Designing for Resiliency - A Passive-Aggressive Approach to Large-Scale Restoration of a River-Wetland Corridor in the Upper Grande Ronde River, Oregon

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Abstract

The U.S. Bureau of Reclamation's Columbia-Pacific Northwest Region River Systems Restoration Group (USBR) planned, designed, and performed engineering during construction of two large-scale river wetland corridor restoration projects in proximity to each other on the Upper Grande Ronde River (UGR) in northeast Oregon from 2015 to 2021. These two Projects, Bird Track Springs (BTS) and Longley Meadows (LM), are in a continuous unconfined floodplain 4 miles in length previously identified in an assessment from USBR as a prioritized reach for improving habitat for endangered salmonids. Both projects have mixed landownership, public and private, with most of the acreage on the Wallowa Whitman National Forest. BTS and LM are separated by private property. Constraints with private property, robust cultural resources, and infrastructure including State Highway 244 required designs that maximized habitat uplift and considered potential impacts to property, infrastructure, and resources. USBR utilized a passive-aggressive approach to design these Projects to be resilient in a changing climate by restoring the river plan form from a single thread degraded river to a functioning river-wetland corridor consisting of complex multi-threaded channel networks (aggressive) and connecting existing relic features on the landscape (passive).

Introduction

A legacy of anthropogenic impacts to this reach of the UGR include beaver trapping, logging, splash damming, grazing, gravel mining, rail roads, and road construction have resulted in a simplified horizontal and vertical planform and degraded physical processes that limit the river's ability to sustain habitat for ESA-listed fish including the UGR population of the Snake River Basin steelhead, the UGR spring Chinook salmon, and resident bull trout. This reach has been subjected to an extensive planning process including the UGR Tributary Assessment (Reclamation, 2014) and the Catherine Creek and UGR Atlas Restoration and Prioritization Framework (Bonneville Power Administration (BPA), 2017) to prioritize habitat enhancement in the UGR based on having a high geomorphic potential to improve physical processes leading to improved habitat conditions due to the unconfined nature of the reach. Simplified, channel focused, previous restoration efforts made temporary improvements in localized areas but largely failed and did not improve the entire reach due to the extent of disturbance to the river corridor and surrounding unconfined floodplain.

In early 2015, Reclamation partnered with the Confederated Tribes of the Umatilla Indian Reservation (C.T.U.I.R.), BPA, the Grande Ronde Model Watershed (GRMW), and the U.S.

Forest Service-Wallowa Whitman National Forest (USFS) to improve habitat conditions for salmonids within the river-wetland corridor of the BTS-LM reach, see **Figure 1**. Ownership within the reach includes USFS lands, two private ranches and a private gun club. USBR provided planning and design services to the C.T.U.I.R., the project sponsor, to facilitate project implementation. The long-term rehabilitation vision (Confederated Tribe of the Umatilla Indian Reservation's River Vision (Quaempts et al. 2018)) for the UGR is to improve physical and ecological processes by rehabilitating and restoring the river to achieve immediate and long-term benefits to Chinook, steelhead, and bull trout at all life stages. The scope of implementation of the BTS and LM Fish Habitat Enhancement Projects was to leverage the geomorphic potential of the large unconfined floodplain resulting in improved floodplain connectivity, hyporheic exchange, riparian conditions, and channel complexity. This in turn will improve habitat conditions and thermal refugia in a critical migration corridor with high potential for in-channel and off-channel juvenile rearing habitat for ESA-listed salmonids that is lacking in this reach of river.

