

**Implementation of Fisheries Enhancement Opportunities on the  
Coeur d'Alene Reservation  
Habitat Restoration Report**

**BPA Project # 1990-044-00**

**Report covers work performed under BPA contract #(s) 76243, 76828**

**Report was completed under BPA contract #(s) 76828**

6/1/2017 – 12/31/2019

A. J. Vitale and S. A. Hallock

Coeur d'Alene Tribe, Plummer, ID, 83851

1 – 2020

**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. A. Hallock. 2020. Implementation of Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation, 6/1/2017 – 12/31/2019 Annual Report, Project #1990-044-00.**

## TABLE OF CONTENTS

<b>1.0 Project Background</b> .....	<b>1</b>
<b>2.0 Study Area</b> .....	<b>2</b>
<b>3.0 Introduction to Habitat Enhancement Actions</b> .....	<b>4</b>
<b>4.0 Summary of Implemented Actions</b> .....	<b>7</b>
Project L_13.4/1.04 - Instream/Fish Passage: Bozard Creek fish passage improvement.....	8
Project L_16.3 - Instream/Fish Passage: Lake Creek fish passage improvement .....	12
Project L_18.5 - Instream/Fish Passage: Upper Lake Creek fish passage improvement .....	15
Project L_13.6/0.0 – Upland/Planting: Lake Creek afforestation of former cropland .....	19
Project L_13.6/2.3 – Instream/Channel Enhancement: Upper Lake Creek wood additions ....	21
Project L_13.6/2.3 – Riparian/Planting: Upper Lake Creek Riparian Planting.....	25
Project B_21.85/0.5 - Instream/Fish Passage: West Fork Benewah Creek fish passage improvement.....	28
Project B_21.85/2.13 - Instream/Fish Passage: South Fork Benewah Creek fish passage improvement.....	31
Project B_8.9/0.5 - Instream/Fish Passage: Bull Creek fish passage improvement .....	34
Project B_8.9/2.16 - Instream/Fish Passage: Bull Creek fish passage improvement .....	34
Project B_19.25: Upland/Road: Reduce sediment delivery to Benewah Creek.....	38
Project B_15.6 – Increase Habitat Complexity: Benewah Creek Beaver Dam Analogs .....	40
Project A_13.9 - Instream/Fish Passage: Alder Creek fish passage improvement.....	46
Project SJ_18.5 – Wetland/Planting: Native Willow Nursery for Support of Restoration Actions .....	49
<b>5.0 Lessons Learned and Adaptive Management</b> .....	<b>54</b>
Refining the approach for beaver aided restoration: Benewah Creek case study.....	54
Beavers generate ecosystem change and climate resilience .....	56
A preliminary prescription for Stage-0 restoration.....	61
Evaluating the Efficacy of Restoration Planning.....	67
<b>6.0 References</b> .....	<b>69</b>
<b>7.0 Appendix A - Project List</b> .....	<b>72</b>

## LIST OF MAPS

Map 1. Locations of the four focal watersheds in the Coeur d’Alene Basin targeted by BPA project 1990-044-00.....	3
Map 2. Locations of completed and planned projects in the Benewah Creek watershed.....	5
Map 3. Locations of completed and planned projects in the Lake Creek watershed.....	6
Map 4. Location of the Benewah Road resurfacing project. ....	39

Map 5. Locations of former beaver dams and restoration structures in the D2 reach of the Eltumish Project in upper Benawah Creek. ....	44
Map 6. Location of native willow nursery on BPA purchased mitigation property near St. Maries, ID. ....	51
Map 7. Disposition of natural dams and restoration structures surveyed during 2010 through 2012 in the phase two reach of the Eltumish Project in upper Benawah Creek .....	58
Map 8. Change in baseflow wetted surface area over four different time periods in a one kilometer stream reach in Benawah Creek .....	59
Map 9. Locations of unconfined, depositional valley types in upper Benawah Creek (after Cupp (1989)). ....	65
Map 10. Locations of unconfined, depositional valley types in upper Lake Creek (after Cupp (1989)). ....	66

### **LIST OF FIGURES**

Figure 1. Daily maximum and minimum water temperatures recorded at loggers deployed at the surface and at the bottom of a beaver influenced pool in Benawah Creek during extreme drought conditions in 2015.. ....	60
Figure 2. Temperature increase across a 2.6 km reach in Benawah Creek during two time periods where beaver were absent (2007-2012) and present (2013-2019) .....	60
Figure 3. The difference in temperature metrics, calculated annually over July and August, between those recorded at Benawah Creek rkm 14.0 and those recorded at Lake creek rkm 7.2 (i.e., Benawah value – Lake value). ....	61

### **LIST OF TABLES**

Table 1. Valley type attributes for unconfined, depositional valleys in the upper Benawah and upper Lake creek watersheds. ....	63
Table 2. Descriptive list of projects proposed for the Lake watershed. ....	73
Table 3. Descriptive list of projects proposed for the Benawah watershed. ....	75

### **LIST OF PHOTOS**

Photo 1. Former culvert configuration at the Bozard Creek stream crossing, spring 2017. ....	10
Photo 2. New Bozard Creek bridge structure during the later stages of construction. ....	10
Photo 3. Finished Bozard Creek bridge in November 2017. ....	11
Photo 4. Newly constructed Bozard Creek bridge in summer 2018. ....	11
Photo 5. The former Lake Creek stream crossing (64” pipe) was identified as a fish barrier. ....	13
Photo 6. Newly installed 112” x 75” arch pipe in October 2018. ....	14
Photo 7. The former upper Lake Creek stream crossing that was identified as a fish barrier. ....	17
Photo 8. A simulated streambed was constructed between the two concrete footings. ....	18

Photo 9. The plate arch culvert was pieced together then lifted on to the concrete footers to finish the job of constructing the new passage structure. .... 18

Photo 10. Treatment reach in the upper Lake Creek subwatershed targeted for LWD placements. .... 23

Photo 11. A 303Cat mini-excavator equipped with a rotating grapple was used to place wood in a variety of configurations within 964 m of the upper Lake Creek subwatershed. .... 23

Photo 12. Large wood was placed in a variety of configurations within the treatment reach, including this log crib jam, that was placed to reduce sheer stress and redirect flows away from an eroding bank. .... 24

Photo 13. Riparian vegetation within the treatment reach is dominated by reed canary grass and douglas spirea and lacks sufficient woody species capable of providing shade, contributing large wood to the channel, and sustaining beaver. .... 27

Photo 14. Survival of aspen planted in test plots exceeded 95% and grew rapidly during their second season in the ground. .... 27

Photo 15. The former West Fork Benewah Creek stream crossing was identified as a fish barrier. .... 29

Photo 16. The new West Fork Benewah Creek stream channel in spring 2018. .... 30

Photo 17. The former South Fork Benewah Creek stream crossing before replacement. .... 33

Photo 18. The new South Fork Benewah Creek culvert in 2018 during high flows. .... 33

Photo 19. The lower Bull Creek stream crossing that was identified as a fish barrier. .... 36

Photo 20. The upper Bull Creek stream crossing that was identified as a fish barrier. .... 36

Photo 22. The upper Bull Creek stream crossing after replacement. .... 37

Photo 23. 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. .... 45

Photo 24. 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. .... 45

Photo 25. The former Alder Creek stream crossing that was identified as a fish barrier. This pipe was undersized. .... 47

Photo 26. The new Alder Creek culvert is shown after construction in September 2018. .... 48

Photo 27. Site preparation included removal of canarygrass using a small dozer. .... 52

Photo 28. Aerial photo of the native willow nursery September, 2019. .... 52

Photo 29. Rows of planted Drummond willow ..... 53

Photo 30. Rows of planted Makenzie willow. .... 53

Photo 31. Example of a Stage-0 anastomosing channel network in the upper Lake Creek watershed. The channel occupies a transition zone between an alluviated, moderate slope bound valley and a wide, alluviated valley floor (after Cupp 1989). .... 64

## 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 (Map 1), and the development of a monitoring program to evaluate the effectiveness of the habitat improvement projects.

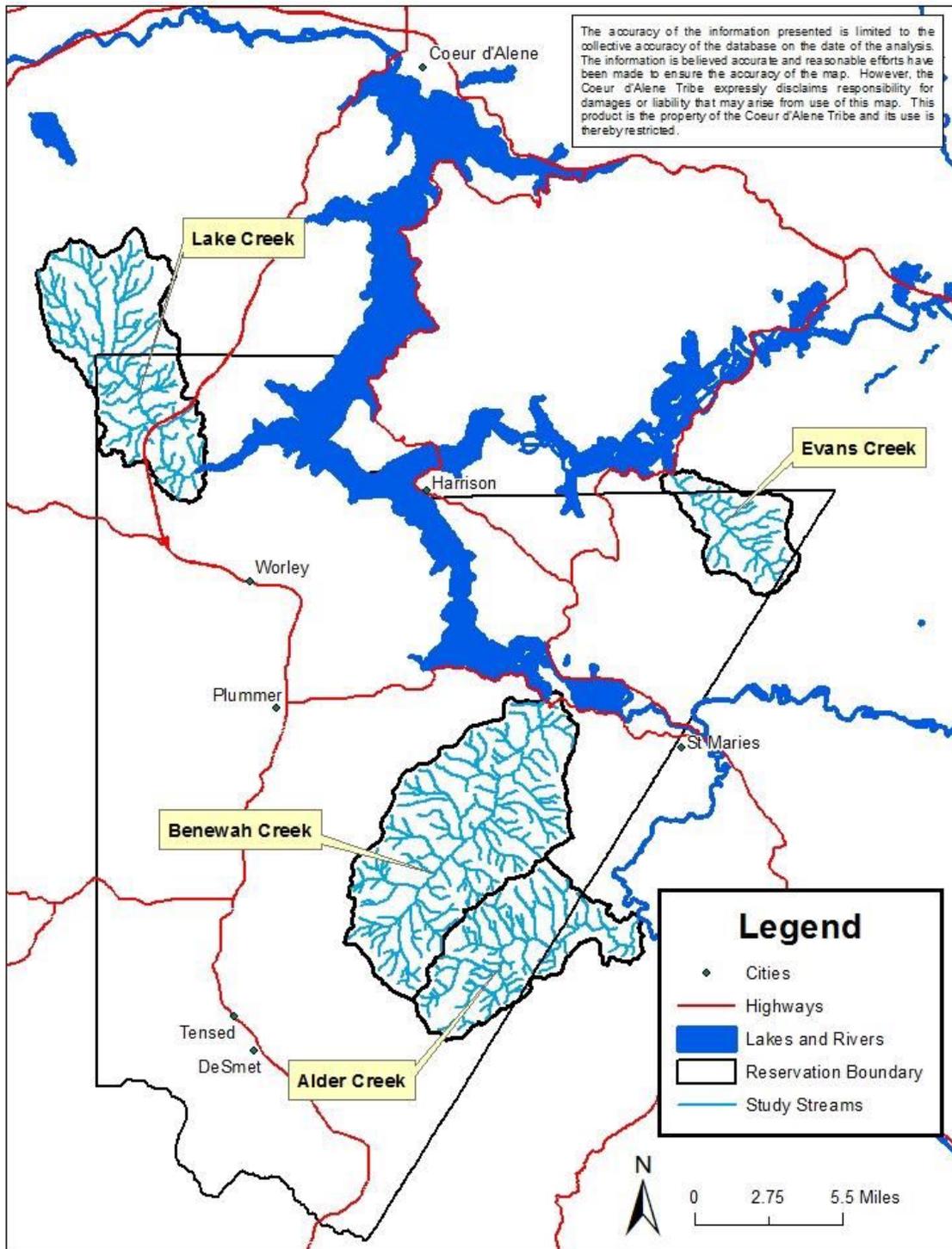
Since that time, the BPA project entitled “Implementation of Fisheries Enhancement Opportunities on the Coeur d’Alene Reservation” (#1990-044-00), which is sponsored and implemented by the Coeur d’Alene Tribe Fisheries Program, has supported the various recovery measures, which have included habitat 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 June 2017 through December 2019 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 (**Error! eference source not found.**). 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 (**Error! Reference source not found.**), 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.

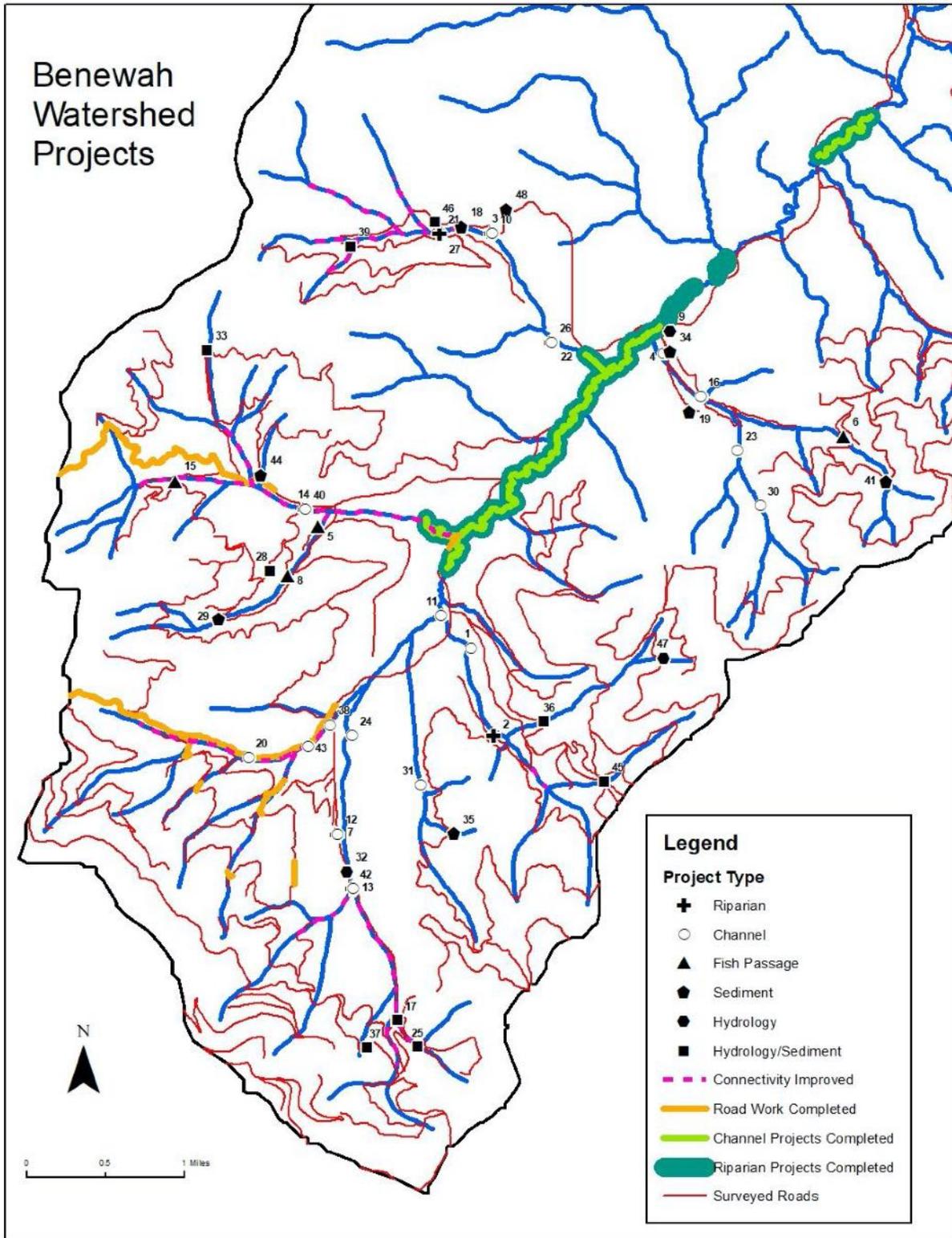


Map 1. Locations of the four focal watersheds in the Coeur d'Alene Basin targeted by BPA project 1990-044-00.

