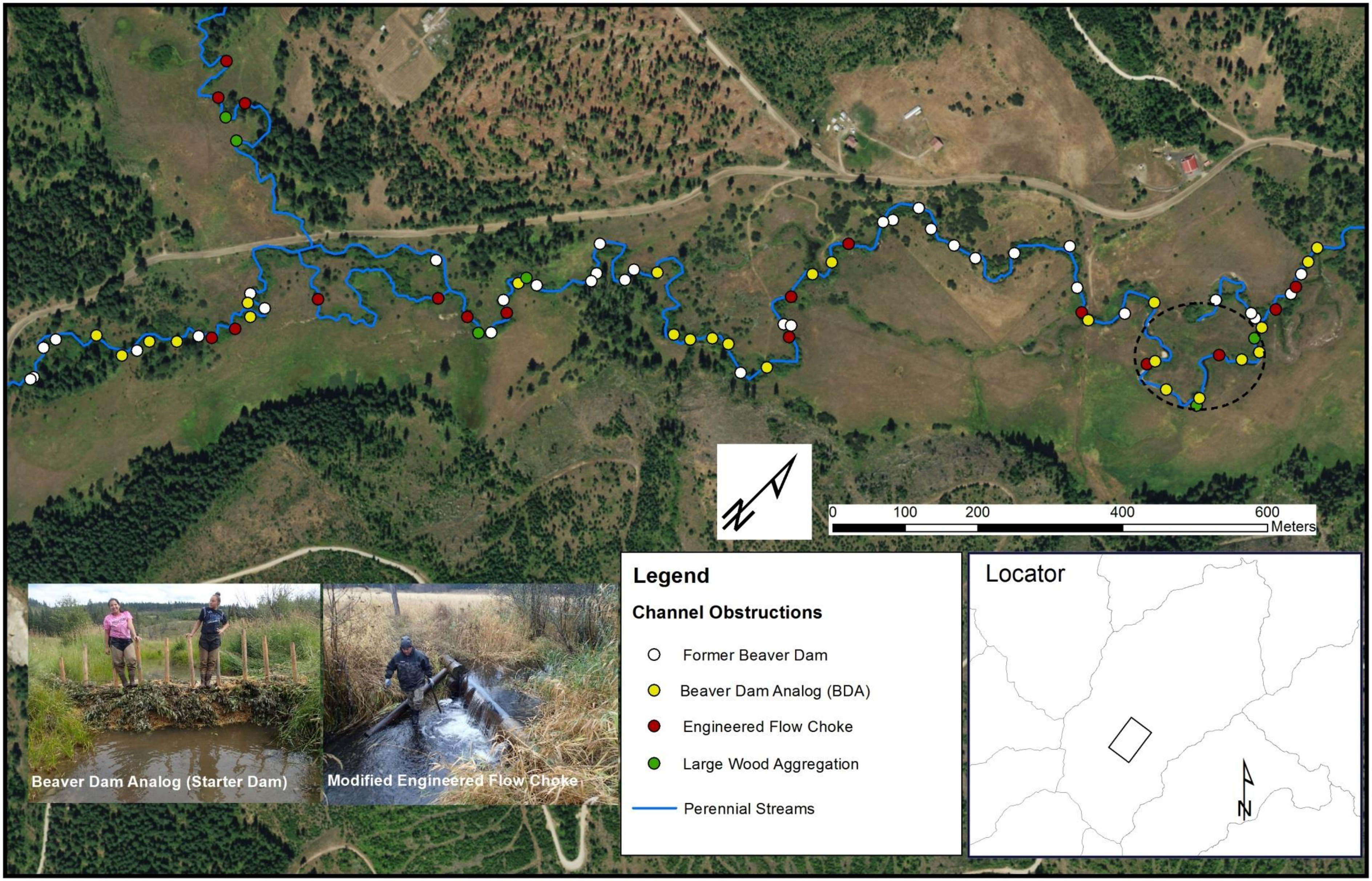

Figure 5. Locations of former beaver dams and restoration structures in the D2 reach of the Ełtumish Project in upper Benewah Creek. Examples of a completed starter dam (a type of Beaver Dam Analog) and a modified engineered flow choke structure are shown in the inset photos. The area highlighted at the right of the photo is the location of fencing and planting that was completed in Spring 2017.

