

SWALE CREEK

RIVERSCAPE RESTORATION

30% DESIGN REPORT

Prepared by:

Anabran Solutions, LLC



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FEBRUARY 2021

PREPARED FOR:
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PROJECT SUMMARY

The Yakama Nation is pursuing low-tech process-based restoration (LTPBR; Wheaton et al. 2019) as part of an integrated effort to restore culturally significant populations of salmonids in the Klickitat River subbasin on Tribal territory both on Reservation lands and in partnership with private land owners (YNFP 2020). In addition to restoring salmonid habitat and fish populations, the Yakama Nation seeks to train a tribal workforce in LTPBR practices and increase engagement and traditional ecological knowledge (TEK) in watershed restoration. This document outlines the 30% restoration design for approximately 0.75 miles of lower Swale Creek, a direct tributary to the Klickitat River, located in the Klickitat River subbasin. The project area was identified in the 2019 Swale Creek Watershed and Trail Enhancement Prioritization Scheme (River Mile 17.5-18.75) as an "opportunity" reach with higher potential to increase floodplain connectivity due to its relatively wide floodplain and persistence of flows (Jones et al., 2019).

Swale Creek is part of the Swale Creek Minor Spawning Area (MiSA) for ESA-listed Mid-Columbia steelhead (*Oncorhynchus mykiss*). In addition to steelhead, ESA-listed Coho (*Oncorhynchus kisutch*) and Chinook (*Oncorhynchus tshawytscha*) salmon utilize lower Swale Creek for spawning and rearing (Conley 2015). Bridgelip suckers (*Catostomus columbianus*), an important "First Food" to the Yakama People are also found in Swale Creek.

Past land management activities including agriculture, road/railroad construction, large floods, and the removal of large wood from streams have resulted in decreased quality and quantity of stream habitat within the Swale Creek watershed including: reduced wood accumulations (e.g., large wood jams), geomorphic diversity (i.e., pool and off-channel habitat), channel-floodplain connectivity, and riparian vegetation. Swale Creek is listed as impaired on Washington's DOE 303(d) list for temperature criteria. The overall goal of restoration on Swale Creek is to improve the quality and quantity of habitat for threatened steelhead and other species by promoting natural fluvial processes that result in a healthy and resilient riverscape. Within this broad management goal, objectives for restoration include: 1) increase the abundance of large wood accumulations, 2) increase in-channel geomorphic diversity, 3) increase the proportion of the valley bottom composed of active channel and active floodplain, and 4) increase wetland and riparian vegetation extent, diversity.

The restoration design outlines Low-Tech Process-Based Restoration methods (Wheaton et al., 2019) in lower Swale Creek to achieve project goals and objectives. LTPBR practices use simple, cost-effective, hand-built structures that mimic beaver dams (beaver dam analogues) and large wood accumulations (i.e., post-assisted log structures). These structural elements will be strategically introduced to the stream in a design intended to amplify natural hydrologic, geomorphic, and biological processes that accelerate the recovery trajectory of Swale Creek and address limiting factors.

This design report describes the project location, goals and objectives, and planning and design approach, and provides a resource assessment, conceptual restoration design, adaptive management plan, and details regarding implementation and logistics.

TABLE OF CONTENTS

Project Summary	1
Table of Contents	2
List of Figures	3
List of Tables	4
Introduction	6
Project Location and Context	7
Preliminary Project Goals and Objectives	9
Planning and Design Approach	10
Low-Tech Process-Based Restoration	10
Rationale for Design	11
Resource Assessment	12
Fisheries Resources and Limiting Factors	12
Valley Setting (Reaches).....	12
Geomorphic Assessment	13
Valley Bottom Composition	13
Channel Characteristics	14
Hydrology	14
Riparian Assessment and Potential to Support Beaver	15
Risk Assessment.....	16
Potential Future Condition	16
Revised Project Objectives	18
Restoration Objectives	18
Restoration Indicators	18
Restoration Indicator Metrics	18
Restoration Design	21
Temporal Design	21
Spatial Design - Reach Delineation	21
Structural Elements and Complex Design	22
Structural Elements.....	22
Complimentary Restoration Priorities	24
Complex Design	24
Adaptive Management	26
Monitoring and Adaptive Management Framework	28
Construction Plan and Logistics	28
Material Sourcing	28
Site Access, Material Staging, and Fueling/equipment Storage	28