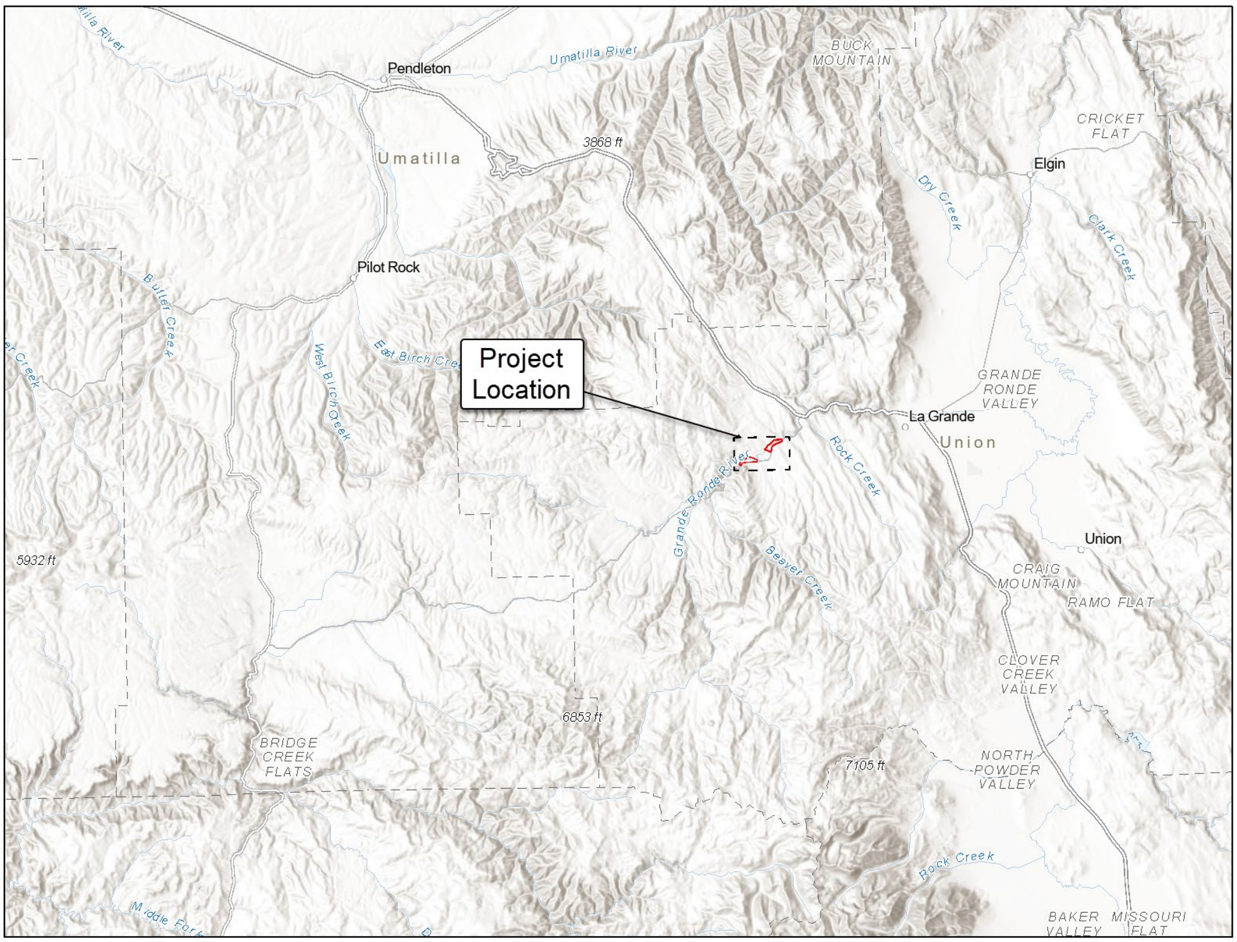

Figure 1 Project Location in Northeastern Oregon

Methods

Investigations

Significant data collection including Real-Time Kinematic (RTK) survey, Light Detection and Ranging (LIDAR), discharge measurements, and a geomorphic assessment was performed to support design. Relic signatures of multi-threaded channels and swales were identified in the resulting topo-bathymetric surface. Field exploration of these relic channels revealed small pockets of intact riparian vegetation of mixed seral stages and occasional open surface water with significantly lower temperature signals than the main stem channel in summer. Hydraulic modeling of the existing conditions revealed that only the low frequency floods above a 10-year to 25-year flood recurrence would activate and connect these relic channels to the main-stem river. Connection to these existing channel opportunities was a desired outcome that offered instant quality habitat especially if there could be a perennial connection for juvenile salmonids. The identification of pockets of cold water throughout the floodplain demonstrated the hyporheic potential of the reach to begin to address habitat limits due to excessive temperatures during the summer.

Constraints

Private property, Highway 244, and significant cultural resources including a historic railroad grade partially limited project opportunity. No disturbance areas were identified in cultural resource surveys. Limiting impacts to private property (flooding) needed to be balanced with the goals of increasing the frequency and duration of floodplain connectivity. Also, a landowner between the two Projects did not allow Project activities on their property which ultimately limited Project actions for both BTS and LM. Highway 244 needed to be protected where new channel alignments directed flow towards the highway or where floodplain activation approached the highway prism.