Photo 3. Starter dams were established in a total of 14 locations during 2015 and 2016, wherein a line of wooden posts was installed using a hydraulic post pounder, followed by weaving branches in between the posts and incorporating straw and mud to create a semi-permeable structure mimicking a natural beaver dam.

Photo 4. Beaver Dam Analogs (BDAs) installed in 2016 maintained a high degree of integrity during summer low flows while elevating stream water levels and the surrounding ground water table through the growing season. Opportunities for establishing riparian plant communities are being tested in these areas with improved wet site conditions.

Project B_18.6/3.2: Upland/Road: Reduce sediment delivery to Windfall Creek

Project Location:

Watershed: Benewah Creek	Legal: S15 T45N R4W NE SW
Sub Basin: Windfall Creek (3.2 rkm)	Lat: 47.241543 N Long: -116.823334 W

Site Characteristics:

Slope/gradient: 3%	Aspect: N	Elevations: 3200
Valley/Channel type: C4/C4	Proximity to water: hydrologically connected roads	

Other: Road segments were improved for 2,574 meters to decrease sediment delivery to the Windfall Creek.

Problem Description: Windfall Creek, a tributary to Benewah Creek, is an important spawning and rearing streams for resident and adfluvial Westslope Cutthroat Trout. A Forest Road and Fish Passage Assessment completed in 2008 identified road segments in the Benewah watershed that directly contribute sediment to these streams (Duck Creek Associates 2009). A prioritization process subsequently completed by the Fisheries program identified areas where additional drainage improvements and road resurfacing was needed (Firehammer et al. 2011). This work is part of the on-going effort by the tribe to improve fish habitat and water quality by managing roads in watersheds that encompass priority streams.

Description of Treatment: This project involved doing road improvements to Windfall Pass Road within the Windfall Creek watershed. Previous road work in the watershed included removing a fish barrier along Windfall Creek on the Benewah Road that opened up 4,344 meters of stream channel to fish passage. From the 2008 study, sediment production for the Windfall Pass Road was predicted to be 26.6 mean tons/annually. By changing the road surface from a native surfaced road to a gravel road, the sediment production was predicted to drop to 4.86 mean tons/annually, a reduction of nearly 82 percent (Duck Creek Associates 2009). In addition, improving drainage on the road will further reduce sediment transport to Windfall Creek. This improvement in sediment production was the focus of the work in this project.

The following construction phases were the focus of restoration work in summer 2015 and 2016:

Road resurfacing was completed on 2,574 meters of native surface road along the upper sections of Windfall Pass Road (Figure 6). Prior to resurfacing, road segments were re-graded and ditches repaired. Two rock sources were used to resurface the road. A base of courser 6” minus rock (3204 CY) was placed first, followed by a surface cover of ¾” minus rock (2746 CY). A roller and a grader were used to complete this work.

A total of six culverts were installed using a Cat 303 mini-excavator to cross drain the resurfaced road segments and prevent water accumulation in roadside ditches. In addition, maintenance work was completed on 13 ditch relief culverts so that they would function properly.