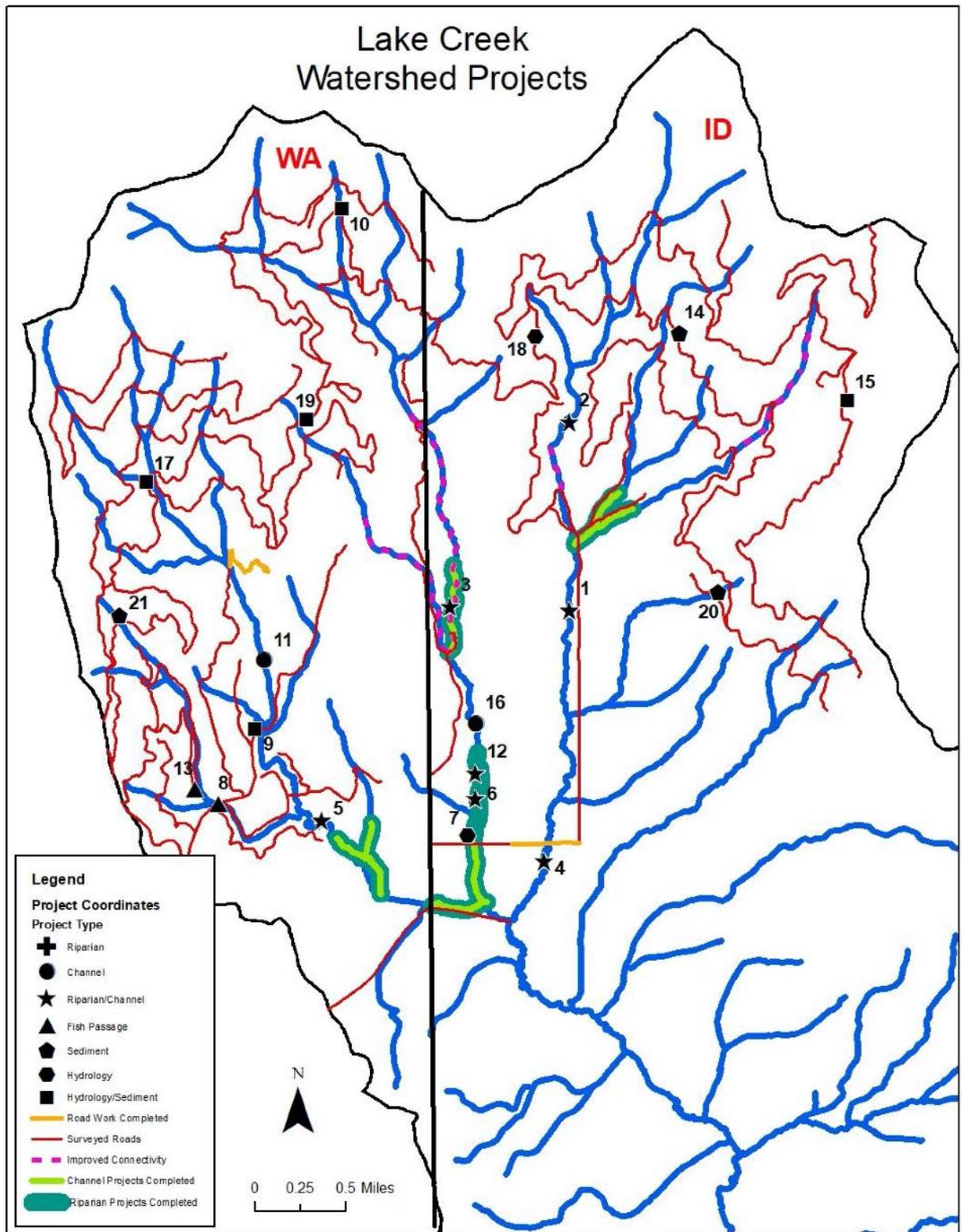
### **3.0 Introduction to Habitat Enhancement Actions**

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 Map 2 and Map 3.



Map 2. Locations of completed and planned projects in the Benewah Creek watershed. Project numbers are cross-referenced to the descriptive list of projects found in Appendix A.



Map 3. Locations of completed and planned projects in the Lake Creek watershed. Project numbers are cross-referenced to the descriptive list of projects found in Appendix A.

## 4.0 Summary of Implemented Actions

Implementation of restoration and enhancement activities occurred in the Alder, Benewah and Lake creek watersheds during 2017-2019. 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., A=Alder Creek, 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\_13.6/2.3 is located in the Lake Creek watershed 2.3 kilometers up a tributary that has its confluence with the mainstem 13.6 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\_13.4/1.04 - Instream/Fish Passage: Bozard Creek fish passage improvement***

### Project Location:

Watershed: Lake Creek	Legal: T48N R6W S1 SE SE
Sub Basin (River km):13.4/1.04	Lat: 47.527428 N Long: -117.026533 W

### Site Characteristics:

Slope/gradient: 1%	Aspect: S	Elevations: 780 m
Valley/Channel type: C4/E5	Proximity to water: In-stream and adjacent floodplain	
Other: Two undersized 48” culverts were replaced with a bridge (19’ inner span) to reduce sediment delivery to Bozard Creek from annual road inundation.		

**Problem Description:** Bozard Creek is an important spawning and rearing stream for resident and adfluvial westslope cutthroat trout in the Lake Creek watershed. This project will replace two 48" pipes with a bridge structure that has an inner span of 19' (Photo 1). This stream crossing frequently flooded, depositing sediment into Bozard Creek. This project will reduce sediment transport into lower Bozard Creek by reducing the transportation of road gravels via flood waters. The new stream crossing will allow for passage of all size classes of trout. The project will ensure connectivity with the upper Bozard Creek watershed, including access to 6,855 meters of potential rearing and spawning habitats with a drainage area of 1,792 ha.

**Description of Treatment:** This project was done in conjunction with the Worley Highway District who has ownership of the stream crossing. In order to complete a design, we collected data describing existing culvert size, length, road characteristics, flow line characteristics, floodplain information, and ground elevations using a Sokkia 530R total station. In addition, cross-section information was collected to identify bankfull width and depth. This information was imported into AutoCAD Civil 3D for analysis. The Idaho Streamstats Website was used to derive discharge values at the site for a variety of flow regimes. The computer program HEC-RAS was used to model flow under the new bridge and develop the hydraulic design of the new stream crossing. The new bridge was designed to safely pass the 100 year flood event. ArcGIS was used to develop location maps and site maps. This data was used to develop a hydraulic design report which was given to J-U-B Engineers Inc. who completed the structural design of the bridge. Permit work was completed by the Tribe. The new bridge spans 19’ and raises the existing road bed by 3.5 feet.

The following construction phases were the focus of restoration work in summer and fall 2017:  
**Phase 1:** Remove existing culverts: An excavator will be used to remove the undersized culverts.

**Phase 2:** Install Bridge. A Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS) was installed at the site. This system includes the use of geotextile material with soil lifts for the bridge foundation. One hundred ninety-two eco-blocks were used on the structure. The greatest amount of time was spent preparing the new foundation for the bridge. Trenches were dug on both sides of the creek and then backfilled with a 12” deep layer of crushed rock and compacted. Woven geo-textile fabric was placed between each “lift” to add additional strength to the foundation. Ecology Blocks were placed one by one in an interlocking configuration to form retaining walls. These walls were constructed starting at 12.5’ below the elevation of the bottom of the bridge in order to provide for scour protection against large floods. The steel bridge

beams were provided by the Worley Highway District and were 2 feet tall. A concrete pad was poured to be the base of the beams. Lying between this concrete and the beams were set of neoprene bearing pads and a steel plate. The steel plates were anchored to the concrete by a bolt and were welded to the base of the beams. The bridge decking consisted of galvanized steel bridge planking that were welded to the beams. Old road signs were creatively used to form a barrier between the beams and the gravel road bed (Photo 2). The new stream bed was created by using rock small riprap to form a meandering stream channel underneath the bridge. This rock will also help protect the new footings against scour. The road was re-graded and additional ditch relief culverts were placed on the site to help divert water from the road before it reached the new bridge. Six inches of gravel were placed on the metal bridge decking to form the road base on top of the bridge. Guard rails were installed to aid in safety. The finished bridge is shown in Photo 3. Photo 4 shows the bridge the following summer after installation.

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.

Project Timeline: NEPA compliance documentation and a Memorandum of Agreement with the Worley Highway District were completed in 2017. Construction was completed September-November 2017. Planting occurred in November 2017.

Project Goals & Objectives: The goal is to reduce sediment transport into Bozard Creek by removing an undersized stream crossing. Native trout will have access to 6,855 meters of prime rearing and spawning habitats upstream of the new bridge.

Relationship to Scope of Work: This work fulfills the Program commitments for WE D and WE G in the 2017 Scope of Work and Budget Request (CR-76243) for the contract period June 1, 2017 - May 31, 2018.



*Photo 1. Former culvert configuration at the Bozard Creek stream crossing, spring 2017. Damage from annual spring flooding can be seen as scour on the road surface.*



*Photo 2. New Bozard Creek bridge structure during the later stages of construction.*



*Photo 3. Finished Bozard Creek bridge in November 2017.*



*Photo 4. Newly constructed Bozard Creek bridge in summer 2018. Notice the new floodplain bench that is forming under the structure.*

## ***Project L\_16.3 - Instream/Fish Passage: Lake Creek fish passage improvement***

### Project Location:

Watershed: Lake Creek  
Sub Basin (River km):16.3

Legal: T49N R6W, S36 SW SW  
Lat: 47.542474 N Long: -117.038414 W

### Site Characteristics:

Slope/gradient: .5% | Aspect: S | Elevations: 780 m  
Valley/Channel type: C4/E5 | Proximity to water: In-stream and adjacent floodplain  
Other: An undersized culvert was replaced to improve fish passage. Native trout will gain improved access to 2,526 meters of potential rearing and spawning habitat.

Problem Description: Lake Creek is an important spawning and rearing stream for resident and adfluvial westslope cutthroat trout in the Lake Creek 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 64” diameter culvert was undersized (Photo 5). 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 Lake Creek watershed, including access to 2,526 meters of potential rearing and spawning habitats with a drainage area of 258 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 112” x 75” x 36’ 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. Five grade control structures, comprised of 20-25 large boulders, were 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). Fifty-seven meters of stream channel was affected by this project. A total of 0.014 ha of wetland was disturbed during construction.

The following construction phases were the focus of restoration work in fall 2018:

Phase 1: Replace existing culvert. A Cat 320 excavator was used to remove the undersized culvert and install the new 112” x 75” arch pipe (Photo 6). 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. Rock rip-rap was placed around the new pipe to help protect the inlet and outlet of

the new pipe. A headwall was placed near inlet of the pipe to help hold the rip-rap in place. The pipe had two baffles, located near the ends of the pipe, to help hold gravel, large cobbles, and small boulders that were placed in the pipe to help accumulate gravel and create fish habitat.

Phase 2: Install ground control and reshape the stream. Five drop structures was installed to connect the upstream and downstream stream reaches. These structures will create grade control as well as provide fish habitat downstream of the new culvert.

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.

Project Timeline: NEPA compliance documentation and a landowner agreement were completed in 2018. Construction was completed in September-October 2018.

Project Goals & Objectives: The goal is to restore connectivity with the upper Lake Creek watershed by removing a barrier to fish passage. Native trout will have access to 2,526 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 D and WE G in the 2018 Scope of Work and Budget Request (CR-76828) for the contract period June 1, 2018 - May 31, 2019.



*Photo 5. The former Lake Creek stream crossing (64" pipe) was identified as a fish barrier.*



*Photo 6. Newly installed 112" x 75" arch pipe in October 2018.*

## ***Project L\_18.5 - Instream/Fish Passage: Upper Lake Creek fish passage improvement***

### Project Location:

Watershed: Lake Creek  
Sub Basin (River km):18.5

Legal: T24N, R 46E, S 19  
Lat: 47.56095 N Long: -117.042106 W

### Site Characteristics:

Slope/gradient: 4.2%	Aspect: SE	Elevations: 840 m
Valley/Channel type: C4/E5	Proximity to water: In-stream and adjacent floodplain	
Other: An undersized culvert was replaced to improve fish passage. Native trout will gain improved access to 182 meters of potential rearing and spawning habitat.		

Problem Description: Upper Lake Creek is an important spawning and rearing stream for resident and adfluvial westslope cutthroat trout in the Lake Creek 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 48” diameter culvert was undersized and set at a 9% slope (perched 0.38 m above the stream channel where bankfull width is 2.43 m (Photo 7). 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 Lake Creek watershed, including access to 182 meters of potential rearing and spawning habitats.

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 Washington 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. ArcGIS was used to develop location maps and site maps. We followed design guidelines outlined in the *Water Crossing Design Guidelines* published by the Washington Department of Fish and Wildlife (2013). We determined that the maximum slope a culvert could have was 5.3%. The minimum size pipe was determined to be 12 feet wide in order to accommodate the bankfull width. In addition, there could be no more than one foot of channel regrade upstream of the new stream crossing.

Three different alternatives were analyzed to determine what design approach to use in replacing the existing pipe. These were 1) bridge, 2) arch pipe, and 3) open bottom arch culvert. The landowner requirements for a bridge stipulated that it be made of pre-cast concrete that would be 16 feet wide and 32 in span. This approach was priced out and determined to be prohibitive due to cost and equipment access. The site has limited access since it is an old logging road. An arch pipe was also considered but was deemed infeasible because of the location of the stream crossing by the hillside. Bedrock was predicted to be present (and later confirmed in field tests). This bedrock made setting the culvert at no more than 5.3% grade infeasible without blasting the

bedrock to a lower elevation. Therefore, an open bottom arch pipe was chosen for the design due to cost considerations and feasibility of construction.

The design called for replacing the existing undersized pipe with a new 15' x 4.66' open bottom arch culvert that was 30 feet long. The culvert was placed on concrete footings that were 5' wide by 3.5' tall. Within the concrete footings was a rebar cage that was pre-assembled and brought to the site. Beneath the culvert, we simulated a stream channel following recommendations by the Washington Department of Fish and Wildlife. Twenty-five meters of stream channel was affected by this project. A total of 0.01 ha of wetland was disturbed during construction. Structural design work for the footings was completed by the landowner.

The following construction phases were the focus of restoration work in fall 2019:

Phase 1: Replace existing culvert. A Cat 320 excavator was used to remove the undersized culvert. The culvert was recycled at a local facility. A diversion pipe was installed to divert water around the construction area.

Phase 2: Installation of concrete footings. In order to create the concrete footings, the existing roadbed was excavated to one foot below the footing bottom design depth. The east footing was excavated first. In the upper portion of the east side footing, bedrock was encountered. Twelve inches of ¾" minus gravel was placed within the footprint of the footing and compacted in areas where there was no bedrock. The formwork for the east footing was modified to accommodate the bedrock. This formwork sat directly on the bedrock and the gravel pad where there was no bedrock present. The footings were designed at a 5.3% slope to match the slope of the stream channel bed underneath the new culvert. Once the east footing was poured, concrete blankets were placed onto the new footing to help it cure. 20-22 CY of concrete was poured for each footing.

The west footing was constructed after the east footing. No bedrock was encountered during the excavation of this footing through several large boulders were unearthed. This footing was aligned with the east footing so that the new culvert could sit on top of both footings within a slotted channel (Photo 8). Photo 9 shows the completed culvert.

Phase 3: Create stream simulation channel. Rounded river rock was used to create the new stream channel between the new footings. The channel was 8 feet wide and the top of bank on both sides matched the top of the footings. Boulders were placed prior to the river rock to help hold channel grade and create roughness. Two grade control structures were placed downstream of the culvert to help hold grade. In addition, an additional grade control structure was placed half-way through the culvert to create a 5.3% stream slope.

Phase 4: Install new open bottom culvert. The new 15' x 4.66' arch culvert was delivered in a series of metal plates and was constructed on site on the existing roadbed. There were nine plates in total. These plates were connected together via bolts by Tribal staff. Once the culvert was assembled, it was placed onto the footings with the excavator. Once the culvert was placed, gravel fill was compacted around and above the pipe.

Phase 5: Planting. Disturbed areas were seeded with native grass seed at a rate of 18 kg/ha.

Project Timeline: NEPA compliance documentation and a landowner agreement were completed in 2019. Construction was completed in September-November 2019.

Project Goals & Objectives: The goal is to restore connectivity with the upper Lake Creek subwatershed by removing a barrier to fish passage. Native trout will have access to 182 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 and WE H in the 2018 Scope of Work and Budget Request (CR-76828) for the contract period June 1, 2018 - May 31, 2019 and WE G for the 2019 Scope of Work and Budget Request (CR-76828) for the contract period June 1, 2019 – May 31, 2020.



*Photo 7. The former upper Lake Creek stream crossing that was identified as a fish barrier.*



*Photo 8. A simulated streambed was constructed between the two concrete footings. The slotted channel in the concrete footings on either side of the streambed that will hold the new culvert in place is clearly visible in this photo.*



*Photo 9. The plate arch culvert was pieced together then lifted on to the concrete footings to finish the job of constructing the new passage structure.*

## ***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 (River Kilometer): 13.6/0.0	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 8.93 ha of previously planted areas and 1 ha of farmed uplands with highly erodible soils adjacent to 1447 m of streams in the upper watershed.		

**Problem Description:** The project site consists of 9.93 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. 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.

In May 2018, a total of 3,450 conifers (ponderosa pine, western larch, and lodgepole pine) were planted. This included inter planting 8.9 hectares that were previously planted in 2014 and 2017. One hectare was planted at a density of 300 trees per acre on former cropland that had not been planted. 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. Spot spraying occurred after planting was complete. 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.