Drivers

Hydrology is fickle in the UGR. Extreme peak floods (~10,000 cfs) are coupled with extremely low flows (~10 cfs) during the late summer. Rain-on-snow events are frequent in this mostly snow-melt driven system. Large-short-duration floods can occur from December-March. More typical spring floods occur from April-May. The UGR basin is mostly mid elevation with many tributaries that go nearly dry in late summer likely due to shallow fluvial aquifers and lack of floodplain storage due to basin wide stream degradation. Ambient temperature is also fickle in the UGR. Really cold temperatures create ice problems upstream of the project reach. Large ice floods with mile long channel spanning ice jams occur every few years. Summers can be extremely hot with lethal water temperatures for salmonids occurring in the mainstem channel upstream of the project reach. Designing a channel network to accommodate higher channel forming flows with orders of magnitude lower low flow conditions is a difficult challenge with the goal of maintaining as many perennial connections as possible to support habitat.

Biology that contributes to channel form has been impacted in this reach. Historically there was significant wood loading from upstream and within the reach. Extensive logging and splash damming activities have severely impacted the amount of in-channel and floodplain wood forcing agents resulting in simplified hydraulics and channel form. The combination of low flow and dry hot arid temperatures also affects plant growth and survival also contributing to the regeneration of riparian vegetation. Few small pockets of healthy intact riparian vegetation exist with many channel banks exhibiting erosion and widening. Occasionally there are large cottonwoods and conifers that fall into the river. There is a legacy to cut these large trees into smaller pieces due to perceived concerns of causing impacts to infrastructure. If allowed to stay intact in the river, there is evidence of resulting sediment deposition and hydraulic complexity from a few large trees. Fortunately, there are beavers that reside within this reach. The ability to dam a large single thread channel and the degraded riparian vegetation limiting food supply have reduced the impact from beavers. There are select areas where small dams have been constructed and large cottonwoods have been felled into the channel. Trapping is still allowed and impact the number of beavers in the area.

The channel form based on geologic conditions does not match what is expected in this reach. The unconfined floodplain, fully available fluvial sediment composition, and moderate valley slope would trend towards this being a response reach. The private property between BTS and LM demonstrates this potential where the railroad prism was removed as part of a previous restoration effort. Removal of the railroad prism that acted as a levy allowed the channel forming flow to spread out reducing stream-power and causing deposition. Very dynamic channel migration (avulsion) and floodplain connectivity are a byproduct. The presence of a hardpan clay layer has influenced head cutting and incision in many areas including the avulsion area.

Considering the hydrologic, biologic, and geologic drivers and utilizing the Stream Evolution Triangle (SET) conceptual model (Castro and Thorne, 2019) this system's existing channel form was largely driven by hydrology and geology and in a Stage 3 or Stage 4 state of channel evolution (Cluer and Thorne, 2014) degrading and widening based on the impacts from beaver trapping, logging, and confinement of the floodplain from railroads and roads. A missing significant component to the reach's geomorphic potential is the lack of biologic influence. Allowing the river to recover on its own would likely take decades. Altering the channel planform from single thread to multi-threaded and providing forcing agents with wood structures would lessen the time for recovery to a more resilient function river-wetland corridor that would vastly increase eco-system services for salmonids.

Design

Due to many factors that included the need to have immediate habitat benefits and the extent of historic disturbance resulting in a simplified channel an aggressive design approach was necessary. This consisted of designing multiple channel threads to replace the dominant single-thread channel that would also allow for a more passive approach in other areas to connect to existing relic features on the landscape. The design process was a team effort with collaboration from engineers, geomorphologists, archeologists, land-managers, and fish biologists. Natural channel design requires the combination of art and engineering as the projects attempted to replicate natural channel features while providing near-term stability.

Channel design consisted of an iterative systematic approach using 3-D surfaces created in AutoCAD Civil3D and modeled in 2-D using Reclamation's SRH2D model. This included iterating horizontal and vertical alignments of channel features, adjusting cross sections of the banks and toes for individual channel units to create surfaces for hydraulic modeling to understand the resulting flow partitioning throughout a complex multi-threaded channel network and floodplain. Hydraulic modeling allowed designers to design stable riffles, to achieve floodplain activation, and to partition flow to achieve project goals and objectives while minimizing risk to existing infrastructure. Model results were also used to assist in performing risk and stability analysis for channel materials and wood structures, risk analysis for recreational use, and to understand flooding potential for private property and infrastructure.