Implementation.....	29
Equipment	29
Construction	29
Conservation Measures	29
References	31
Appendix A - Principles of Riverscape Health and Restoration	33
Riverscape Principles	33
Restoration Principles.....	33
Appendix B - Project Area Photos	34
Appendix C - Predicted Streamflow Values and their Utility	36
Appendix D - PALS and BDA Construction Methods, Structure Types, and Schematics.....	37
Appendix E - Complex Objectives	45
Appendix F - Adaptive Management Framework	46
Appendix G - HIP General Conservation and Implementation Measures	47
Appendix H - HIP Small Wood Conservation Measures	49

LIST OF FIGURES

Figure 1. Location of the Swale Creek project area within the Klickitat River subbasin in south-central Washington.	7
Figure 2. Project area location within the Swale Creek watershed.	8
Figure 3. Overview map of the Swale Creek project area. Parcels outside of those managed by the Yakama Nation and Washington State Parks are in private ownership.	9
Figure 4. Outline depicting an adaptation of NRCS’s Conservation Planning Process used to guide the lower Swale Creek restoration planning and design process (from Wheaton et al. 2019).	10
Figure 5. Conceptual schematic of valley bottom geomorphic composition in the lower Swale Creek project area. Note that the target floodplain is limited by the old railway prism running parallel to the valley bottom on the right side of the photo.	13
Figure 6. Examples of geomorphic conditions in lower Swale Creek. See Appendix B for additional project area photos.	14
Figure 7. Predicted values of streamflow on Swale Creek for up to 100-year recurrence interval events. Solid black line represents the predicted value, dotted grey lines represent the upper and lower prediction interval. Data retrieved from Streamstats (https://streamstats.usgs.gov/ss/) Accessed 01/10/2021 and are based on Mastin et al. (2016).	15
Figure 8. Project area map showing the locations of infrastructure (Klickitat Trail and temporary structures) within the valley bottom.	16
Figure 9. Horseshoe Bend Road bridge over Swale Creek is located approximately 0.75 miles downstream from the project area.	16
Figure 9. Stream evolution model (SEM) proposed by Cluer and Thorne (2014) illustrating approximate stages and pathways associated with recovery to Stage 0. Restoration in Swale Creek is intended to accelerate recovery trajectories.	17
Figure 11. Example of a mid-channel post-assisted log structure (PALS) designed to mimic woody debris accumulations.	22
Figure 12. Example of beaver dam analogue (BDA) reinforced with posts.	23

Figure 13. Example of natural wood (alder) recruitment leading to channel aggradation and increased complexity. Felling trees directly into the channel and leaving them unanchored has the potential to promote similar processes in lower Swale Creek. Photo from Tenmile Creek in southeast Washington. 24

Figure 14. Conceptual restoration design outlining structure type and location for the lower portion of the project area on lower Swale Creek. 25

Figure 15. Adaptive management for monitoring and ongoing restoration of LTPBR complexes. Many of the concepts illustrated are also applicable at the scale of an individual structure or the entire project. From Chapter 6 of Wheaton et al. (2019; <http://lowtechpbr.restoration.usu.edu>). 26

Figure 16. Stream evolution model (SEM) proposed by Cluer and Thorne (2014) illustrating possibility of multiple recovery trajectories. Two different recovery trajectories are highlighted by the blue and green polygons. The blue polygon highlights a counter-clockwise recovery trajectory, beginning with a stream in Stage 3, while the green polygon highlights a clockwise recovery trajectory beginning from the same starting condition. See text below for description of two potential recovery trajectories. 27