Project Timeline: Initial site preparation occurred in April and trees were planted in May 2018, 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 M in the 2017 Scope of Work and Budget Request (Contract #76243) for the contract periods dating June 1, 2017 through May 31, 2018.

## ***Project L\_13.6/2.3 – Instream/Channel Enhancement: Upper Lake Creek wood additions***

### Project Location:

Watershed: Lake Creek

Legal: T49N, R6W, S36 SW ¼

Sub Basin (River Kilometer): 13.6/2.3 rkm

Lat: 47.543732N Long: -117.037573W

### Site Characteristics:

Slope/Valley gradient: 1-2%

Aspect: S

Elevations: 780 m

Valley/Channel type: IX/E4

Proximity to water: Instream and adjacent floodplain

Other: Large wood was placed in 964 meters of channel to increase habitat complexity and improve floodplain connectivity.

**Problem Description:** A wood recruitment study was conducted in 2007 and 2008 to examine 1) the capacity of riparian areas to provide wood to streams over time, 2) measure existing instream wood quantities, and 3) describe the complex relationship between riparian management, wood and aquatic habitat within local streams (Duck Creek Associates 2008). Significant wood related habitat functions were associated with instream wood loading rates that exceeded 6 m<sup>3</sup>/100 m. Subsequently, stream segments with wood loads falling below this threshold were prioritized for treatment. Furthermore, riparian areas that lacked the capacity to meet this target over time were identified so that alternative management practices could be developed in cooperation with landowners to meet habitat objectives (Firehammer et al. 2011). Adding large wood to these priority stream reaches as a near term strategy is the primary means of increasing wood-related habitat function, including habitat diversity, sediment storage, grade control, habitat cover, connectivity with floodplains and increasing productivity through enhanced food web interactions.

Currently, approximately 87% of the total stream length within the Upper Lake Creek sub-watershed falls below the target threshold for wood loading of 6 m<sup>3</sup>/100 m. Riparian vegetation within the treatment reach was significantly altered dating back to the 1940's when native floodplain forest communities were altered by logging, grazing and agriculture (Photo 10). The riparian community is now dominated by reed canary grass and douglas spirea - which provide sufficient root mass to maintain streambank stability - but generally lacks woody species capable of providing shade or contributing large wood to the channel. Habitat surveys completed in 2017 confirmed that instream large wood was absent in measurable quantities and therefore the reach lacked much of the positive functions attributable to in-channel wood.

While this reach of Upper Lake Creek supports moderate to high densities of Age 1+ cutthroat trout in the range of 20-50 fish/100m, little use of the reach by adfluvial fish for spawning or rearing has been noted in the recent past (Firehammer and Vitale 2018). This may be due in part to the presence of a fish passage barrier located on the subject property at rkm 2.3. The removal of this barrier in 2018 improved passage to no less than 2526 m of cold water habitat in the upper watershed to migratory cutthroat trout. As such, these reaches represent good opportunity for improving the habitat attributes that can contribute in the short term to increasing stream productivity, and especially for the adfluvial life history variant.

Description of Treatment: Large woody debris was placed in Upper Lake Creek between river kilometer 2.3 and 3.2 where instream wood was lacking prior to treatment. High resolution aerial imagery was acquired using a DJI M600 Pro Hexacopter drone to assist in planning for wood placements. The drone flight was conducted early in the spring while stream runoff was approximately equal to the 1.2 year return interval flood and prior to emergence of perennial grasses that would obscure the view of channel patterns at a fine scale. When the drone imagery was processed, it allowed for identification of primary flow paths, as well as floodplain channels, swales and off-channel wetlands, all of which were much more difficult to identify during low flow periods when these features were hidden by vegetation. The imagery was subsequently used to stake the field locations for wood placement that were then coded for specific configurations.

A Cat 303 mini-excavator equipped with a rotating grapple was used to place 145 logs, ranging in size from 0.15 – 0.51 m diameter and 4.2 – 7.3 m long (2-3 times the bank-full width), and 27 whole trees, totaling approximately 42 cubic meters (14 MBF). The wood was placed in a variety of configurations within the bankfull channel and floodplain during base flow conditions in late August. Placements included (in relation to the bankfull channel) parallel, transverse, bridged, partial- and fully-buried, as well as complex, channel spanning log jam structures. Forty-three individual treatments were installed. Both the locations and configurations were deliberately selected to achieve specific hydraulic effects, including: scour, deposition, and sorting of stream gravels; increase roughness to reduce near-bank sheer stress and improve bank stability; provide grade control (i.e., vertical/horizontal stability); create backwater effects comparable to natural beaver dams where floodplain channels diverged/converged from the primary flow path; and to provide overhead and instream hiding cover for fish (Photo 11). Existing vegetation was preserved as much as possible, and especially mature woody vegetation, which was often used to provide stable anchor points for wood placements.

Project Timeline: A landowner agreement was negotiated and signed in 2018. Permits and NEPA compliance documentation were received in early 2019. Wood was placed in August and September of that year. Additional wood will be placed in a downstream reach measuring 538 m is to be completed in 2020.

Project Goals & Objectives: Objectives include increasing instream wood quantities and associated wood related habitat function to meet a wood loading target of 6 m<sup>3</sup>/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 O and WE I in the scopes of work and budgets for the contract periods June 1, 2018 - May 31, 2019 (Contract #76828).



*Photo 10. Treatment reach in the upper Lake Creek subwatershed targeted for LWD placements. Riparian vegetation has been significantly altered in the past by logging, grazing and agriculture, leaving few woody species capable of providing natural recruitment of wood to the channel.*



*Photo 11. A 303Cat mini-excavator equipped with a rotating grapple was used to place wood in a variety of configurations within 964 m of the upper Lake Creek subwatershed.*



*Photo 12. Large wood was placed in a variety of configurations within the treatment reach, including this log crib jam, that was placed to reduce shear stress and redirect flows away from an eroding bank. Bankfull channel width is 2.7 meters.*

## ***Project L\_13.6/2.3 – Riparian/Planting: Upper Lake Creek Riparian Planting***

### Project Location:

Watershed: Lake Creek	Legal: T49N, R6W, S36 SW ¼
Sub Basin (River Kilometer): 13.6/2.3 rkm	Lat: 47.543732N Long: -117.037573W

### Site Characteristics:

Slope/Valley gradient: 1-2%	Aspect: S	Elevations: 780 m
Valley/Channel type: IX/E4	Proximity to water: Floodplain	

Other: Project to treat 21.9 hectares of floodplain and 1464 m of streambank to improve riparian function and condition over a period of 3-4 years.

Problem Description: Historically, the upper Lake Creek valley was a mosaic of open stands of conifers, wet meadows and stream corridor riparian forest. Forest composition and structure was maintained by frequent fires. A compositionally diverse, coniferous dominated forest was likely distributed along complex gradients of elevation, aspect and site water balance. Tree species likely included: ponderosa pine, western white pine, western larch, Douglas fir, lodgepole pine, grand fir, western red cedar, Engelmann spruce, aspen and black cottonwood. Riparian vegetation within the treatment reach was significantly altered dating back to the 1940's when native floodplain forest communities were altered by logging, grazing and agriculture (Photo 13). The riparian community is now dominated by reed canary grass and douglas spirea - which provide sufficient root mass to maintain streambank stability - but generally lacks woody species capable of providing shade or contributing large wood to the channel. Several remnant beaver dams have been identified on the subject property, but the lack of preferred woody species makes it impractical to sustain beaver populations that would in turn have beneficial impacts on aquatic habitats. Without treatment, these riparian areas are not likely to meet our management objectives of >75% canopy cover in 2nd order tributaries and 70% of stream reaches with the ability to meet instream wood loading criteria over 150 years.

Description of Treatment: A primary strategy being utilized for Upper Lake Creek riparian restoration is the utilization of aspen, black cottonwood and willow species to rapidly change the current degraded riparian ecosystem into a diverse self-sustaining riparian forest. These species will be most successful in competing with the non-native reed canary grass that is dominant across most of the floodplain and provide preferred forage species for beaver. Establishment of a deciduous forest along the floodplain and stream banks will provide exceptional hydrologic, biogeochemical and plant and animal habitat functional lift within 5-10 years as well as control the trajectory of ecosystem development over next 100+ years.

Hydrologically, dense plantings of aspen and cottonwood will supply local beaver populations with ample dam building materials resulting in local backwater flooding of adjacent wetlands. These hydrologically restored areas will support a diverse emergent, scrub-shrub and forested wetland plant community. Additionally, other hydrologic functions will be enhanced (per Jankovsky-Jones 1999), including dynamic water storage, energy dissipation, and long-term surface water storage. Enhanced biogeochemical functions (also per Jankovsky-Jones 1999) will include the ability of the wetland to contribute to local water quality by the removal of imported

nutrients, contaminants, and other elements or compounds. Enhanced beaver dam construction will significantly support wetland sediment and nutrient retention and removal functions.

Planting in the floodplain and adjacent to the stream is proposed for up to 1464 m of channel to provide shade to moderate water temperature, maintain stream bank stability, increase wildlife habitat values, and improve aesthetics. Plantings will consist of aspen, which will spread by suckering once established, followed by cottonwood and a variety of willow species in select locations where improving stream bank stability or maintaining undercut banks is desirable for fisheries. Planting methods for aspen and cottonwood will emulate those used by the landowner in the past which have proven to be successful; wherein individual planting sites are identified, treated with an aquatics approved herbicide (e.g., Rodeo®) in the spring, planted with containerized stock, then fenced to protect plants from animal browse. Willow plantings will utilize dormant live cuttings, placed in narrow trenches (12”wide x 4’deep) dug with a Cat 303.5 mini excavator where access permits. Willow plantings would likely need to be fenced until the plants are established, after which fences would be removed.

The stream buffer bounded by agricultural production, where woody vegetation is generally lacking, is scheduled to be planted over several years. A small test plot encompassing an area adjacent to the ponded water upstream of the primary access road was planted in Spring 2018 utilizing 60 containerized aspen trees. Survival of these trees exceeded 95% during the first growing season and the limited browse that was observed over winter should not affect long-term survival and growth (Photo 14). A second treatment utilizing 500 aspen trees was planted in Spring 2019 adjacent to approximately 964 meters of channel lying north of the ponded area and extending upstream to the ag/forest boundary. All of these plantings were fenced with 6 foot tall welded wire to discourage animal browse while they become established.

Project Timeline: A small test plot consisting of 60 containerized aspen trees was planted in Spring 2018. More widespread planting of 500 aspen was accomplished along 964 meters of channel in Spring 2019. A third treatment is anticipated for Spring 2021 adjacent to 500 meters of channel lying south of the primary access road and extending to the south property boundary. Additional plantings will occur throughout the longer reach to improve the diversity of the developing riparian forest.

Project Goals & Objectives: Reestablish a patchwork of native vegetation communities on approximately 4.39 hectares of the floodplain to lay the foundation for a compositionally and structurally diverse riparian ecosystem to develop over the next 25-50 years. Provide for significant increases in canopy density and overhanging vegetation over a 20 year timeframe. Focus plantings on preferred species (black cottonwood, aspen and willow sp.) to support and sustain colonization of the site by beaver.

Relationship to Scope of Work: This project fulfills the Program commitments for WE N and for WE H for the contract periods dating June 1, 2018 through May 31, 2020 (Contract #76828).



*Photo 13. Riparian vegetation within the treatment reach is dominated by reed canary grass and douglas spirea and lacks sufficient woody species capable of providing shade, contributing large wood to the channel, and sustaining beaver.*



*Photo 14. Survival of aspen planted in test plots exceeded 95% and grew rapidly during their second season in the ground. All planted trees were fenced with 6-foot tall welded wire to discourage animal browse while they become established.*

***Project B\_21.85/0.5 - Instream/Fish Passage: West Fork Benawah Creek fish passage improvement***

Project Location:

Watershed: Benawah Creek	Legal: T45N R4W S26 SE NW
Sub Basin (River km):21.85/.5	Lat: 47.217811 N Long: -116.800336 W

Site Characteristics:

Slope/gradient: 2%	Aspect: E	Elevations: 902 m
Valley/Channel type: E5	Proximity to water: In-stream and adjacent floodplain	
Other: An undersized culvert was replaced to improve fish passage. Native trout will gain improved access to 6,871 meters of potential rearing and spawning habitat.		

Problem Description: West Fork Benawah Creek is an important spawning and rearing stream for resident and adfluvial westslope cutthroat trout in the Benawah 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 36” diameter culvert was undersized and perched 0.11 m above the stream channel (Photo 15). Bankfull width is 2.4 m. The outlet of the culvert was damaged which ranked the replacement of this stream crossing as a high priority. The project will restore connectivity with the upper West Fork Benawah Creek watershed, including access to 6,871 meters of potential rearing and spawning habitats with a drainage area of 668 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 83” x 57” x 32’ 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. There was a natural grade control downstream of the pipe that backed water into the culvert once construction was completed. Twenty-four meters of stream channel was affected by this project. A total of 0.01 ha of wetland was disturbed during construction.

The following construction phases were the focus of restoration work in summer 2017:

Phase 1: Replace existing culvert. A Cat 320 excavator was used to remove the undersized culvert and install the new 83” x 57” arch pipe (Photo 16). 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. 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: Planting. Disturbed areas were seeded with native grass seed at a rate of 18 kg/ha.

Project Timeline: NEPA compliance documentation and a Memorandum of Agreement with Benewah County were completed in 2017. Construction was completed in August 2017.

Project Goals & Objectives: The goal is to restore connectivity with the upper West Fork Benewah Creek subwatershed by removing a barrier to fish passage. Native trout will have access to 6,871 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 and WE I in the 2017 Scope of Work and Budget Request (CR-76243) for the contract period June 1, 2017 - May 31, 2018.



*Photo 15. The former West Fork Benewah Creek stream crossing was identified as a fish barrier.*



*Photo 16. The new West Fork Benewah Creek stream channel in spring 2018.*

***Project B\_21.85/2.13 - Instream/Fish Passage: South Fork Benewah Creek fish passage improvement***

Project Location:

Watershed: Benewah Creek	Legal: T45N R4W S35 SW NE
Sub Basin (River km):21.85/2.13	Lat: 47.202678 N Long: -116.798289 W

Site Characteristics:

Slope/gradient: 3%	Aspect: NE	Elevations: 890 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 3,958 meters of potential rearing and spawning habitat.		

Problem Description: South Fork Benewah 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 0.27 m above the stream channel (Photo 17). Bankfull width is 4.66 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 South Fork Benewah Creek watershed, including access to 3,958 meters of potential rearing and spawning habitats with a drainage area of 712.24 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 96” x 67” 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. Bedrock was encountered during construction resulting in the culvert being installed above design elevation. As a result, metal baffles were installed in the pipe to help catch spawning gravel and create resting areas for migrating fish. In addition, one grade control structure, comprised of 35 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). Fifty-one meters of stream channel was affected by this project. A total of 0.02 ha of wetland was disturbed during construction.

The following construction phases were the focus of restoration work in summer 2017:

Phase 1: Replace existing culvert. A Cat 320 excavator was used to remove the undersized culvert and install the new 96" x 67" 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. 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. Photo 18 shows the new pipe during high flows.

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.

Phase 3: Disturbed areas were seeded with native grass seed at a rate of 18 kg/ha.

Phase 4: Retrofit the new culvert with metal baffles.

Project Timeline: NEPA compliance documentation and a Memorandum of Agreement with Benewah County were completed in 2017. Construction was completed in August 2017. The culvert retrofit was completed in September 2018.

Project Goals & Objectives: The goal is to restore connectivity with the upper West Fork Benewah Creek subwatershed by removing a barrier to fish passage. Native trout will have access to 3,958 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 F and WE J in the 2017 Scope of Work and Budget Request (CR-76243) for the contract period June 1, 2017- May 31, 2018.



*Photo 17. The former South Fork Benewah Creek stream crossing before replacement.*



*Photo 18. The new South Fork Benewah Creek culvert in 2018 during high flows.*

***Project B\_8.9/0.5 - Instream/Fish Passage: Bull Creek fish passage improvement***

***Project B\_8.9/2.16 - Instream/Fish Passage: Bull Creek fish passage improvement***

Project Location:

Watershed: Benewah Creek	Legal: Erikson Road (Benewah County)
Sub Basin (River km):8.9/0.5 and 8.9/2.16	Lat: 47.272938 N Long: -116.716028 W
	Lat: 47.27772 N Long: -116.696691 W

Site Characteristics (lower culvert/upper culvert):

Slope/gradient: 5%	Aspect: E	Elevations: 816 m/ 841 m
Valley/Channel type: C4/C4	Proximity to water: In-stream and adjacent floodplain	
Other: Two undersized culverts were replaced to improve fish passage. Native trout will gain improved access to 2,607 meters of potential rearing and spawning habitat.		