Bird Track Springs

An aggressive re-alignment of the channel planform was opted for at BTS. The existing channel was straightened, over widened, plane bed with limited pools, mostly devoid of wood, and acted like a flume (transport reach) in what historically was a response reach consisting of multi-threaded channels with significant wood loading. The Project team attempted to develop various hyporheic flow paths throughout the site. Designers created a plan form that utilized short interstitial flow paths through gravel bars, long flow paths through the subterranean floodplain and raised the water surface in the channel through hydraulic controls using riffles to literally "soak up the sponge" available in the expansive floodplain. Channel units including riffle-pool sequences with significant abrupt 90-degree bends loaded with wood were designed to force scour to maintain deep pools and provide hydraulic diversity in proximity to cover for salmonids. Multiple channels were designed to provide depth, velocity, and substrate complexity, to increase available habitat, and to activate "passively" existing relic channels available on the floodplain. This multi-threaded network was designed with resiliency in mind to allow for inundation of the entire floodplain during moderate floods and to provide pressure relief for ice-induced flooding. During base flows, the deep pools and varied subterranean flow paths provide upwellings of cold water through hyporheic exchange providing thermal refugia in areas with proximity to cover. By significantly lowering the channel slope and spreading out the available energy into multiple channels, this reach was transformed from a static-transport reach to a dynamic-response reach, see **Figure 2**.