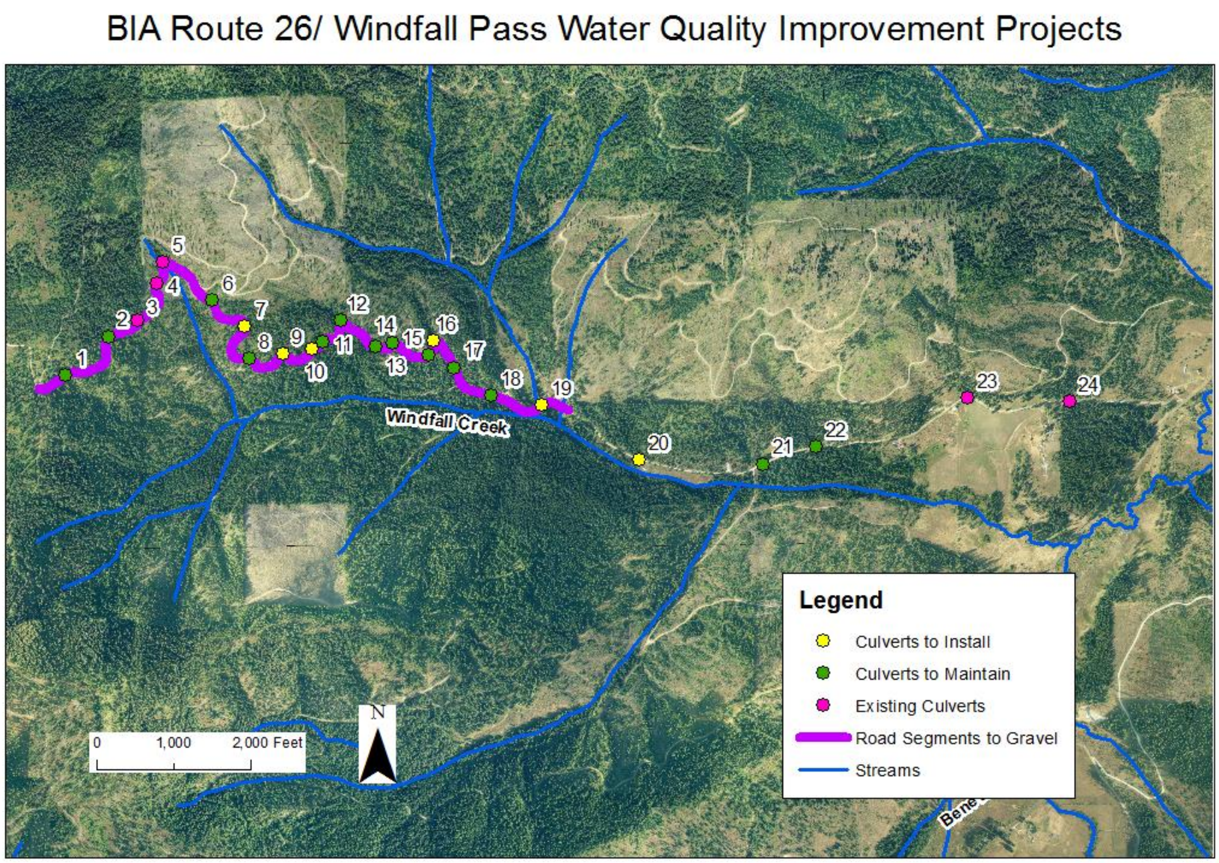

Figure 6. Map of road treatments area on Windfall Pass Road.

Photo 5. Sediment transported to an unnamed tributary to Windfall Creek prior to resurfacing (left panel). Road segment along Windfall Pass road prior to resurfacing (right panel).

Photo 6. Resurfaced section of Windfall Pass in October 2016.

Project Timeline: NEPA compliance documentation and landowner agreement were completed in 2015. Construction for the project was completed June 2015 – May 2017.

Project Goals & Objectives: Reduce sediment delivery and improve drainage along road segments that are hydrologically connected and delivering sediment to important spawning and rearing streams.

Relationship to Scope of Work: This work fulfills the Program commitments for WE H in the 2015 Scope of Work and Budget Request (CR-69003) for the contract period June 1, 2015 - May 31, 2016 and for Program commitments for WE H in the 2016 Scope of Work and Budget Request (CR-72851) for the contract period June 1, 2016 - May 31, 2017.

Project B_19.6/1.2 - Instream/Fish Passage: Schoolhouse Creek fish passage improvement

Project Location:

Watershed: Benewah Creek	Legal: T45N R4W S25 SW NE
Sub Basin: School House Creek (1.2 rkm)	Lat: 47.223056 N Long: -116.773889 W

Site Characteristics:

Slope/gradient: 2%	Aspect: NW	Elevations: 865 m
Valley/Channel type: C4/E5	Proximity to water: In-stream and adjacent floodplain	

Other: An undersized culvert was replaced to improve fish passage. One cross-vane was installed to create grade control within the project reach. Native trout will gain improved access to 833 meters of potential rearing and spawning habitat.

Problem Description: Schoolhouse Creek is an important spawning and rearing stream for resident and adfluvial westslope cutthroat trout in the Benewah watershed. This stream crossing was identified as an adult and juvenile fish barrier in the Forest Road and Fish Passage Assessment completed in 2008 (Duck Creek Associates 2009). The existing 60" diameter culvert was undersized and perched 0.35 m above the stream channel where bankfull width is 3.38 m. A prioritization process completed by the Fisheries program ranked the replacement of this stream crossing as a high priority. The project will restore connectivity with the upper Whitetail Creek watershed, including access to 833 meters of potential rearing and spawning habitats with a drainage area of 422 ha.