Figure 17. Overview of fueling/equipment storage locations, natural material staging areas, and road access for the lower Swale Creek project area. 29

Figure 18. Aerial photos looking down (top photo) and up (bottom photo) valley illustrating valley bottom riparian and floodplain characteristics. 34

Figure 19. Aerial photos illustrating riparian, floodplain, and channel characteristics in the Swale Creek project area. 35

Figure 20. Typical schematic sketches of a bank-attached PALS intended to cause lateral channel migration through deposition of material on point and diagonal bars and erosion of high bank features. From Chapter 4 of Wheaton et al. (2019; <http://lowtechpbr.restoration.usu.edu>). 38

Figure 21. Typical schematics of a mid-channel PALS designed to induce channel complexity, encourage mid-channel deposition, and encourage channel avulsion. From Chapter 4 of Wheaton et al. (2019; <http://lowtechpbr.restoration.usu.edu>). 40

Figure 22. Typical schematics of a channel-spanning PALS. Channel spanning PALS are designed to be passable by fish at all flows. From Chapter 4 of Wheaton et al. (2019; <http://lowtechpbr.restoration.usu.edu>). 41

Figure 23. Example of PALS evolution over the course of one year promoting processes of wood accumulation. A and B show a mid-channel PALS becoming a bank-attached PALS, C and D show a bank-attached PALS becoming a debris jam, and E and F show a bank-attached PALS becoming a mid-channel PALS. The geomorphic changes imposed by the presence of the PALS in each example shows clear alterations to the channel bed and hydraulics. From Chapter 4 of Wheaton et al. (2019; <http://lowtechpbr.restoration.usu.edu>). 42

Figure 24. Profile schematic of post-assisted BDA. Given the potential flashy hydrograph within Tenmile Creek, BDAs will primarily be reinforced with posts. From Chapter 4 of Wheaton et al. (2019; <http://lowtechpbr.restoration.usu.edu>). 44

LIST OF TABLES

Table 1. Description of dominant hydrologic, hydraulic, substrate, and morphological characteristics of Stage 0 channels. Realization of Stage 0 in lower Swale Creek is limited by the railway prism that dissects the valley bottom. Therefore Stage 8 may be a more appropriate target. Adapted from Cluer and Thorne (2014). 17

Table 2. Restoration objectives and their link to broader management goals. 18

Table 3. Current and target indicator metrics and their link to specific project objectives for the project area. Target metrics are estimated for the As-Built project occurring just after the first phase of implementation and short, medium, and long-term time periods following subsequent phases. Ranges in future target metrics indicate uncertainty in the timeline and outcomes from the restoration treatment. Current pool and large wood accumulation metrics were derived from Kuhn and Romero (2020). 20

Table 4. Estimated time table for phased implementation in lower Swale Creek. Structure estimates are approximations. The number of new structures and those that need maintenance in subsequent phases will be assessed through the adaptive management process.	21
Table 5. Complex descriptions outlining risk, objectives, and an estimate of structure types and numbers.	25
Table 6. Predicted streamflow intervals in the project area on lower Swale Creek.	36
Table 7. Description of general process-based complex objectives and intended physical and biological responses.	45

INTRODUCTION

The Yakama Nation is pursuing low-tech process-based restoration actions (LTPBR; Wheaton et al. 2019) as part of an integrated effort to restore culturally significant populations of salmonids in the Klickitat River subbasin on Tribal territory both on Reservation lands and in partnership with private land owners (YNFP 2020). In addition to restoring salmonid habitat and fish populations, the Yakama Nation seeks to train a tribal workforce in LTPBR practices and increase engagement and traditional ecological knowledge (TEK) in watershed restoration.