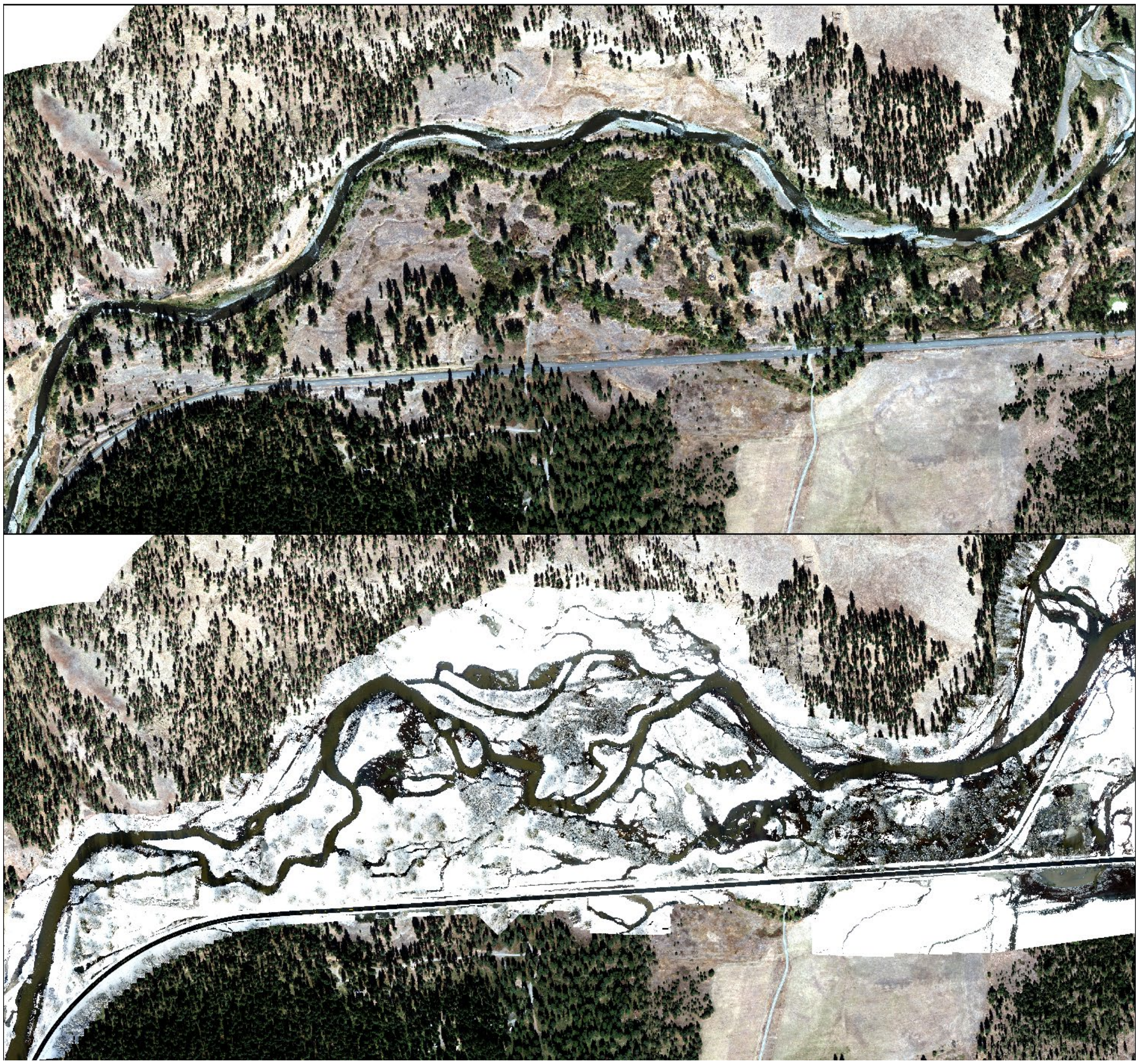

Figure 2 Bird Track Springs Pre-Project (Upper) and Post Implementation February 2020 (Lower). Background image from LIDAR September 2012 Watershed Sciences (Upper) and drone image (Lower) courtesy of Grande Ronde Model Watershed.

Longley Meadows

LM exhibits a large unconfined floodplain at the upstream and middle reaches of the project and a moderately confined floodplain at the downstream reach. A more passive approach was utilized at the upstream and downstream reaches due to landowner constraints. In the middle of the project, an aggressive re-alignment was designed to raise the water surface to access the adjacent floodplain and move the river away its rip-rapped straightened alignment along Oregon Highway 244. The overall channel planform in the upstream large floodplain was more sinuous than at BTS, has an important tributary connection Jordan Creek, and had small areas exhibiting decent riparian recovery with beaver activity. The upstream reach of the channel connected with the adjacent floodplain at annual flood flows. However, the middle portion of the channel was incised, largely disconnected from its floodplain near the highway, and exhibited static flume-like characteristics. Passive modifications included minor excavation to perennially activate existing relic channels, adding wood structures for hydraulic complexity and to promote deposition, robust riparian plantings, and through the addition of floodplain roughness features. New channel segments within the middle portion of the LM channel re-alignment, were designed to mimic natural riffle-pool channel units. Riffles were designed to raise the water surface and provide vertical grade control to activate floodplain and side channel features. Pools were designed at natural high-energy bends and constrictions where hydraulic forces would maintain these deep features. Glides (tail-outs) were designed to create uniform velocity conditions and substrate to mimic natural features. The majority of constructed channel features were completed with materials found onsite. At the Lower end of the Project a side channel network was created to increase habitat complexity while maximizing the availability of an adjacent forested floodplain. See **Figure 3** below of the transformed channel and floodplain.