Problem Description: Bull Creek is an important spawning and rearing stream for resident and adfluvial westslope cutthroat trout in the Benewah watershed. In March 2017, significant flooding occurred in Bull Creek causing two culverts along Erikson Road to completely wash out. Benewah County, who manages the road where the culverts are located, put in temporary pipes in order to get the road open so that residents could reach their homes. In summer of 2017, the fisheries program evaluated these temporary pipes and determined that they were barriers to fish passage. These pipes were undersized and were placed in such a way to cause outlet drops (Photo 19 and Photo 20). The project will restore connectivity within the Bull Creek watershed, including access to 2,607 meters of potential rearing and spawning habitats with a drainage area of 593 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.

Lower Bull Creek: the design called for replacing the existing undersized 36" diameter pipe with a new 87" x 63" x 36' 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 (Error! Reference source not found.)**. One grade control structure was placed ownstream of the structure. Twelve inch baffles were installed in the pipe at the inlet, middle, and outlet of the pipe to hold in stream gravel. Twenty-four meters of stream channel was affected by this project. A total of 0.01 ha of wetland was disturbed during construction.

Upper Bull Creek: the design called for replacing the existing undersized pipe with a new 73" x 55" x 30' 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 (Photo 21). One grade control structure was placed downstream of the structure. Twelve inch baffles were installed in the pipe at the inlet, middle, and outlet of the pipe to hold in stream gravel. Twenty-one meters of stream channel was affected by this project. A total of 0.009 ha of wetland was disturbed during construction.

The following construction phases were the focus of restoration work in summer 2019:

Phase 1: Replace existing culverts. A Cat 320 excavator was used to remove the undersized culverts and install the new pipes. Before installing the new pipes, bedding material consisting of  $\frac{3}{4}$ " 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. 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: Planting. Disturbed areas were seeded with native grass seed at a rate of 18 kg/ha.

Project Timeline: This project was part of a Memorandum of Agreement with Benewah County that was signed in 2017. NEPA compliance documentation was completed in summer 2019. Construction was completed in September 2019.

Project Goals & Objectives: The goal is to restore connectivity in the Bull Creek watershed by removing two barriers to fish passage. Native trout will have access to 2,607 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 F in the 2018 Scope of Work and Budget Request (CR-76828) for the contract period June 1, 2017 - May 31, 2018 and WE D and WE E for the 2019 Scope of Work and Budget Request (CR-76828) for the contract period June 1, 2019 – May 31, 2020.



*Photo 19. The lower Bull Creek stream crossing that was identified as a fish barrier.*



*Photo 20. The upper Bull Creek stream crossing that was identified as a fish barrier.*



*Photo 21. The upper Bull Creek stream crossing after replacement*

***Project B\_19.25: Upland/Road: Reduce sediment delivery to Benewah Creek***

Project Location:

Watershed: Benewah Creek	Legal: Benewah Road (Benewah County)
Sub Basin (River Kilometer): 19.25	Lat: 47.234389 N Long: -116.783703 W

Site Characteristics:

Slope/gradient: 1%	Aspect: Various	Elevations: 841 m
Valley/Channel type: C4/C4	Proximity to water: hydrologically connected roads	
Other: Road segments were improved for 154 meters to decrease sediment delivery to the Benewah Creek.		

Problem Description: 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 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 implementing road improvements to the Benewah Road within the Benewah Creek watershed. Previous road work within the watershed included road regrading and resurfacing of 2,574 meters of the Windfall Pass road. Besides adding gravel, an additional 6 ditch relief culverts were installed and 13 ditch relief culverts were maintained to improve drainage on the Windfall Pass Road. Prior work on the Benewah Road involved removing a fish barrier on Windfall Creek that opened up 4,344 meters of stream channel to fish passage.

This project involved adding gravel and cross drains to 154 meters of the Benewah Road that frequently floods (Map 4). The road will be raised 2.5 feet in order to prevent flooding from Windfall Creek from carrying sediment into Benewah Creek which parallels the Benewah Road. In addition, improving drainage on the road will further reduce sediment transport to Benewah Creek. This reduction in direct sediment delivery was the focus of this project.

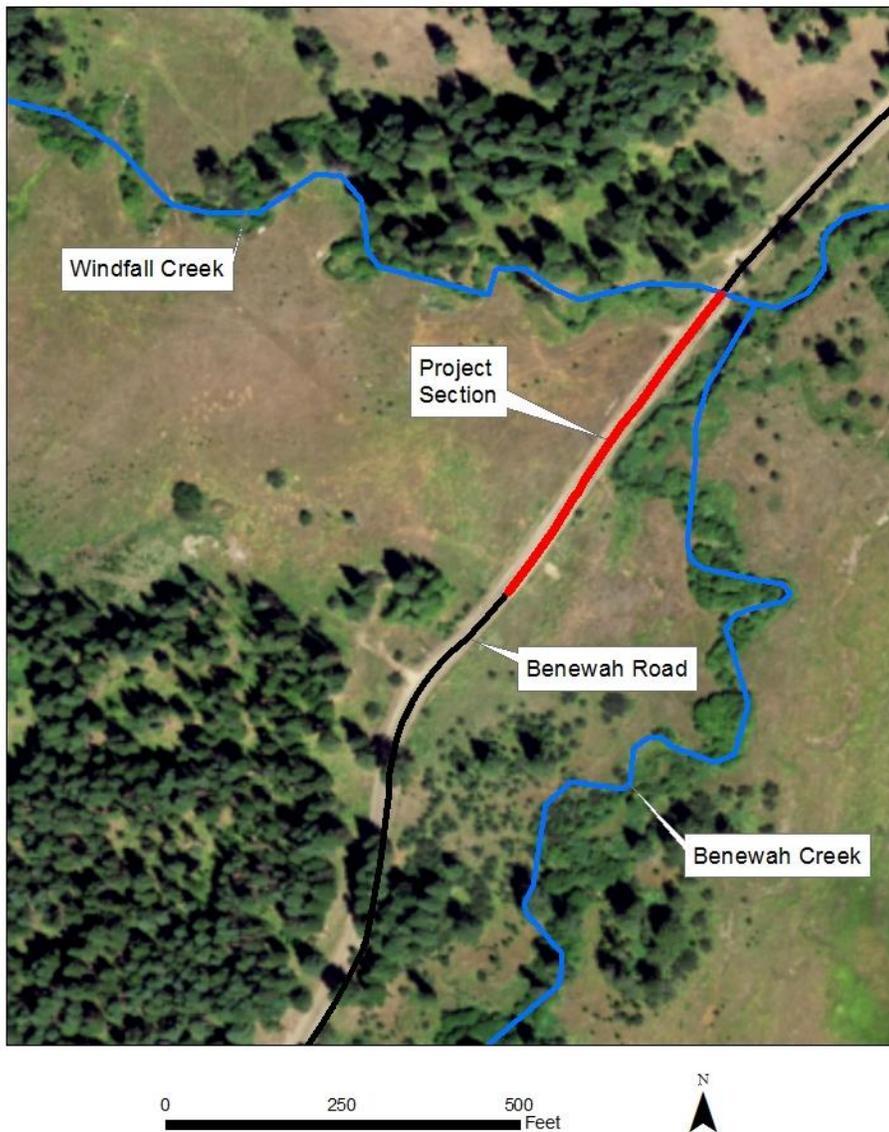
The following construction phases were the focus of restoration work in summer 2018: Road resurfacing was completed on 154 meters of the Benewah Road. Prior to resurfacing, pit run material from a nearby pit was hauled and spread over the existing road in order to raise it 2.5-3 feet. A surface cover of ¾" minus rock was spread on the top 6 inches. A roller and a grader were used to complete this work. Two ditch relief culverts were installed using a Cat 303 mini-excavator to cross drain the resurfaced road segments and prevent water accumulation in roadside ditches.

Project Timeline: NEPA compliance documentation and a memorandum of agreement were completed in 2018. Construction for the project was completed July 2018.

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 J in the 2018 Scope of Work and Budget Request (CR-76828) for the contract period June 1, 2018 - May 31, 2019.

### Project Location Benewah Road Resurfacing



*Map 4. Location of the Benewah Road resurfacing project.*

## ***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 5090 native riparian plants within 2.83 hectares of fenced floodplain habitats at two locations between 2017-2019.		

**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 (Map 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 underpins the need, and at the same time, highlights the opportunity for refining the restoration approach. In fact, monitoring data reinforces the need for such an adaptive approach. For example, PIT-tagged cutthroat trout have exhibited seasonal movements wherein they move from small, second-order tributaries to mainstem reaches during summer and fall rearing periods, and move downstream into restored sections of the upper Benewah mainstem in winter prior to their outmigration to Coeur d'Alene Lake (Firehammer et al. 2016). The seasonal utilization of these habitats by fishes during critical stages in their life history provides a simple illustration of the importance of protecting or restoring these 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 (Map 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 22). In some 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 (Map 5). 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 effectively elevated stream water levels, and presumably ground water levels as well, through the growing season (Photo 23). However, only a fraction of these same dams remained intact and functional at high flows and significant maintenance was required to rebuild the BDAs in order to sustain these functions over a period of several seasons.

These observations led to a plan to replant areas in close proximity to the most stable structures where previous attempts to establish native plants had failed, presumably due to drier than desirable site conditions during the growing season. During spring 2017, an area encompassing approximately 3 acres in proximity to the stream channel (rkm 16.3) was fenced and then planted in order to test whether these treatments can indeed provide favorable site conditions for plant establishment. 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. Additional fencing at a separate 4 acre site of floodplain wetlands (rkm 17.8) was completed during summer of 2018. This area was planted with 1750 deciduous trees, including alder, dogwood, cottonwood and aspen, in fall of 2018. An additional 1000 dormant willow poles were planted here in spring 2019. Plant survival in these areas was significantly better than during previous attempts and all species have become established and are well represented in the fenced compounds.

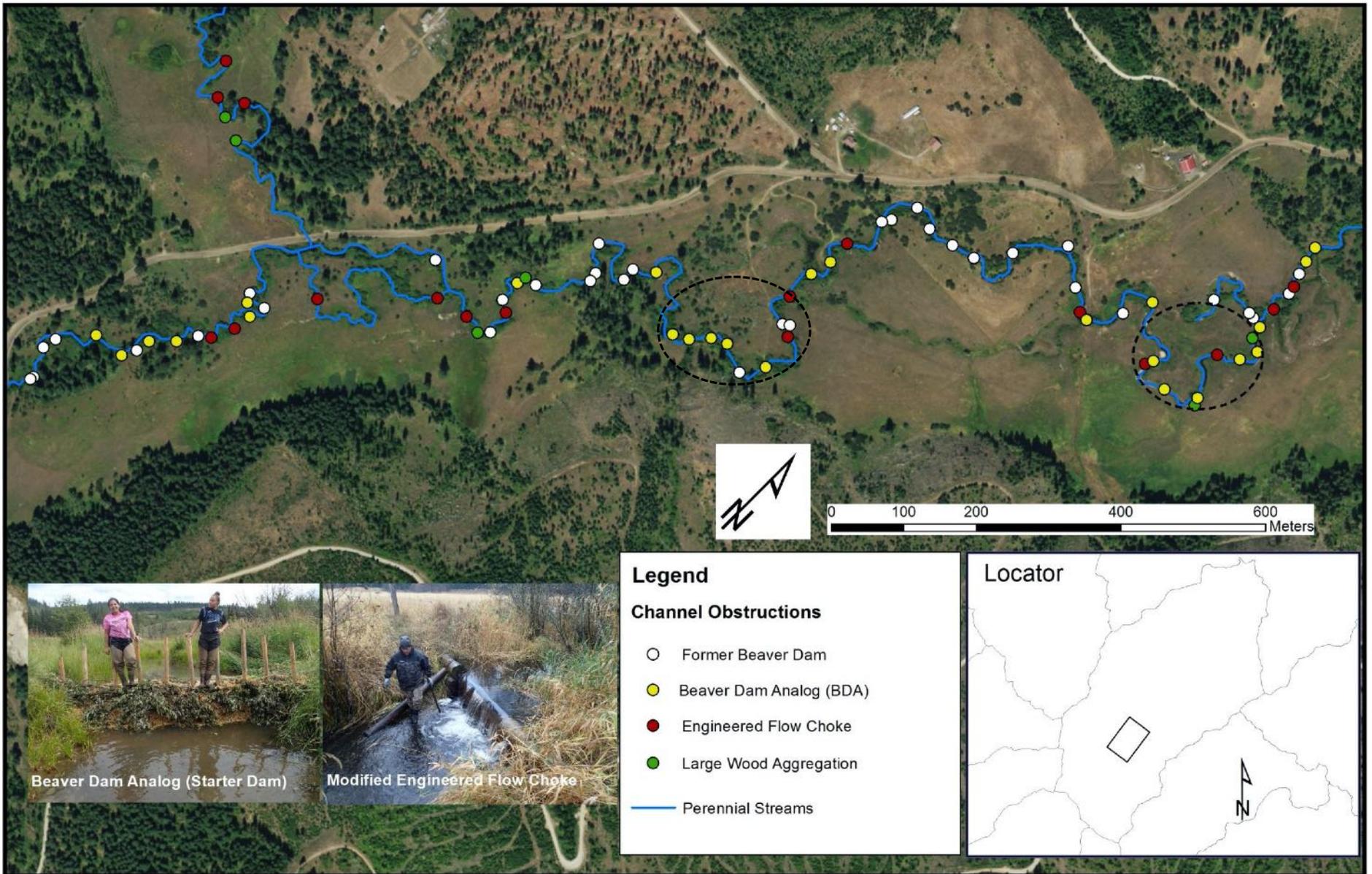
The maintenance of BDAs in this manner should continue along with annual plugging of engineered flow-choke structures that are in proximity to these high priority plantations. Because maintenance of willow weaves can be both time and material intensive at larger scales, it is important to prioritize these activities and focus on the areas where there is the greatest potential for perpetuate the investments being made in restoring key riparian process functions. Where these efforts help to establish more diverse riparian plant communities these sites will require less maintenance over time and in turn will become focal points for recolonization by beavers. Natural beaver dams working in concert with built structures will in turn promote reconnection of floodplain surfaces on a larger scale. The establishment of native riparian plant communities comprised of species preferred by beaver for food and dam building will likewise contribute to sustaining beaver on the landscape. Longer lived, less transient dams should become building blocks for resilient and dynamic beaver dam complexes and the beaver-generated floodplain wetlands and the wet meadow, scrub-shrub, and forested plant communities envisioned for this project.

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. Fencing and riparian plantings encompassing another 4 acres were completed in fall 2018 and spring 2019.

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 N in the 2017 Scope of Work (Contract #76243) for the contract period June 1, 2017 - May 31, 2018; for WEs P and Q in the 2018 Scope of Work (Contract #76828) for the contract period June 1, 2018 – May 31, 2019; and for WEs K and L in the 2019 Scope of Work (Contract #76828) for the contract period June 1, 2019 – May 31, 2020.



Map 5. Locations of former beaver dams and restoration structures in the D2 reach of the Eltumish Project in upper Benawah 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 areas highlighted with dashed lines are the locations of fencing and planting that were completed between Spring 2017 - Spring 2019.



*Photo 22. 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 23. 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 A\_13.9 - Instream/Fish Passage: Alder Creek fish passage improvement***

### Project Location:

Watershed: Alder Creek  
Sub Basin (River km):13.9

Legal: T44N R3W S4 SE SE  
Lat: 47.184722 N Long: -116.716667 W

### Site Characteristics:

Slope/gradient: 2% | Aspect: NW | Elevations: 910 m  
Valley/Channel type: E4 | Proximity to water: In-stream and adjacent floodplain  
Other: An undersized culvert was replaced to improve fish passage. Native trout will gain improved access to 5,632 meters of potential rearing and spawning habitat.

Problem Description: Alder Creek is an important spawning and rearing stream for resident and adfluvial westslope cutthroat trout. This stream crossing was identified as a juvenile fish barrier in the Forest Road and Fish Passage Assessment completed in 2008 (Duck Creek Associates 2009). The existing 36” diameter culvert was undersized (Photo 24). The stream channel at this location has a bankfull width of 3.13 m. Locals who live in the area indicated that the stream crossing flooded every year. A prioritization process completed by the Fisheries program ranked the replacement of this stream crossing as a high priority due to its frequent flooding. The project will restore connectivity with the upper Alder Creek watershed, including access to 5,632 meters of potential rearing and spawning habitats with a drainage area of 1,186 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 128” x 83” x 40’ 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. There was a natural grade control downstream of the pipe that backed water into the culvert once construction was completed. Twenty-four meters of stream channel was affected by this project. A total of 0.01 ha of wetland was disturbed during construction.