Description of Treatment: We collected data describing existing culvert size, length, road characteristics, flow line characteristics, floodplain information, and ground elevations using a Sokkia 530R total station. This information was imported into AutoCAD Civil 3D for analysis. In addition, cross-section information was collected to identify bankfull width and depth. Engineering drawings and specifications were developed for the new stream crossing structure using a variety of computer software. The Idaho Streamstats Website was used to derive discharge values at the site for a variety of flow regimes. The Federal Highway Administration's HY-8 Culvert Hydraulic Analysis Program was used to size the culvert. Once the culvert size and shape was determined, we used Fish Xing software to examine its characteristics for fish passage. ArcGIS was used to develop location maps and site maps.

The design called for replacing the existing undersized pipe with a new 77" x 52" x 50' arch pipe that more closely matched the bankfull channel width. The new pipe was countersunk to provide natural substrate in the bottom of the culvert and eliminate the outlet drop. One grade control structure, comprised of 20-25 large boulders, was constructed to hold substrate in the new culvert and to provide more uniform channel grade in the vicinity of the of the stream crossing. The grade control structure was designed following specifications for cross-vanes developed by Rosgen (1996). Forty-eight meters of stream channel was affected by this project. A total of 0.03 ha of wetland was disturbed during construction.

The following construction phases were the focus of restoration work in summer 2016:

Phase 1: Replace existing culvert. A Cat 320 excavator was used to remove the undersized culvert and install the new 77" x 52" arch pipe. Before installing the new pipe, bedding material consisting of ¾" minus gravel was placed in the excavated pipe trench and compacted. The new pipe was delivered in 2 separate sections that were connected during construction. The used culvert was given back to the landowner for reuse. The existing roadbed was capped with imported gravel. Rock rip-rap was placed around the new pipe to help protect the inlet and outlet of the new pipe. Large cobbles and small boulders were hand placed in the pipe to help accumulate gravel and create fish habitat.

Phase 2: Install ground control and reshape the stream. One drop structure was installed to connect the upstream and downstream stream reaches. This structure will create grade control as well as provide fish habitat downstream of the new culvert. We also reshaped the stream channel on the downstream end of the project reach so that it had access to a floodplain bench.

Phase 3: Planting. A total of 50 one-gallon woody plants and 200 herbaceous grass plugs were planted along the stream channel and within the new riparian and upland areas created by removing sections of the abandoned road. Disturbed areas were seeded with native grass seed at a rate of 18 kg/ha.

Photo 7. The former Schoolhouse Creek stream crossing was identified as a fish barrier (left panel). The new Schoolhouse Creek culvert is shown after construction in September 2016. Note the newly created floodplain bench (right panel).

Project Timeline: NEPA compliance documentation and a landowner agreement were completed in 2015. Construction was completed in August and planting occurred in September 2016.

Project Goals & Objectives: The goal is to restore connectivity with the upper Schoolhouse Creek subwatershed by removing a barrier to fish passage. Native trout will have access to 833 meters of prime rearing and spawning habitats upstream of the new culvert.

Relationship to Scope of Work: This work fulfills the Program commitments for WE E in the 2015 Scope of Work and Budget Request (CR-69003) for the contract period June 1, 2015 - May 31, 2016 and for Program commitments for WE E in the 2016 Scope of Work and Budget Request (CR-72851) for the contract period June 1, 2016 - May 31, 2017.

Project B_21.5/1.0 Upland/Road: Reduce sediment delivery to WF Benewah Creek

Project Location:

Watershed: Benewah Creek	Legal: T45N R4W S27 SE NE, NE SE
Sub Basin: WF Benewah Creek (1.0 rkm)	Lat: 47.21584. N Long: -116.81706 W

Site Characteristics:

Slope/gradient: 3%	Aspect: E	Elevations: 926 m
Valley/Channel type: E3/C4	Proximity to water: hydrologically connected roads	

Other: Seven cross-drain relief culverts were added to 3,167 meters of the Benewah Road to improve drainage and decrease sediment delivery to the West Fork Benewah Creek.

Problem Description: The West Fork Benewah Creek is an important spawning and rearing stream for resident and adfluvial westslope cutthroat trout. A Forest Road and Fish Passage Assessment completed in 2008 identified road segments in the Benewah watershed that directly contribute sediment to these streams (Duck Creek Associates 2009). A prioritization process subsequently completed by the Fisheries program identified areas where additional drainage improvements were needed (Firehammer et al. 2011). This work is part of the on-going effort by the tribe to improve fish habitat and water quality by managing roads in watersheds that encompass priority streams.