Past land management activities including agriculture, road/railroad construction, large floods, and the removal of wood from streams have decreased the quality and quantity of stream habitat within the Swale Creek watershed including reduced wood accumulations (e.g., large wood jams), geomorphic diversity (i.e., pool and of-channel habitat), channel-floodplain connectivity, and riparian vegetation. Swale Creek is part of the Swale Creek Minor Spawning Area (MiSA) for ESA-listed Mid-Columbia steelhead (*Oncorhynchus mykiss*). In addition to steelhead, ESA-listed Coho (*Oncorhynchus kisutch*) and Chinook (*Oncorhynchus tshawytscha*) salmon utilize lower Swale Creek for spawning and rearing (Conley 2015). The overall goal of restoration on Swale Creek is to improve the quality and quantity of habitat for threatened steelhead and other species by promoting natural fluvial processes that result in a healthy and resilient riverscape

This document provides a 30% design report for approximately 0.75 miles on lower Swale Creek. The design follows planning, implementation, and project management guidelines identified by the Natural Resources Conservation Service's (NRCS) Conservation Planning Process built within an adaptive management framework. This report provides an overview of the project location, restoration goals and objectives, an assessment of resources, the restoration design approach that includes estimated structure types and quantities, an assessment of potential risks to infrastructure, and an overview of adaptive management for the project.

PROJECT LOCATION AND CONTEXT

Swale Creek is a tributary to the Klickitat River located within the Klickitat River subbasin in south-central Washington. (Figure 1). The Swale Creek watershed encompasses 126 mi² with a maximum elevation of 3,220 feet and a minimum elevation of 518 feet at its confluence with the Klickitat River near Wahkiacus (Figure 2). Annual precipitation averages 18 inches. The upper watershed is located on a plateau that is characterized by relatively flat topography which transitions quickly into a canyon in the lower third of the watershed. Vegetation in the lower watershed consists of ponderosa pine, Douglas fir, and Oregon white oak on upland slopes and a mix of alder and willow in riparian areas within valley bottoms. In the upper watershed, vegetation is dominated by cropland and open grasslands. A majority of the watershed is in private ownership (including off Reservation Tribal land) surrounding isolated parcels of State land.