The following construction phases were the focus of restoration work in summer 2018:

Phase 1: Replace existing culvert. A Cat 320 excavator was used to remove the undersized culvert and install the new 128” x 83” arch pipe (Photo 25). 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. 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. Construction was overseen by a contractor working for Stimson Lumber Company.

Phase 2: Disturbed areas were seeded with native grass seed at a rate of 18 kg/ha.

Project Timeline: NEPA compliance documentation and a Memorandum of Agreement with Stimson Lumber company in 2016. Construction was completed in September 2018.

Project Goals & Objectives: The goal is to restore connectivity with the upper Alder Creek subwatershed by removing a barrier to fish passage. Native trout will have access to 5,632 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 H in the 2017 Scope of Work and Budget Request (CR-376243) for the contract period June 1, 2017 - May 31, 2018 and WE I in the 2018 Scope of Work and Budget Request (CR-76828) for the contract period June 1, 2018-May 31, 2019.



*Photo 24. The former Alder Creek stream crossing that was identified as a fish barrier. This pipe was undersized.*



*Photo 25. The new Alder Creek culvert is shown after construction in September 2018.*

## ***Project SJ\_18.5 – Wetland/Planting: Native Willow Nursery for Support of Restoration Actions***

### Project Location:

Watershed: St. Joe River/CDA Lake	Legal: T46N R2W S17
Sub Basin: Hepton Lake	Lat: 47.331487N Long: -116.626013W

### Site Characteristics:

Slope/gradient: 0%	Aspect: NA	Elevation: 650 m
Valley type: X	Proximity to water: Adjacent to lacustrine habitat	
Other: Project treats approximately 6.8 ha (17 acres) of previously farmed wetlands adjacent to open water lacustrine and backwater riverine habitat.		

**Problem Description:** Aquatic ecosystem restoration is an evolving discipline, encompassing a wide array of approaches, many of which are defined by current and desired conditions and the degree of departure from undisturbed reference sites. Where restoration in the past may have been focused on treating symptoms of disturbance, such as reducing erosion through hardening of streambanks, a desirable alternative is to remove the source of disturbance and facilitate the recovery of natural processes. One benefit of this changing approach is the greatly reduced need for material inputs and continued manipulation over time as natural processes are allowed to come into equilibrium. The role and use of native plant materials is an integral component of most restoration prescriptions that adhere to this approach.

Much of the wetland, stream and lake habitats prioritized for treatment throughout the Coeur d’Alene Reservation and surrounding land has been degraded or significantly altered by anthropogenic activities. Major restoration actions prescribed for many of these areas emphasize a reliance on the functions and values imparted by native plant communities to some degree. The need for native wetland plant species, especially woody species like willows, greatly exceeds their availability in the natural environment. Reliance on commercial nurseries alone to meet these needs is an exceedingly costly proposition that places an excessive burden on the limited financial resources available to the Tribe and other agencies for implementing projects. Therefore, The Coeur d’Alene Tribe, with support from the Coeur d’Alene Basin Restoration Partnership, has established a nursery for native willow species that can be made available for restoration projects in an effort to reduce costs over time while providing a steady and identifiable supply.

**Description of Treatment:** In the fall of 2018, approximately 6 hectares (15 acres) of the nursery was prepared for planting (Map 6). The existing vegetation consisting of mostly reed canarygrass *Phalaris arundinacea* was mowed, wildlife exclusion fence was installed and rows for planting were scalped to remove the majority of the canarygrass biomass. Shade/weed fabric was installed in all prepared rows. In March and April of 2018, a total of 16,000 willow poles (4,000 each of Drummond *S. drummondiana*, pacific *S. lucida*, makenzie *S. prolixa* and sitka *S. sitchensis* willow) were planted. Willows species were isolated from each other in accessible rows for future harvest. Overall survival is estimated to be 85% – 90%, with the lowest survival rates observed in sitka willow and the highest in pacific and makenzie willow

**Project Timeline:** Initial site preparation occurred in October, 2018 (Photo 26 and Photo 27). Final plantings are scheduled to be completed by spring, 2021. These additional plantings will

include 3 more endemic species of willow which include bebb *S. bebbiana*, geyer *S. geyeriana* and sandbar *S. exigua*, scheduled for 2020, along with other native deciduous plants such as black cottonwood *Populus trichocarpa* and native birch species *Betula spp.* to be planted in 2021 in a separate 2 acre enclosure within the same project location. Photo 28 and Photo 29 shows the planted rows in summer 2019.

Project Goals & Objectives: The project goal is to establish a stooling bed for native willows covering no less than 17 acres that can provide a steady supply of cuttings for riparian and floodplain restoration projects.

Willow cuttings are used in a large proportion of stream and lake restoration projects throughout the Coeur d'Alene and St. Joe subbasins. Willows cuttings can be difficult and expensive to collect from natural systems, especially while they are dormant. Purchasing willow poles from local vendors is costly and as demand increases for restoration projects, their availability will diminish. Furthermore, a supply of willows from a location and elevation which closely resembles the restoration location will likely increase survival of planted cuttings.

Objectives:

1. Maintain up to 7 species of endemic riparian willows within a local plantation.
2. Maintain up to 40,000 individual hardwood plants.
3. Provide consistent and easy access to cuttings during periods of dormancy.

Relationship to Scope of Work: This project fulfills the Program commitments for WE J in the 2019 Scope of Work and Budget Request (Contract #76828) for the contract period dating June 1, 2019 through May 31, 2020.



Map 6. Location of native willow nursery on BPA purchased mitigation property near St. Maries, ID.



*Photo 26. Site preparation included removal of canarygrass using a small dozer.*



*Photo 27. Aerial photo of the native willow nursery September, 2019.*



*Photo 28. Rows of planted Drummond willow*



*Photo 29. Rows of planted Makenzie willow.*

## 5.0 Lessons Learned and Adaptive Management

### *Refining the approach for beaver aided restoration: Benawah Creek case study*

In Benawah 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 Benawah 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 a reach of mainstem Benawah Creek between rkm 15.6 and 20.3 (referred to as the phase two restoration reach) 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. These approaches are now commonly 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 3.1 km of the upper mainstem of Benawah Creek. We have documented overbank flows across the valley bottom at discharges equal to the 1.5-year return interval flood in the vicinity of our structures, whereas other reaches without stable beaver dams require much higher discharge for overbank flow. Thus, from the riparian floodplain restoration perspective, we are already seeing some of the intended results, where floodplain flow path swales and relict channels are more frequently engaged and those that have been replanted are moving toward recovery of natural wet vegetation communities. However, in the same timeframe we documented a 79 percent reduction in the direct influence by beaver on aquatic habitats in the reach (Map 7). We speculate that this would significantly affect the overall scale and trajectory 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 as beaver apparently dispersed to adjacent stream reaches (upstream and downstream) where riparian resources were less limiting.

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 stream habitats. Moreover, 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.

The absence of beaver activity in the reach reinforces the need for refining the restoration approach and highlights some opportunities. Monitoring data further corroborates the need for such an adaptive approach. For example, PIT-tagged cutthroat trout have exhibited seasonal movements wherein they are observed moving from small, second-order tributaries to mainstem reaches during summer and fall rearing periods, and move downstream into restored sections of the upper Benewah mainstem in winter prior to their outmigration to Coeur d'Alene Lake (Firehammer et al. 2016). The seasonal utilization of these habitats by fishes during critical life stages provides a simple illustration of the importance and value in restoring and conserving these habitats in the watershed.

The past mapping and monitoring of beaver dams in upper Benewah Creek identifies nearly 50 specific locations where construction of BDAs may be appropriate. Starter dams were established in 13 of these locations, 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). In most cases the posts have remained intact across several high flow periods, and several dams that were constructed by hand functioned in much the same manner as log flow-choke structures that mimic the hydraulic function of stable natural beaver dams during flooding. We have direct evidence of beaver utilizing and reworking these structures and taking over their maintenance in different locations. The addition of BDAs in this manner therefore should increase both the abundance and life span of natural dams if/when beaver should return, which in turn should promote reconnection of floodplain surfaces on a larger scale. We recognize the value of such longer lived, less transient dams in serving as the building blocks for resilient and dynamic beaver dam complexes that support thriving colonies of beaver. At the same time, our recent experience suggests that maintenance of willow weaves can be time and material intensive at larger scales. Specifically, the needs in the 3.2km reach of mainstem Benewah Creek, and in other places where the positive feedback mechanism described above is operating, easily outstrips the means and capacity of our program. We therefore recognize a need to prioritize these interventions and focus on the areas where there is the greatest potential to perpetuate the investments being made in restoring key riparian process functions. Where these efforts help to establish more diverse riparian plant communities these sites will require less maintenance over time and in turn will become focal points for recolonization by beavers.

Additional opportunities for adaptive management exist at the 17 locations where engineered flow choke structures have been built in Benewah Creek, as these structures could be modified to function more like natural dams. Currently these structures locally reduce water velocities, create significant backwater effects at higher flows, and substantially increase connectivity with the valley bottom floodplain. But during low flows they provide little functionality that is similar to a beaver dam. 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 tablets thereby

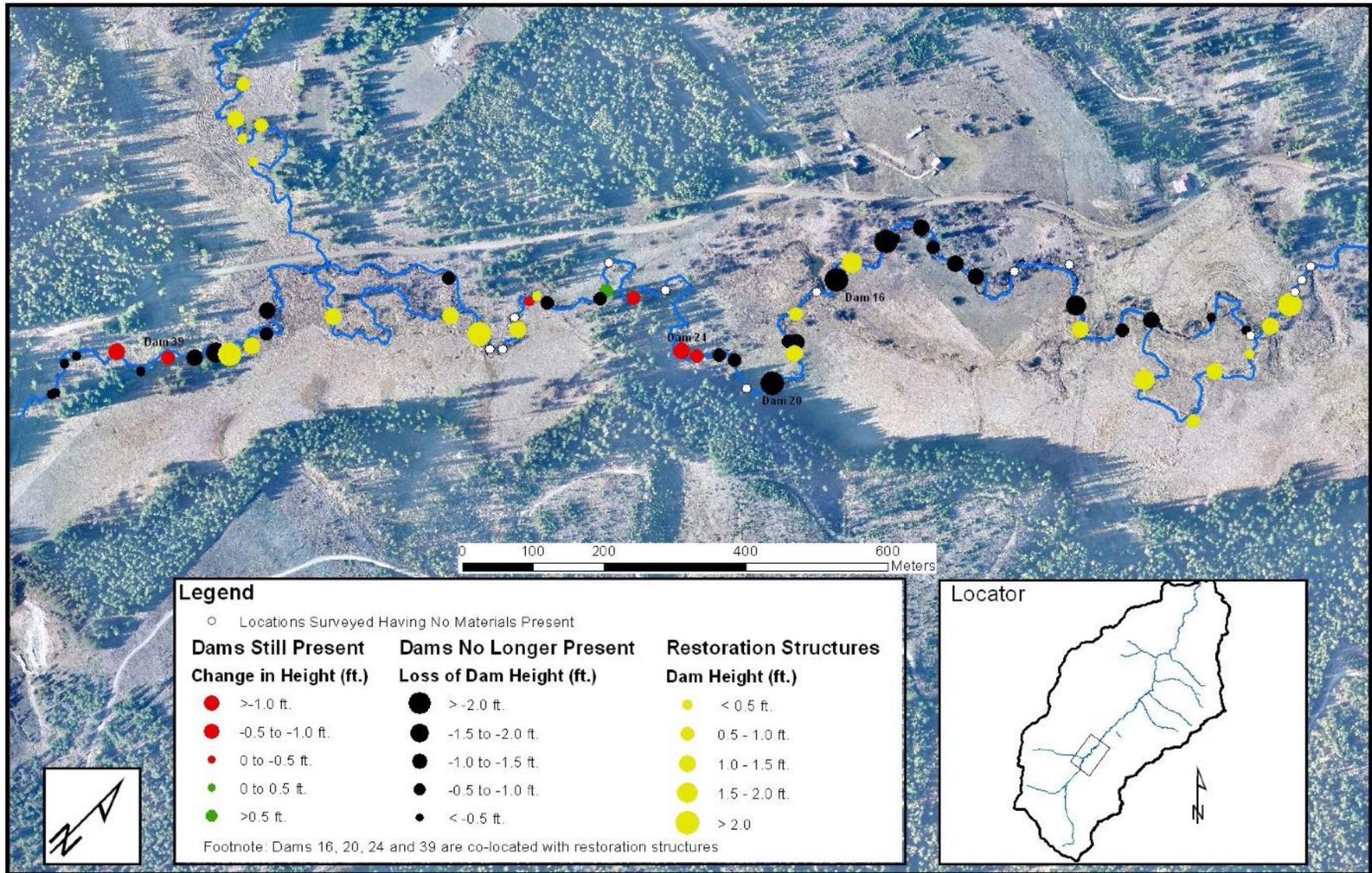
providing more viable planting locations. We have experimented with this approach in recent years with some success. Consistent with the original intent of this work, these refinements are very low impact and cost effective, requiring investments primarily in manual labor. In this setting, natural beaver dams working in concert with built structures will perhaps be more successful in promoting reconnection of floodplain surfaces on a larger scale to improve the trajectory of ecosystem recovery. The establishment of native riparian plant communities comprised of the species preferred by beaver for food and dam building will likewise contribute to sustaining beaver on the landscape. Longer lived, less transient dams should become building blocks for resilient and dynamic beaver dam complexes and the beaver-generated floodplain wetlands and the wet meadow, scrub–shrub, and forested plant communities envisioned for this project.

### ***Beavers generate ecosystem change and climate resilience***

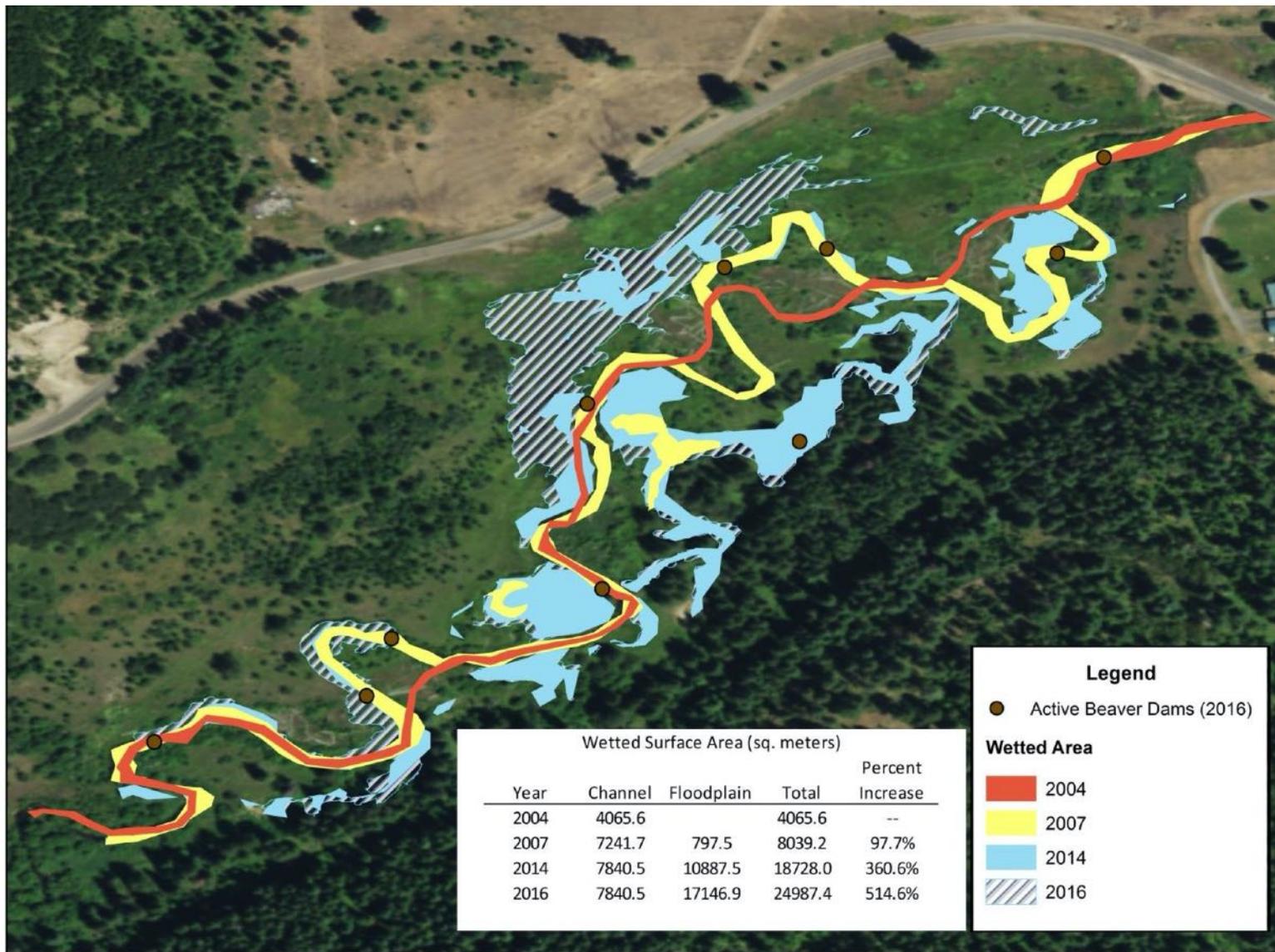
Beaver activity, though not documented in 2013 and 2014 surveys conducted across the Benewah mainstem reach addressed by phase two restoration described above, was found to be prevalent in the reaches between rkm 13.0 and 15.3 addressed by an earlier phase of restoration. Apparently, some of the beaver colonies that occupied upstream habitats dispersed downstream as riparian resources became limiting. As many as nine active beaver dams across the first kilometer upstream of a constructed grade control have been found to substantially influence both in-channel and riparian habitats. Whereas stream restoration conducted during 2005-2006, which entailed reactivating historic channel meanders and elevating the streambed to promote floodplain connectivity, increased the amount of inundated habitat by almost 100% during base flow periods, the beaver dam complex that developed beginning in 2013 has increased the spatial extent of wetted surface area by more than 500% percent over original, pre-restored conditions (Map 8). The mapping of these complex stream and wetland habitats effectively illustrate the development of a Stage-0 (anastomosing) channel network as described by Cluer and Thorne (2013), wherein nearly the entire valley surface is connected at base flow. Conversely, across phase two restoration reaches, not only was dam-building activity absent in recent surveys, but abandoned, intact dams, which used to inundate channel length, have been virtually eliminated during repeated winter and spring high flow events over several years.