Description of Treatment: This project involved doing road improvements to a county road within the West Fork Benewah Creek sub-watershed. Previous road work in this area included removing a fish passage barrier along West Fork Benewah Creek at km 21.5/1.7 that opened up 3,390 meters to fish passage.

Before treatment, only four relief culverts were present along 3,167 meters of the steepest sections of the Benewah Road from the top of Lolo Pass to Fletcher Road. A total of seven culverts were installed using an excavator to cross drain the road segments and prevent water accumulation in roadside ditches (Figure 7). The new cross-drains were located where springs or other small channels drained into the streamside ditch on the Benewah Road. Also during construction, the ditches were repaired and the road was re-graded. This work was completed in spring/summer 2015.

Project Timeline: NEPA compliance documentation and landowner agreement were completed in 2014. Construction for the project was completed from April-June 2015.

Project Goals & Objectives: Reduce sediment delivery and improve drainage along road segments that are hydrologically connected and delivering sediment to important spawning and rearing streams.

Relationship to Scope of Work: This work fulfills the Program commitments for WE G in the 2014 Scope of Work and Budget Request (CR-65197) for the contract period June 1, 2014- May 31, 2015.

Benewah Road by Lolo Pass

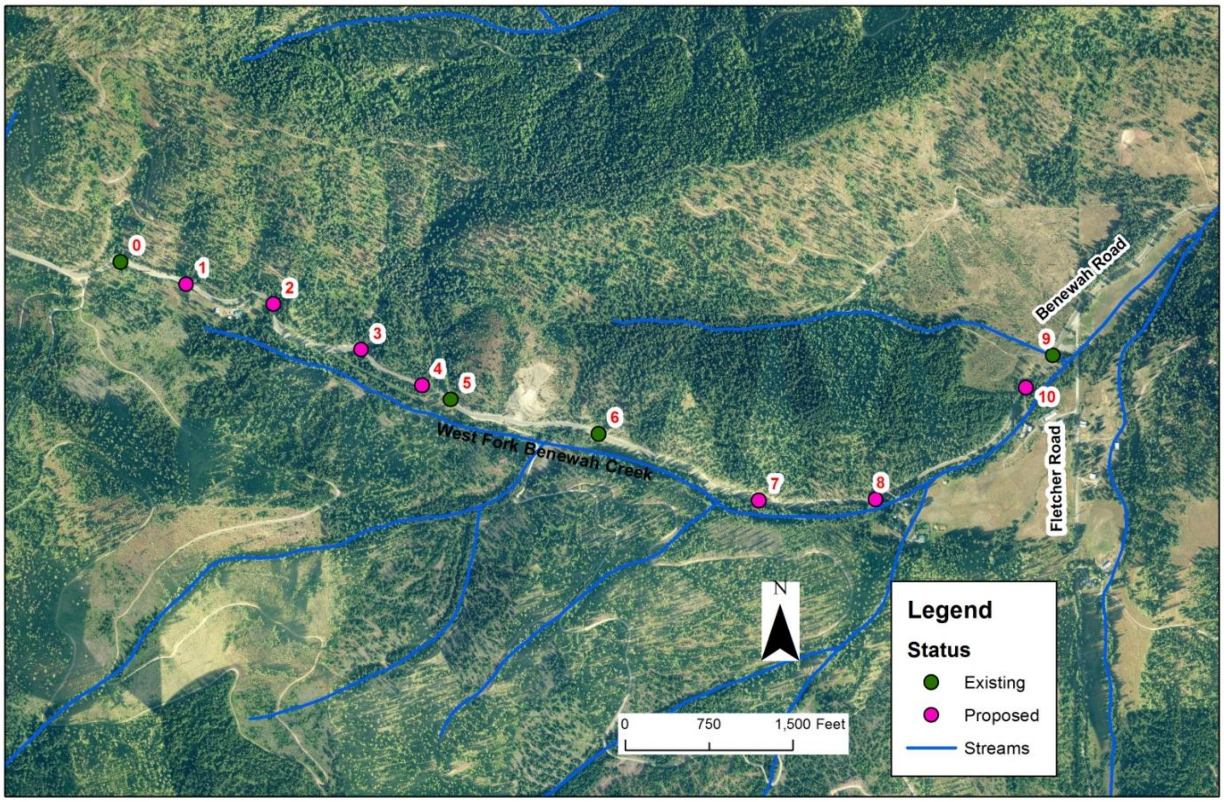

Figure 7. Location of cross-drains that were added to the Benewah Road from the top of Lolo Pass to Fletcher Road.