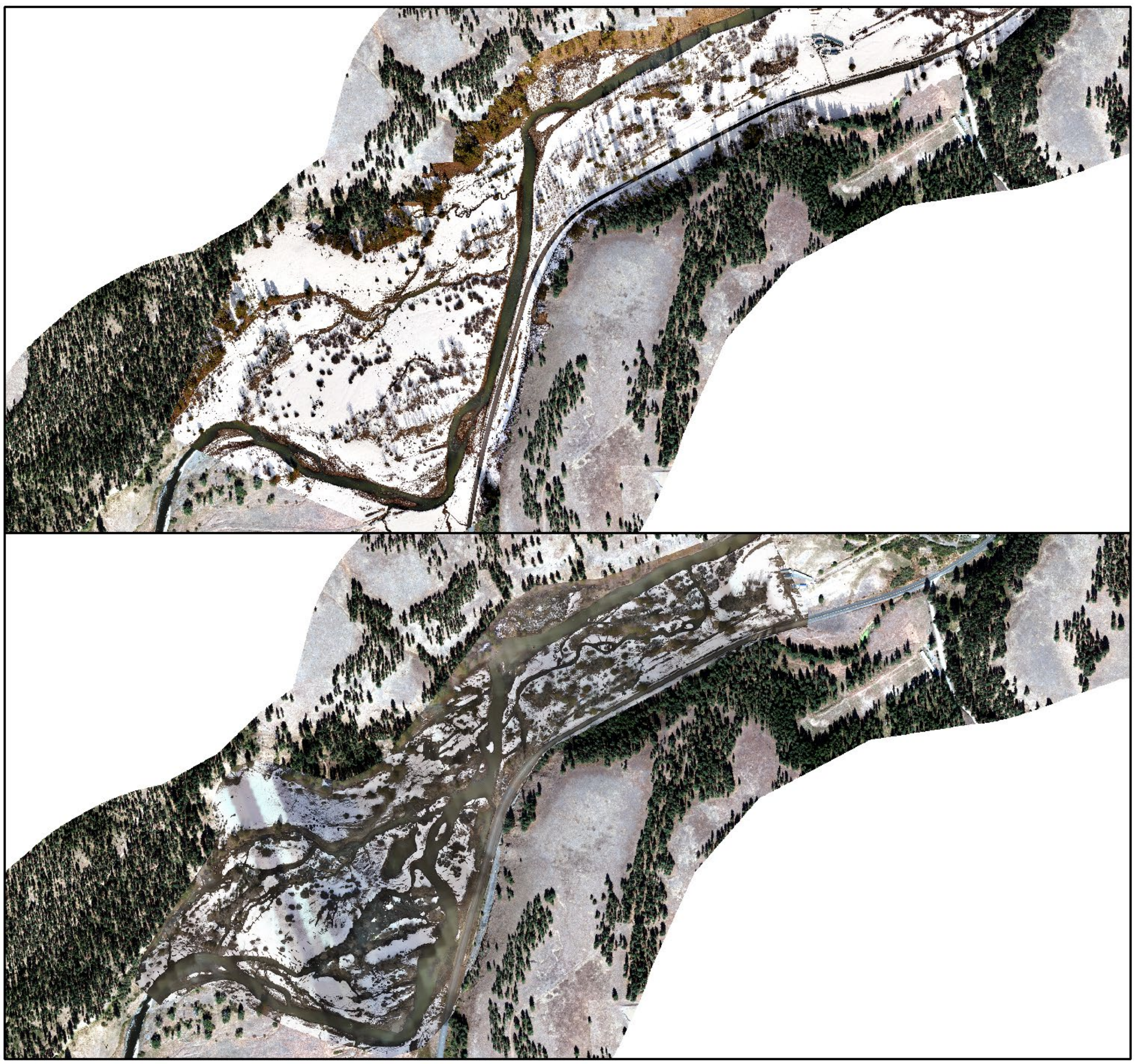

Figure 3 Longley Meadows Pre-Project March 2023 (Upper) and Post Implementation March 2022 (Lower). Background image from LIDAR September 2012 Watershed Sciences (Upper) and drone image (Lower and Upper) courtesy of Grande Ronde Model Watershed.

Implementation

Construction implementation while working in ESA-listed streams requires significant planning. Care of water including by-pass channels, temporary bridges, fish removal, and turbidity management were carefully sequenced to minimize impacts to species of concern and wetlands. Creation of new channels and filling of existing channels requires significant earthwork with the goal of balancing cut-fill within the project boundary. The use of GPS guided heavy equipment was critical with the large amount and complexity of earthwork grading. This required the design surfaces, alignments, sections, profiles, structures, and access roads to be available electronically in multiple software platforms for operators, surveyors, and construction inspectors to build the project. Construction of riffles was a critical component of implementation as they perform the vertical hydraulic control for the project. Riffle materials were generated on-site from sorted excavated materials and carefully mixed and graded to the design specifications to remain stable. This required large areas to sort, screen, and mix materials. Large wood structures require attention to detail to provide temporary bank protection, create forcing agents, provide habitat complexity, and to allow for the regeneration of native riparian communities. Accounting for wood quantities, storage, and transport is a major effort. Construction over multiple seasons in adverse weather conditions and potential flooding required careful planning. Engineering during construction was constant to account for balancing cut/fill discrepancies, habitat opportunities not realized during design, and to inspect/approve of constructed elements. Construction observation and reporting were critical to the design team to relate to what was happening on the ground with multiple crews working over large areas. **Figure 4** shows BTS with the Grande Ronde River in by-pass during year 2 construction.

Figure 4 Bird Track Springs Year 2 Implementation August 2019. Image courtesy of Grande Ronde Model Watershed

Many lessons were learned during the design and implementation of these large-scale restoration projects. Some examples include: 3-D design surfaces generated from LiDAR tend to over-estimate fill volumes, timing and placement of plants and live-stakes greatly contributes to survival and succession, utilizing large wood structures and bank-treatments that are modular/adaptable can help account for variances of bank height and source wood size, large cobbles required for riffle design can be difficult to source on-site, and planning for unknowns like fire restrictions and global pandemics is strongly recommended to be successful.

References

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