The extensive floodplain connectivity found at this site undoubtedly influences the types, quantities and qualities of hydrological benefits that are central to the productivity of aquatic, riparian and floodplain ecosystems. The most obvious evidence of this as beaver became established was the recharge of the shallow aquifer that kept the floodplain moist and contributed to base flows. This influence was especially apparent during the extreme drought conditions that existed in 2015 when, by contrast, many of the second order tributaries in the watershed dewatered and became intermittent for a period of time during the summer even as the mainstem became wetter. The interaction of stream hydrology with groundwater via the hyporheic zone increases the capability of the watercourse to support a diverse range of valuable habitats, especially during low flows (Boulton et al. 1998). Less obvious, but still well supported in the literature, is the ability of well-connected floodplains to absorb, retain and then release floodwater, increasing the hydroperiod, slowing times to concentration, and attenuating downstream flood peaks (Junk et al. 1989; Poff et al. 1997). This refugia from hydrologic extremes (flood and drought) is important to the persistence of habitat and ecosystem benefits.

To be considered resilient, habitat and ecosystem benefits must be able to withstand disturbance in general, and floods and droughts in particular. Given climate change projections for warmer and dryer summers, consideration of water temperature trends at both micro- and meso- scales is instructive in understanding the capacity of these habitats to remain resilient. Whereas external factors control the net flux of heat to the stream, the presence of deep pools connected to the hyporheic zone affect how water temperatures respond (Triska et al. 1989; Poole and Berman 2001). In fact, one of the most impressive features of this beaver-modified site is the diversity of bedforms, bars, islands, banks, riparian margins, confluences and diffluences. The primary channel upstream of the several beaver dams consists of deep pools with residual depths exceeding 1 meter, and the depth of some pools approaching 2 meters. Measured water temperatures at the bottom of a deep, beaver-influenced pool during the summer of 2015 rarely exceeded the criteria for cold water biota (17°C) during the hottest time of year, even while surface water temperatures approached 25°C (Figure 1). When beaver were present, their influence evidently had a moderating effect on two metrics of summer temperature, overall mean and mean of daily maximum, across 2.6 km of stream habitats that were the target of earlier restoration efforts (Figure 2). While measured temperature metrics may actually be greater in some years during the period after beaver colonization, this is likely a function of elevated summer temperatures in upstream reaches, and the moderating influence of beaver on stream temperatures remains in effect as a mechanism linked to the relatively greater interaction of stream hydrology with groundwater via the hyporheic zone. To get a better sense of temperature trends, we calculated a metric wherein the value is the measured temperature at this mainstem Benewah Creek site minus the temperature at an untreated control site in the Lake Creek watershed where temperatures have been historically colder (Figure 3). Both the mean temperature difference and the mean maximum temperature difference show distinct declining trends for these metrics over time, indicating that the Benewah Creek site is warming less quickly over the last 12 years following restoration treatments. Furthermore, the moderating influence of beaver on temperature trends is especially apparent in the years between 2013-2019 where the difference in temperature metrics is significant compared with the period prior to their occupation of the Benewah Creek site. These collective responses make a compelling argument for the promise of increasing biodiversity, promoting the recovery of cold water biota, improving the resilience and sustainability of ecosystem services both in the restored reach and those downstream, and instilling climate resilience at the reach scale.



Map 7. Disposition of natural dams and restoration structures surveyed during 2010 through 2012 in the phase two reach of the Eltumish Project in upper Benawah Creek. Potential locations of Beaver Dam Analogues (BDAs) are indicated by surveyed point locations lacking dam materials or active dams.



Map 8. Change in baseflow wetted surface area over four different time periods in a one kilometer stream reach in Benewah Creek. Time periods represented include a pre-restoration year (2004), a post-restoration year (2007), and several years that depicts the influence of an active, expanding beaver dam complex (2014-2016). The locations of active beaver dams are also indicated.

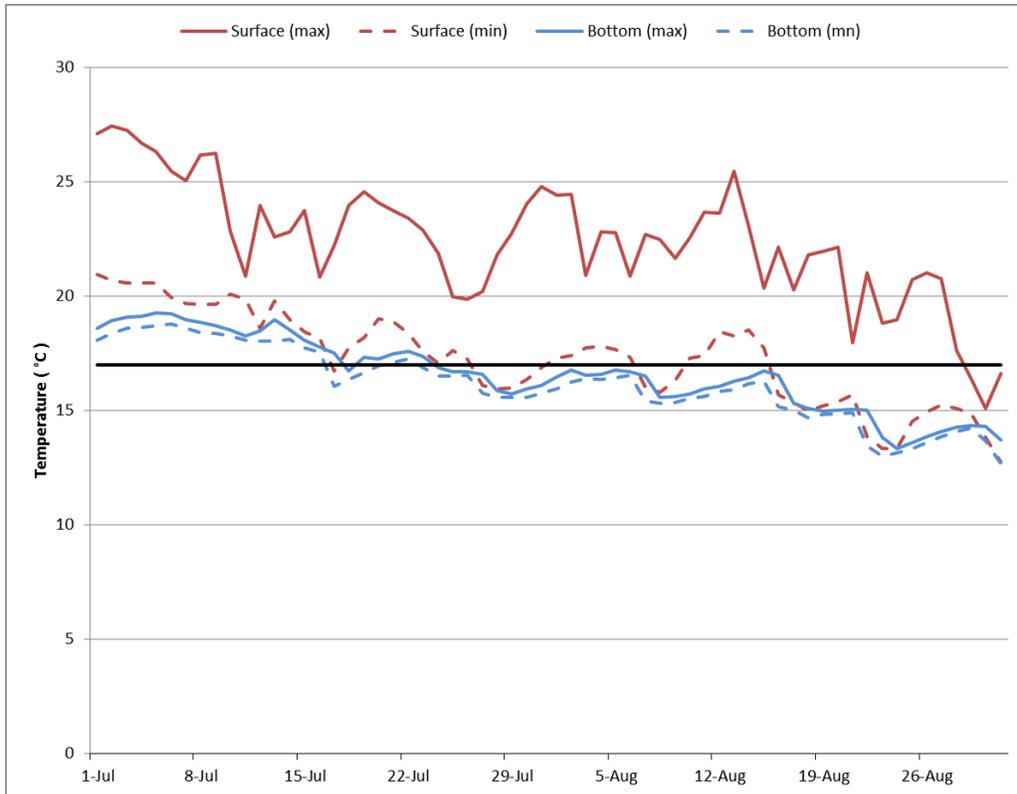


Figure 1. Daily maximum and minimum water temperatures recorded at loggers deployed at the surface and at the bottom of a beaver influenced pool in Benewah Creek during extreme drought conditions in 2015. The solid black line corresponds to water temperature criteria for support of cold water biota.

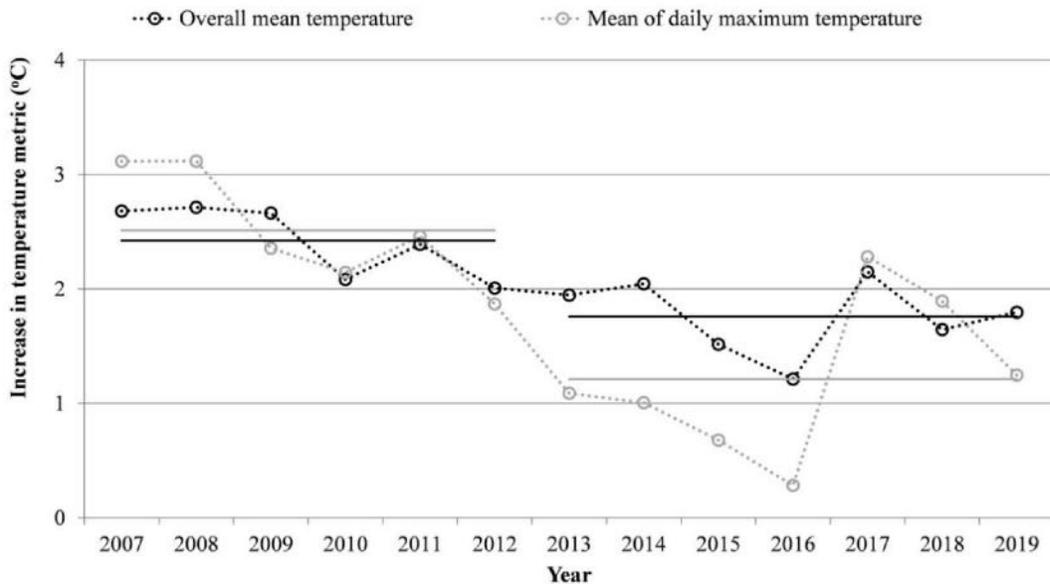


Figure 2. Temperature increase across a 2.6 km reach in Benewah Creek during two time periods where beaver were absent (2007-2012) and present (2013-2019). Horizontal lines are the time period averages for the overall mean and the mean of daily maximum temperatures annually calculated across all days in July and August, the warmest period during each year.

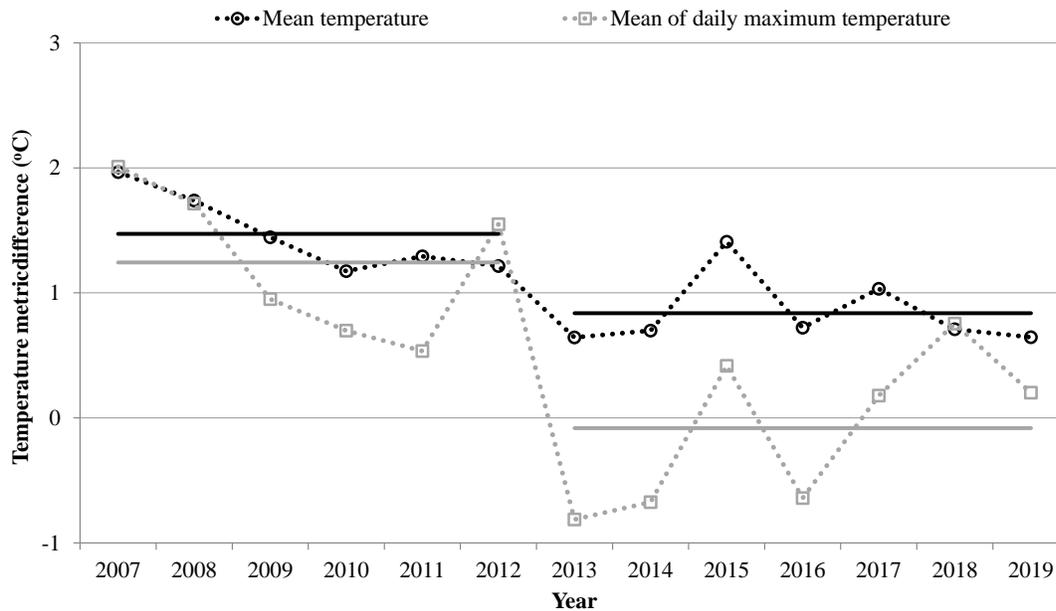


Figure 3. The difference in temperature metrics, calculated annually over July and August, between those recorded at Benewah Creek rkm 14.0 and those recorded at Lake creek rkm 7.2 (i.e., Benewah value – Lake value). Solid lines represent averages over two time periods where beaver were absent (2007-2012) and present (2013-2019) in Benewah Creek.

### ***A preliminary prescription for Stage-0 restoration***

Recently there has been a growing recognition by restoration practitioners that recovery objectives for aquatic habitat metrics are based on a narrow range of species needs, as well as channel evolution models and design tools biased toward single-threaded and “sediment-balanced” channel patterns (Cluer and Thorne 2013; Powers et al. 2018). Consequently, there has been a strong call from the scientific community to embrace the restoration of diversity in river processes to improve project effectiveness (Beechie et al. 2010, 2013; Wohl et al. 2005, 2015; Woelfle-Erskine, Wilcox and Moore, 2012). Cluer and Thorne (2013) introduced a Stream Evolution Model (SEM) that updates well-established models to include pre-disturbance channel forms consisting of multi-threaded networks of branching streams and connected wetlands, and considers how the SEM linked to ecosystem benefits might be used to better understand, manage and restore freshwater aquatic systems.

The dynamically meta-stable network of anabranching channels with vegetated islands (Stage-0) is of interest here, given its underrepresentation on the managed landscape and the potential for supporting more diverse and resilient physical and vegetative attributes with relatively greater habitat and ecosystem benefits (Cluer and Thorne 2013). Specifically, the connection to broad floodplains offer refugia across a wide range of flood events, high water table and significant hyporheic connectivity. The prominence of floodplain attributes and processes may help buffer channel networks from disturbance and instill greater resilience to flood and drought brought about by drivers of catchment-scale disturbance including climate change (temperature, precipitation, rain-snow partitioning) and land-use change (urbanization, deforestation,

agricultural intensification). Powers et al. (2018) discussed a methodology for Stage-0 restoration developed through implementation of nearly 20 projects across a wide range of landscapes. The restoration process has been applied to a wide variety of geologic, climatic, and valley settings and on a range of channel sizes, where the only common factor among all the completed projects is the depositional valley type. The process begins with identifying unconfined, depositional valleys and determining relic channel features and valley slope.

There are several existing examples of Stage-0 channel networks that help us place the restoration process and potential in the context of our focal watersheds. Each of these examples feature a number of shared attributes. The local example in the Benewah Creek watershed was discussed at length in this report (See: Beavers generate ecosystem change and climate resilience). This developing Stage-0 channel lies in a wide alluvial valley - >20 times the active channel width - with a slope of 0.7% and flows through a mix of young forest and wet meadows surrounded by lands held in conservation status. The site was previously characterized by a high density of relict channel features that were reconnected and enhanced during the restoration process. These floodplain features then became the defining physical template of the anastomosing channel network once beaver began to occupy the site (Map 8). There are several examples of Stage-0 channel networks in the Lake Creek watershed as well (Map 10). Both sites are located in unconfined depositional valleys with widths >10 times the active channel width and with slopes less than 0.9%. One of the channel networks flows through young managed forest, the other through wet meadows comprised of predominantly non-native grasses surrounded by managed forest and agriculture (Photo 30). Beavers figure prominently at all of these sites with habitats currently occupied or a history of recent occupation. In addition, all of these sites are at least partially bounded by changes in geomorphological conditions. For example, each of the sites lies downstream from higher gradient sediment transport/supply reaches occupying different valley types, and in one instance a geologic grade control defines the downstream boundary.