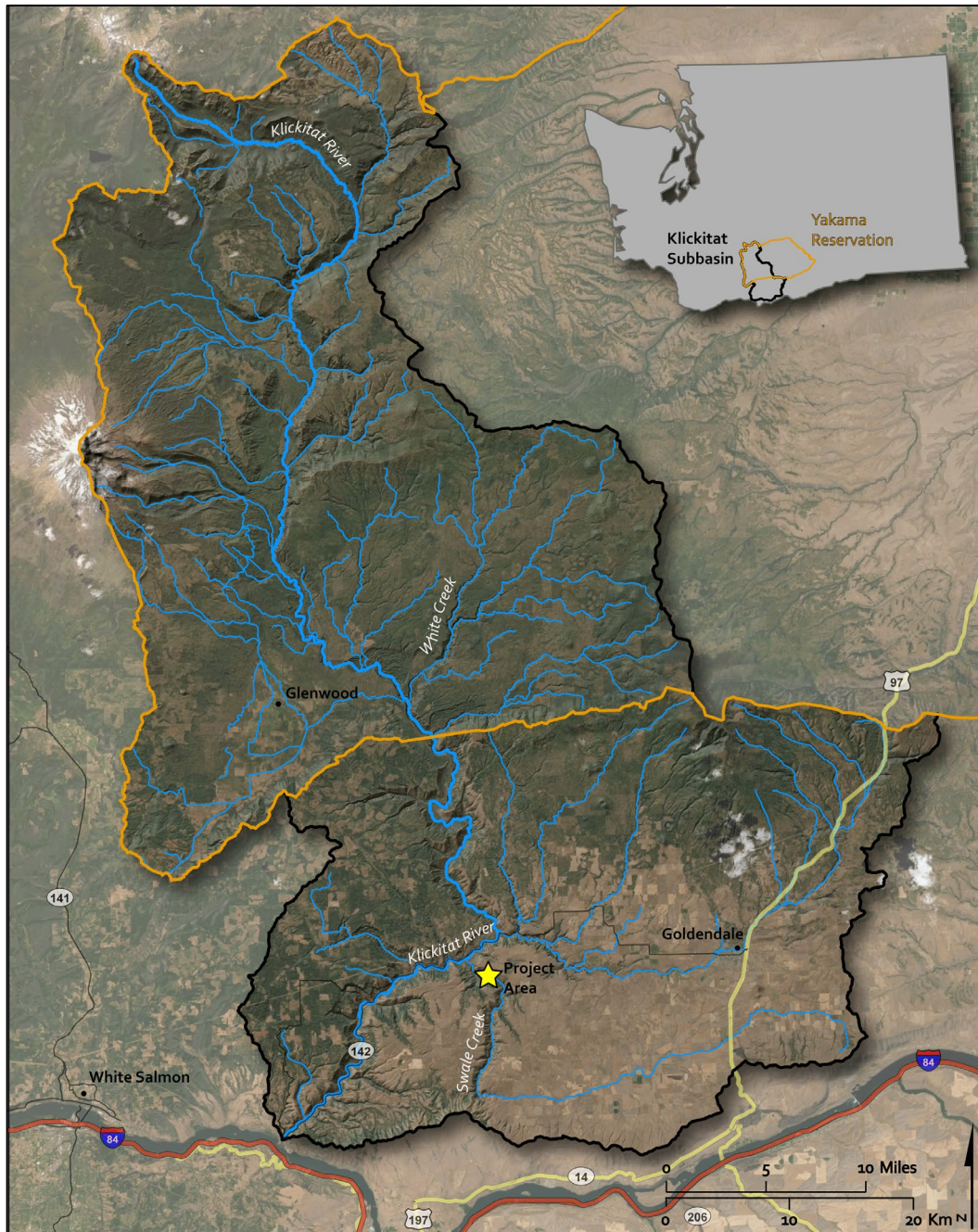


Figure 1. Location of the Swale Creek project area within the Klickitat River subbasin in south-central Washington.