5.0 References

DeVries, P., K. L. Fetherston, A. Vitale, S. Madsen. 2012. Emulating rivering landscape controls of beaver in stream restoration. Fisheries 37(6): 246-255.

Duck Creek Associates, Inc. 2008. Wood recruitment inventory and analysis. Final report prepared for the Coeur d'Alene Tribe Fisheries Program.

Duck Creek Associates. 2009. Road condition and fish passage inventory and analysis. Report prepared for the Coeur d'Alene Tribe Fisheries Program, Plummer, Idaho. 84 pp. (with appendices).

Firehammer, J.A., A.J. Vitale, and S.A. Hallock. 2011. Implementation of fisheries enhancement opportunities on the Coeur d'Alene Reservation, 2009 Annual Report. Project No. 1990-044-00; Contract No. 00047583. U.S. Department of Energy, Bonneville Power Administration, Portland, OR.

Firehammer, J.A., A.J. Vitale, S.A. Hallock, and T. Biladeau. 2013. Implementation of fisheries enhancement opportunities on the Coeur d'Alene Reservation. 2011-2012 Annual Report. Project No. 1990-044-00. U.S. Department of Energy, Bonneville Power Administration, Portland, OR.

Firehammer, J. A., A. J. Vitale, and S. H. Hallock. 2016. Implementation of Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation, 1/1/2013 – 12/31/2014 Annual Report, Project #1990-044-00Intermountain Province Subbasin Plan 2004

Lillengreen, K.L., T. Skillingstad, and A.T. Scholz. 1993. Fisheries habitat evaluation on tributaries of the Coeur d'Alene Indian Reservation. Bonneville Power Administration, Division of Fish and Wildlife, Portland Or. Project # 90-44. 218p

MacCracken, J. G., and A. D. Lebovitz. 2005. Selection of in-stream wood structures by beaver in the Bear River, southwest Washington. Northwestern Naturalist 86:49-58.

Mallet, J. 1969. The Coeur d'Alene Lake fishery. Idaho Wildlife Review. May-June, 1969. 3-6 p.

Pollock, M. M., G. R. Pess, T. J. Beechie, and D. R. Montgomery. 2004. The importance of beaver dams to coho production in the Stillaguamish River basin, Washington, USA. North American Journal of Fisheries Management **24**:749-760.

Pollock, M. M., J. M. Wheaton, N. Bouwes, C. Volk, N. Weber, and C. E. Jordan. 2012. Working with beaver to restore salmon habitat in the Bridge Creek intensively monitored watershed: Design rationale and hypotheses. NOAA Technical Memorandum **NMFS–NWFSC–120**:1-47.

Pollock, M.M., G. Lewallen, K. Woodruff, C.E. Jordan and J.M. Castro (Editors) 2015. The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains. Version 1.0. United States Fish and Wildlife Service, Portland, Oregon. 189

pp. Online at: http://www.fws.gov/oregonfwo/ToolsForLandowners/RiverScience/Beaver.asp.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

Scholz, A.T., D.R. Geist, and J.K. Uehara. 1985. Feasibility report on restoration of Coeur d'Alene Tribal Fisheries. Upper Columbia United Tribes Fisheries Center. Cheney, WA. 85 pp.

U.S. Environmental Protection Agency. 2005. Total maximum daily load (TMDL) for sediments in the waters of Lake Creek in Coeur d'Alene Lake Subbasin, Idaho. Region 10, Seattle, WA. 68 p.

U.S. Forest Service. 1998. Biological assessment: St. Joe River Basin/North Fork Clearwater. U.S. Fish and Wildlife Service, bull trout Section 7(a)2 consultation. 145p.

Vitale, A.J., D. Lamb, and J. Scott. 2003. Implementation of Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation. 2002. Annual Report. Project No. 1990-04400, 111 electronic pages, (BPA Report DOE/BP-00010885-1)

Westbrook, C.J., D.J. Cooper, and B.W. Baker. 2006. Beaver dams and overbank floods influence groundwater-surface water interactions of a Rocky Mountain riparian area. Water Resources Research 42: 1-12.