There are no less than 7,900 m and 9,600 m of unconfined depositional valley types in the upper Benewah and Lake creek watersheds, respectively (Table 1). These include mainstem reaches and the lower portion of 2<sup>nd</sup> order tributaries that serve as primary habitats for spawning and early lifestage rearing of westslope cutthroat trout (Map 9 and Map 10). All of these reaches are characterized by broad valleys (>10 times the active channel width) that offer significant space for lateral migration. Approximately 30% of the total reach length features diverse vegetation communities across the valley bottoms that include a component of woody species in the predominant cover type. These reaches offer the advantage of providing greater relative ecosystem benefits related to primary production, nutrient cycling, hydraulic and morphological diversity, sediment storage capacity, substrate sorting and patchiness and driving shallow hyporheic flow (Cluer and Thorne 2013), or improved trajectories toward greater functioning following restoration. Not all of these stream reaches are immediately suitable for restoration. While 5,903 m (74% of total) of stream reaches in the Benewah Creek watershed are surrounded by lands held in conservation status, only 1,412 m (15% of total) of stream reaches in the Lake Creek watershed are similarly situated. Intensive landuses are important in that they describe and facilitate an understanding of the recent disturbance histories in these reaches, but also require special consideration in planning for restoration. The geomorphological boundary conditions for all of these stream reaches are not yet fully defined. But these are important

factors in delineating the suitable extent for Stage-0 restoration, as are the presence of relic channel features (Power et al. 2018). Defining these conditions is an important next step to advance this restoration prescription.

In our preliminary prescription for potential Stage-0 reaches, we included consideration of vegetation cover types and adjacent landuse to help further inform the restoration planning process. Existing vegetation communities provide a template for understanding the expected ecosystem benefits following restoration, as described above. Landuse is also an important consideration for planning, as recovery of an anastomosing channel network will be constrained by space that can be made available for lateral migration and stream evolution. Prospective sites with adjacent intensive landuses (e.g., agriculture) may necessitate negotiation of easements that provide for sufficient space to accommodate expected physical and ecological changes and protect those benefits. Projects in these areas will likely require additional time to negotiate, and perhaps, a phased approach to implementation.

*Table 1. Valley type attributes for unconfined, depositional valleys in the upper Benewah and upper Lake creek watersheds.*

Watershed/stream	Valley type <sup>1</sup>	Valley slope (%)	Valley width (m)	Reach length (m)	Cover type <sup>2</sup> (%)		Landuse <sup>3</sup> (%)		
					Meadow	Forest	Agriculture	Forest	Conservation
<b>Benewah Creek</b>									
Benewah (mainstem)	B2	0.5-0.8	184-418	5396	65	35	0	23	77
Benewah (mainstem)	C4	0.5	75-120	936	0	100	0	0	100
Windfall	B2	1	150	673	0	100	18	0	82
Schoolhouse	B2	1.1	181-287	672	100	0	100	0	0
Whitetail	B2	1.7	100	261	36	64	0	0	100
<b>Lake Creek</b>									
Lake (mainstem)	C4	0.8	56-236	291	19	81	0	84	19
Bozard	C4	0.56-1.9	70-134	4078	66	34	0	34	0
Upper Lake	C4	0.4	45-137	2388	80	20	48	20	31
WF Lake	C4	0.8	56-130	2681	79	23	55	23	22
WF Lake	E3	0.8	82	199	0	100	0	100	0

<sup>1</sup> After Cupp 1989

<sup>2</sup> Cover type describes valley bottom vegetation as Forest/Scrub Shrub (woody sp.) or Meadow (herbaceous sp.) as a percentage of reach length

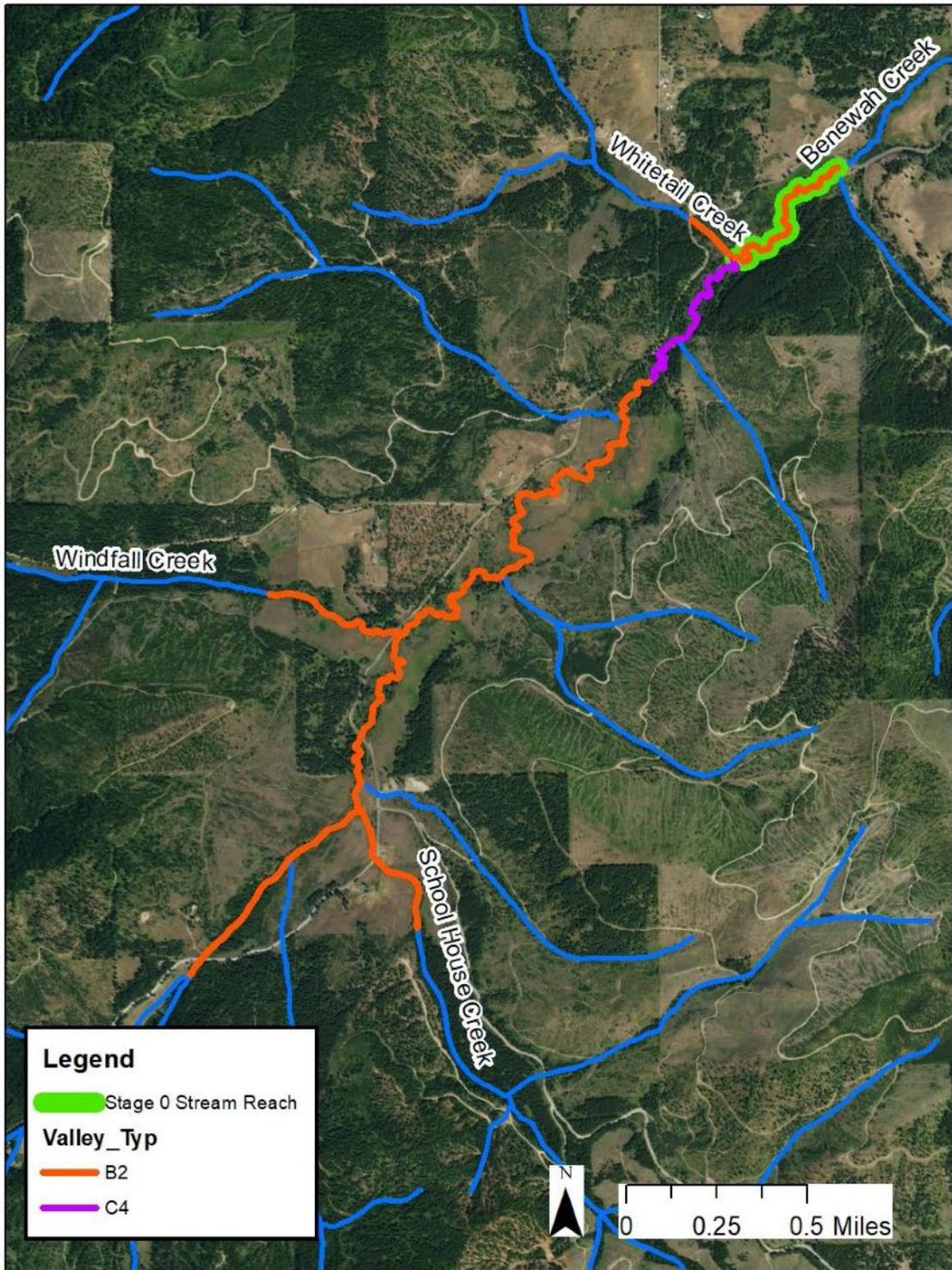
<sup>3</sup> Adjacent landuse is categorized as Agriculture, Managed Forest or Conservation as a percentage of reach length

Our preliminary prescription focuses on the upper and middle reaches of target watersheds by considering geomorphic setting and disturbance history, but also taking into account proximity to important habitats for adfluvial fish production as well as correlations between observed behaviors of fish habitat use and survival. For example, juvenile fish tagged in the tributaries across the upper Lake Creek watershed outmigrate both during early and later periods in the spring. However, fish that leave later, regardless of their tributary of origin, have exhibited higher growth rates than those that leave earlier (Firehammer et al. 2016, 2018, 2019). Juvenile return data has shown that the larger outmigrants return to spawn at much greater rates than smaller ones. Delaying downstream movement to permit additional growing opportunities may therefore be an adaptation to increase survival rates. Similar relationships between delayed outmigration and growth rate, whereby fish temporarily utilized low-velocity reaches for apparent feeding opportunities, have been documented for juvenile chinook salmon (Sommer et al. 2001). Fish originating from the Bozard sub-drainage have been found to exit Bozard creek

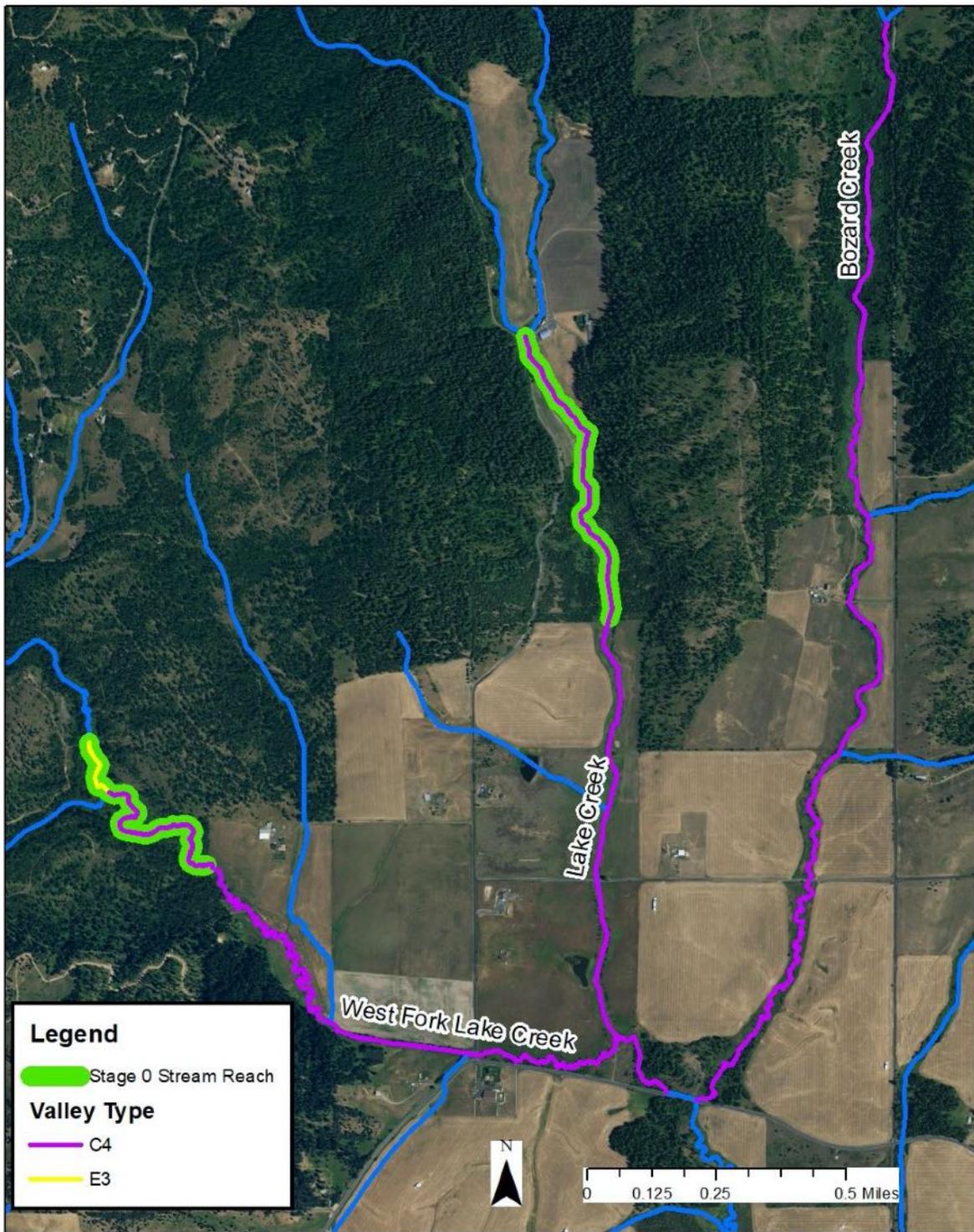
in early spring, and then in lieu of sustained downstream movement, they have temporarily ascended other sub-drainages, where they have spent an extended period prior to eventually outmigrating. The reason why this behavior has been exhibited by fish outmigrating from Bozard creek, and not from fish leaving other sub-drainages is not well understood. Possibly, low-velocity refuge habitat, that would support temporary feeding behavior, may not be adequately available in this sub-drainage, resulting in juveniles being displaced under periods of high spring discharge. Thus, planning for Stage-0 restoration in places properly situated for fish to access these habitats should be an important consideration to accommodate these behaviors and improve opportunities for increased growth and survival across the target watersheds.



*Photo 30. Example of a Stage-0 anastomosing channel network in the upper Lake Creek watershed. The channel occupies a transition zone between an alluviated, moderate slope bound valley and a wide, alluviated valley floor (after Cupp 1989). This Stage-0 channel encompasses nearly 950 m in the valley and is bounded by managed forest and agricultural land uses.*



Map 9. Locations of unconfined, depositional valley types in upper Benewah Creek (after Cupp (1989). Existing Stage 0 channel networks are highlighted.



Map 10. Locations of unconfined, depositional valley types in upper Lake Creek (after Cupp (1989). Existing Stage 0 channel networks are highlighted.

## *Evaluating the Efficacy of Restoration Planning*

The planning exercise completed in 2011 resulted in prioritization of restoration actions within the tributaries that encompass the upper watersheds and identification of 105 projects in the Benewah and Lake creek watersheds. This list was subsequently revised as additional project scoping could take place, resulting in a refined list of 65 and 31 projects in Benewah and Lake watersheds, respectively. Collectively these projects affect approximately 21 km of road, 28 km of riparian and stream habitats (many of these projects overlap) and 18 fish passage projects. Contemplating the implementation of such a comprehensive scope of work can be intimidating, but on the other hand, it provides a clear road map for achieving project objectives that can be tracked over time and greatly facilitates the planning and coordination that leads to putting projects on the ground. For example, by looking at land ownership associated with these projects we saw that 49% of projects were situated on lands owned by just 4 industrial forest landowners and another 39% of projects were situated on lands owned by just 18 small private landowners. This puts the longer term work plan into perspective and it effectively highlights where strategic partnerships lie, and informs opportunities for improving the efficiency and cost-effectiveness of project implementation (e.g., by coordinating the implementation of adjacent projects).

Significant progress continues to be made as we have worked to complete the projects that were identified as priorities for restoration. Agreements have been negotiated to implement projects with all the industrial landowners and with Benewah County, as well as with several smaller private landowners. These agreements help to build relationships that will facilitate implementation well into the future. In the Benewah Creek watershed, 19 projects have been completed since 2012. Eleven projects have been completed in the Lake Creek watershed during the same time period. Maintenance of existing projects also occurred during this time period, mainly focused on maintaining the beaver dam analogs. If similar resources are available to implement this scope of work into the foreseeable future, one can anticipate that 12 to 15 years may be required to complete all of the projects described in Appendix A.

There is some discrepancy to note between projected and actual restoration metrics as projects are implemented. For example, for a subset of the completed projects described above, projected metrics developed during the scoping exercise estimated treatments for 5.54 km of stream and riparian habitats, 1.75 km of roads, and 14 km of stream habitats with improved fish passage. The actual metrics for these same projects as reported after implementation was 2.6 km of stream and riparian treatments, 1.1 km of road improvements, and 11.1 km of stream habitats with improved fish passage. These differences stem from a number of issues, including: 1) overlap in project types, primarily between riparian and channel projects, that overestimate the scope of treatments during the planning phase; 2) changes in on-the-ground conditions and habitat needs between the time that assessments were completed and projects were implementation; and 3) discrepancy between mapped versus measured habitat attributes. Nevertheless, including project metrics as part of the initial planning exercise was an important component of the prioritization process and this discussion simply illustrates the value in tracking these metrics as projects are implemented.

Good project planning has implications that extend well beyond the implementation of BPA funded mitigation efforts and supports other Tribal priorities. There is continuity across

generations of Tribal members in the long held belief in their role as caretakers of the lands and resources (fish, water, wildlife, roots, medicines, etc.) that were endowed to them by the creator. Access to these resources is imperative to upholding traditional practices and ceremonies, is central to the physical, emotional and spiritual well-being of the people and is a natural extension of tribal sovereignty. These priorities are directly related to the core values of the Tribe in relation to the natural world: Relationship, Respect, Responsibility, Reciprocity. Where project planning can help to create intersections with land tenure strategies and natural resources conservation and restoration priorities these core values are upheld and reinforced. The preliminary planning for Stage-0 restoration described in this document becomes an important part of these intersecting interests. The advantage of these channel networks in terms of moderating sediment transfer, promoting sediment exchange and enhancing the sediment processing functions offered by the active floodplain of an alluvial valley are well established and ecologically superior. However, for reasons described above, interest in recovery of anastomosing channel networks can be constrained by space that is needed for lateral migration and stream evolution. Constraints imposed by development, infrastructure, and landuse/ownership all may complicate, delay or prevent this as a restoration goal. Land tenure strategies such as fee-title purchase or conservation easements become an important set of tools for realizing this goal.