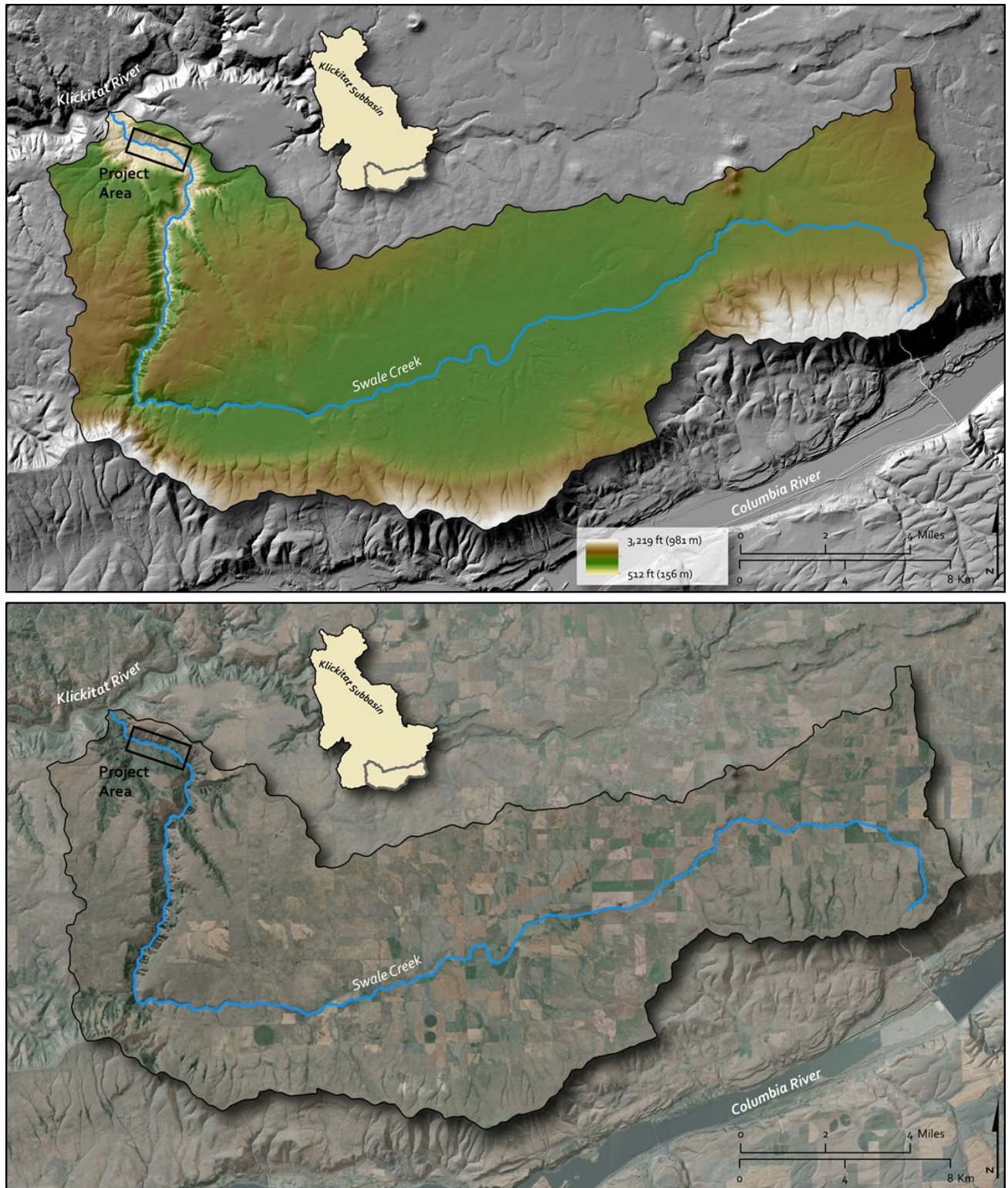


Figure 2. Project area location within the Swale Creek watershed.

The project area begins one mile upstream from the confluence with the Klickitat River and extends for approximately 0.75 miles upstream. This segment of lower Swale Creek was identified in the 2019 Swale Creek Watershed and Trail Enhancement Prioritization Scheme (River Miles 17.5-18.75) as an “opportunity” reach with higher potential to increase

floodplain connectivity due to its relatively wide floodplain and persistence of flows. The project area includes Yakama Nation managed land, land in private ownership, and the decommissioned railway (e.g., Klickitat Trail) managed by Washington State Parks (Figure 3). The channel gradient ranges from approximately 1.0-1.5% and averages 1.4% throughout.