Finally, project planning has led to leveraging of much needed funding necessary to meet project goals and objectives. During the 2018-2019 calendar years alone, more than \$4.28 million in grant funding has been leveraged from various sources to support BPA mitigation efforts on the Coeur d'Alene Reservation. Project planning therefore is certainly among the most important tools for communicating project goals, objectives and bridging the gap between resource needs and capacity to help realize priorities.

## 6.0 References

- Beechie, T., Imaki, H., Greene, J., Wade, A., Wu, H., Pess, G., Roni, P., Kimball, J., Stanford, J., Kiffney, P and Mantua, N. 2013. Restoring salmon habitat for changing climate. *River Research and Applications*, 29(8): 939-960.
- Beechie, T.J., Sear, D.A., Olden, J.D., Pess, G.R., Buffington, J.M., Moir, H., ...Pollock, M.M. 2010. Process-based principles for restoring dynamic river systems. *BioScience*, 60: 209-222
- Boulton A.J., Findlay S., Marmonier P, Stanley E.H., Valett H.M. 1998. The function significance of the hyporheic zone in streams and rivers. *Annual Review of Ecology and Systematics* 29: 59-81.
- Cluer, B. and C. Thorne. 2013. A stream evolution model integrating habitat and ecosystems benefits. *River Research and Applications*, 30: 135-154.
- Cupp, C.E. 1989. Valley segment type classification for forested lands of Washington. Washington State Department of Natural Resources. Timber, Fish, and Wildlife Agreement Report TFW-AM-89-001. Olympia, WA. 44 pp.
- 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, and S. A. Hallock. 2016. Implementation of Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation, 1/1/2015 – 12/31/2017. Annual Report, Project #1990-044-00.
- Firehammer, J. A., and A. J. Vitale. 2018. Implementation of Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation, 1/1/2013 – 12/31/2014 Annual Report, Project #1990-044-00.
- Junk W.J., Bayley P.B., Sparks R.E. 1989. The flood pulse concept in river floodplain systems. *Canadian Special Publication of Fisheries and Aquatic Sciences* 106: 110-127.

- 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.
- Poole G.C., Berman C.H. 2001. Pathways of human influence on water temperature dynamics in stream channels. *Environmental Management* 27: 787-802.
- Poff, N.L., Allan J.D., Bain M.B., Karr J.R., Prestegard K.L., Richter B., Sparks R., and J. Stromberg. 1997. The natural flow regime: a new paradigm for riverine conservation and restoration. *BioScience* 47: 769-784.
- 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>.
- Powers, P.D., Helstab, M, and S.L. Niezgoda. 2019. A process-based approach to restoring depositional river valleys to Stage 0, an anastomosing channel network. *River Research Applications*. 35: 3-13.
- 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.
- Sommer, T.R., M.L. Nobriga, W.C. Harrell, W. Batham, and W.J. Kimmerer. 2001. Floodplain rearing of juvenile chinook salmon: evidence of enhanced growth and survival. *Canadian Journal of Fisheries and Aquatic Sciences* 58: 325-333.

- Triska F.J., Kennedy V.C., Avanzino R.J., Zellweger G.W., Bencala K.E. 1989. Retention and transport of nutrients in a third-order stream in northwestern California: hyporheic processes. *Ecology* 70: 1893-1905.
- 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)
- Wohl E, Angermeier P.L., Bledsoe B., Kondolf G.M., MacDonnel L., Merritt D.L., Palmer M.A., Poff N.L., Tarboton D. 2005. River restoration. *Water Resources Research* 41: W10301. DOI 10.1029/2005WR003985.
- Woelfle-Erskine C., Wilcox A.C., Moore J.N. 2012. Combining historical and process perspectives to infer ranges of geomorphic variability and inform river restoration in a wandering gravel-bed river. *Earth Surface Processes and Landforms*. DOI: 10.1002/esp.3276
- 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.

## 7.0 Appendix A - Project List

Table 2. Descriptive list of projects proposed for the Lake watershed. Project numbers are cross-referenced to the locations found in Map 3.

Project Number	Project Title	Project Descriptions	Process Impairment	Priority Score	Project Type <sup>1</sup>	Ownership Type <sup>2</sup>	Project Metrics <sup>3</sup>
1	Bozard Creek riparian planting and LWD addition	Riparian planting and LWD addition, rkm 1.4-3.5, to address 1463m of channel w/ 150 yr wood deficits	High	87	RC	P	732
2	Bozard Creek riparian management prescriptions and LWD addition	Develop silvicultural prescription and add LWD, rkm 3.5-6.1, to address 1792m of channel w/50-150 yr wood deficits	High	87	RC	I	896
3	Upper Lake Creek riparian planting and LWD addition	Riparian planting and LWD addition, rkm 1.8-3.9, to address 1464m of channel w/ 150 yr wood loading deficits	High	87	RC	P	732
4	Bozard Creek riparian planting and LWD addition	Riparian planting and LWD addition, rkm 0.0-1.4, to address 994m of channel w/ 150 yr wood deficits	High	86	RC	P	497
5	WF Lake Creek riparian management and LWD addition	Riparian management and LWD addition, rkm 0.9-2.3, to address 667m of channel w/ 150 yr wood loading deficits	High	86	RC	S	334
6	Upper Lake Creek riparian planting and LWD addition	Riparian planting and LWD addition, rkm 0.8-1.0, to address 182m of channel w/ 150 yr wood loading deficits	High	73	RC	P	91
7	Improve road drainage and reduce sediment delivery	Install cross drains on road 4514	Low	72	H	C	157
8	Olsen Creek culvert replacement	Improve fish passage on Olsen Creek at fish barrier, 4600_2090	Low	69	P	C	1480
9	Improve road drainage and reduce sediment delivery	Add cross-drains and resurface 609m of road 4600	Moderate	68	HS	P	850
10	Improve road drainage and reduce sediment delivery	Replace stream crossing at 4000_12615, install cross drains on road 4001, and resurface 457m of roads 4000 and 4001	Low	67	HS	I	533
11	WF Lake Creek LWD addition	Add LWD, rkm 2.3-3.9, to address 1136m of channel w/ 50 yr wood loading deficits	High	67	C	P	1136
12	Upper Lake Creek riparian planting and LWD addition	Riparian planting and LWD addition, rkm 1.0-1.4, to address 420m of channel w/ 150 yr wood loading deficits	High	66	RC	P	210
13	Olsen Creek culvert replacement	Improve fish passage on Olsen Creek at adult fish barrier, 4303_5630	Low	66	P	P	390
14	Improve road drainage and reduce sediment delivery	Replace stream crossing at 4500_13590, and resurface 365m of roads 4925, 4920, 4505 and 4500	Moderate	63	S	I	425
15	Improve road drainage and reduce sediment delivery	Replace stream crossing at 4920_10805, add cross-drains to road 4920, and resurface 396m of roads 4920 and 4923	Moderate	63	HS	I	487
16	Upper Lake Creek LWD addition	Add LWD, rkm 1.4-1.8, to address 441m of channel w/ 150 yr wood loading deficits	High	63	C	P	441
17	Improve road drainage and reduce sediment delivery	Replace stream crossing at 4014_5490, resurface 914m of roads 4010, 4014 and 4015, and install cross drains on 4014	Moderate	63	HS	I	974
18	Improve road drainage and reduce sediment delivery	Install cross drains and resurface 365m of roads 4500 and 4510	Moderate	61	H	I	512
19	Improve road drainage and reduce sediment delivery	Install cross drains on road 4023 and resurface up to 213m of roads 4023 and 4022	Low	60	HS	I	278

Project Number	Project Title	Project Descriptions	Process Impairment	Priority Score	Project Type <sup>1</sup>	Ownership Type <sup>2</sup>	Project Metrics <sup>3</sup>
20	Reduce sediment delivery	Replace stream crossing at 4506_1255	Moderate	57	S	I	20
21	Reduce sediment delivery	Resurface 304m of roads 4303, 4302 and 4017	Moderate	54	S	I	304

<sup>1</sup> Project Type: C=channel; H=hydrology; P=passage; R=riparian; S=sediment

<sup>2</sup> Ownership Type: C=county; I=industrial; P=private; S=state

<sup>3</sup> Project metrics are specific to project type and are summarized as follows: P= length (m) of low gradient habitat (<10%) available upstream of barrier; R= length (m) of stream channel treated; C= length (m) of channel treated; H= length (m) of treated road directly delivering sediment; S= length (m) of treated road

Table 3. Descriptive list of projects proposed for the Benewah watershed. Project numbers are cross-referenced to the locations found in Map 2.

Project Number	Project Title	Project Descriptions	Process Impairment	Priority Score	Project Type <sup>1</sup>	Ownership Type <sup>2</sup>	Project Metrics <sup>3</sup>
1	School House Creek LWD addition and riparian planting	Add LWD, rkm 0.3-0.7, to address 300m of non-forested channel w/ 150 yr wood loading deficits	High	84	C	P	300
2	School House Creek riparian management prescriptions	Develop silvicultural prescription, rkm 0.7-2.2, for increasing growth and recruitment	High	82	R	I	1500
3	Whitetail Creek riparian management prescriptions	Develop silvicultural prescription, rkm 1.7-2.6, for increasing growth and recruitment	Moderate	82	R	I	900
4	EF Hodgson Creek LWD addition	Add LWD, rkm 0.0-0.8, to address 580m of channel w/ 50 yr wood loading deficits	High	81	C	P	580
5	SF Windfall Creek culvert replacement	Improve fish passage on SF Windfall Creek at fish barrier, 3158_235	Moderate	80	P	I	1352
6	Hodgson Creek Culvert Replacement	Improve fish passage on Hodgson Creek at adult fish barrier, road 3724_945.	Low	79	P	I	930
7	SF Benewah Creek riparian planting	Riparian planting, rkm 0.8-1.5	Moderate	79	R	P	700
8	SF Windfall Creek culvert replacement	Improve fish passage on SF Windfall Creek at fish barrier, 3155_3045	Moderate	79	P	I	853
9	Improve road drainage and reduce sediment delivery	Install cross drains on road 3700.	Low	78	H	C	104
10	Whitetail Creek LWD addition	Add LWD, rkm 1.7-2.6, to address 342m of channel w/ 50 yr wood loading deficits	High	78	C	I	342
11	School House Creek LWD addition	Add LWD, rkm 0.0-0.3, to address 225m of channel w/ 150 yr wood loading deficits	High	76	C	I	225
12	SF Benewah Creek LWD addition	Add LWD, rkm 0.5-1.4, to address 670m of channel w/ 150 yr wood loading deficits	High	76	C	P	670
13	SF Benewah Creek riparian management prescriptions	Develop silvicultural prescription, rkm 1.5-3.2, for increasing growth and recruitment	High	76	R	P	1700
14	Windfall Creek riparian management prescriptions	Develop silvicultural prescription, rkm 1.2-2.6, for increasing growth and recruitment	High	76	R	P	1400
15	Windfall Creek culvert replacement	Improve fish passage on Windfall Creek at fish barrier, road 3169_110	Moderate	76	P	P	1057
16	Hodgson Creek LWD addition	Add LWD, rkm 0.2-1.2, to address 350m of channel w/ 50 yr wood loading deficits	High	74	C	P	350
17	Improve road drainage and reduce sediment delivery	Install cross drains and resurface 833m of roads 3100, 3101, 3102	High	73	HS	I	1320
18	Reduce sediment delivery	Resurface 367m of roads 3205, 3204, and 3203	Low	73	S	I	367
19	Reduce sediment delivery	Replace stream crossing at 3701_3090.	Moderate	72	S	P	20

Project Number	Project Title	Project Descriptions	Process Impairment	Priority Score	Project Type <sup>1</sup>	Ownership Type <sup>2</sup>	Project Metrics <sup>3</sup>
20	WF Benewah Creek LWD addition	Add LWD, rkm 1.0-1.6, to address 300m of channel w/ 50 yr wood loading deficits	High	72	C	I	300
21	Whitetail Creek LWD addition	Add LWD, rkm 2.6-3.0, to address 226m of channel w/ 50 yr wood loading deficits	High	72	C	I	226
22	Whitetail Creek riparian planting	Riparian planting, rkm 0.5-1.1	Moderate	72	R	P	600
23	Hodgson Creek LWD addition	Add LWD, rkm 1.2-2.1, to address 256m of channel w/ 50 yr wood loading deficits	High	71	C	P	256
24	SF Benewah Creek LWD addition	Add LWD, rkm 0-0.5, to address 340m of channel w/ 150 yr wood loading deficits	High	71	C	P	340
25	Improve road drainage and reduce sediment delivery	Replace culverts (4 non-fish bearing), install cross-drains, and resurface 1072m of road, 3103_0-1950 and 3118_0-1570	High	71	HS	P	1659
26	Whitetail Creek LWD addition	Add LWD, rkm 0.5-1.1, to address 270m of channel w/ 50 yr wood loading deficits	High	71	C	P	270
27	Whitetail Creek riparian management prescriptions	Develop silvicultural prescription, rkm 2.6-3.0, for increasing growth and recruitment	Moderate	71	R	I	400
28	Improve road drainage and reduce sediment delivery	Install cross drain and resurface up to 390m of road 3155	High	70	HS	I	450
29	Improve road drainage and reduce sediment delivery	Replace ford crossings with culverts at 3156_600 and 3156_783, and resurface 681m of roads 3151 and 3156	Moderate	69	S	I	741
30	Hodgson Creek LWD addition	Add LWD, rkm 2.1-2.7, to address 100m of channel w/ 50 yr wood loading deficits	High	68	C	P	100
31	IDL Creek LWD addition	Add LWD, rkm 1.0-1.9, to address 400m of channel w/ 150 yr wood loading deficits	High	68	C	I	400
32	Improve road drainage on Fletcher Rd.	Install cross drains on 304m of road, 3100_1950-2950	High	68	H	C	304
33	Improve road drainage and reduce sediment delivery	Replace stream crossing 3178_23156, install cross drains and resurface 905m of roads 3178 and 3185	High	68	HS	P	1111
34	Reduce sediment delivery	Resurface 274m of road 3702	Low	67	S	P	274
35	Improve road drainage and reduce sediment delivery	Replace stream crossing at 3003_7480	Low	67	S	S	20
36	Improve road drainage and reduce sediment delivery	Install cross drain on road 3530 and 3532, resurface 76m of road 3532 and replace stream crossing at 3503_4430	Moderate	67	HS	I	324
37	Improve road drainage and reduce sediment delivery	Install cross drains and resurface 481m of road 3105	High	67	HS	I	366
38	WF Benewah Creek LWD addition	Add LWD, rkm 0.0-0.5, to address 100m of channel w/ 150 yr wood loading deficits	High	67	C	P	100

Project Number	Project Title	Project Descriptions	Process Impairment	Priority Score	Project Type <sup>1</sup>	Ownership Type <sup>2</sup>	Project Metrics <sup>3</sup>
39	Improve road drainage and reduce sediment delivery	Install cross drains and resurface 246m of roads 3203 and 3205	Moderate	67	HS	I	367
40	Windfall Creek LWD addition	Add LWD, rkm 1.2-2.6, to address 460m of channel w/ 50 yr wood loading deficits	High	66	C	P	460
41	Reduce sediment delivery	Resurface 152m of road 3711	Low	65	S	I	152
42	SF Benawah Creek LWD addition	Add LWD, rkm 1.4-3.2, to address 850m of channel w/ 50 yr wood loading deficits	High	65	C	P	850
43	WF Benawah Creek LWD addition	Add LWD, rkm 0.5-1.0, to address 320m of channel w/ 150 yr wood loading deficits	High	65	C	P	320
44	Improve road drainage and reduce sediment delivery	Replace stream crossing 3175_300 and resurface 180m of road 3175	Moderate	65	S	I	240
45	Improve road drainage and reduce sediment delivery	Resurface 182m of roads 3511, 3512 and 3543, install cross-drains on road 3530	Moderate	64	HS	I	285
46	Reduce sediment delivery	Replace undersize culvert, install cross-drains and resurface 59m of road 3203_990	Moderate	63	HS	I	118
47	Improve road drainage and reduce sediment delivery	Install cross drains on road 3521	Moderate	61	H	I	205
48	Reduce sediment delivery	Resurface 102m of road 3200	Low	58	S	I	102

<sup>1</sup> Project Type: C=channel; H=hydrology; P=passage; R=riparian; S=sediment

<sup>2</sup> Ownership Type: C=county; I=industrial; P=private; S=state

<sup>3</sup> Project metrics are specific to project type and are summarized as follows: P= length (m) of low gradient habitat (<10%) available upstream of barrier; R= length (m) of stream channel treated; C= length (m) of channel treated; H= length (m) of treated road directly delivering sediment; S= length (m) of treated road