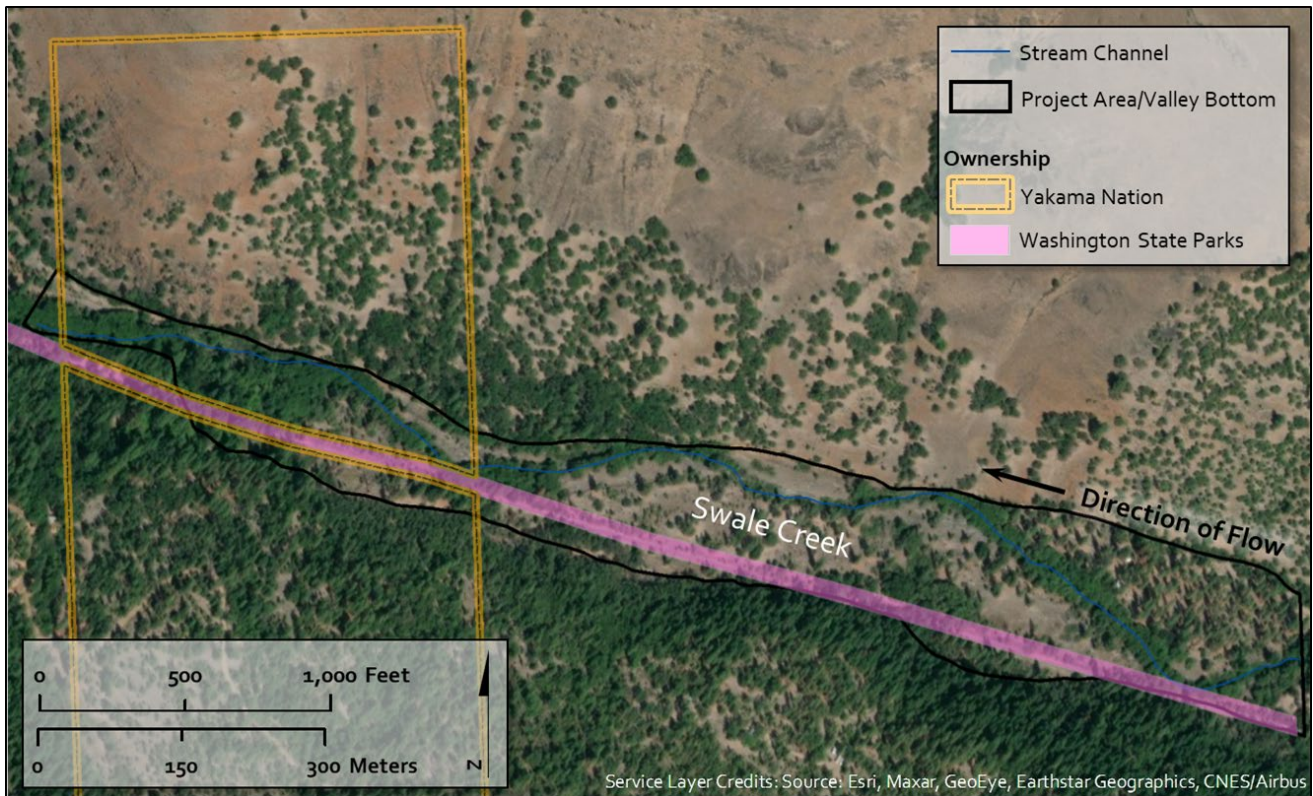


Figure 3. Overview map of the Swale Creek project area. Parcels outside of those managed by the Yakama Nation and Washington State Parks are in private ownership.

PRELIMINARY PROJECT GOALS AND OBJECTIVES

The overall goal of restoration in lower Swale Creek is to promote natural fluvial processes that result in a healthy and resilient riverscape and increase habitat quantity, quality, and diversity for threatened steelhead, Coho, and Chinook. Within this broad management goal, preliminary objectives for restoration provided by the Yakama Nation include:

1. enhancing in-channel habitat conditions,
2. increasing the wetted perimeter of the active channel,
3. increasing shallow aquifer storage/recharge,
4. reducing active channel hydraulic severity, and
5. increasing the duration of low flows.

Later in the planning process we revisit these goals and objectives and recommend indicators to evaluate the effectiveness of restoration and help facilitate the adaptive management process.

PLANNING AND DESIGN APPROACH

The lower Swale Creek riverscape restoration design follows an adaptive management framework that has three phases: 1) Collection and Analysis (focused on planning), 2) Decision Support (design), and 3) Application and Evaluation (implementation, monitoring, and additional phases as needed; Figure 4). In this report, the planning process includes components specific to riverscape restoration that are consistent with LTPBR designs and practices with the overall intent of presenting the preliminary restoration goals and objectives of the project, conducting resource assessment, risk, and recovery assessment, using those results to refine/recast the goals and objectives of the conceptual design, and arrive at measurable indicators to evaluate progress toward objectives (Wheaton et al. 2019).

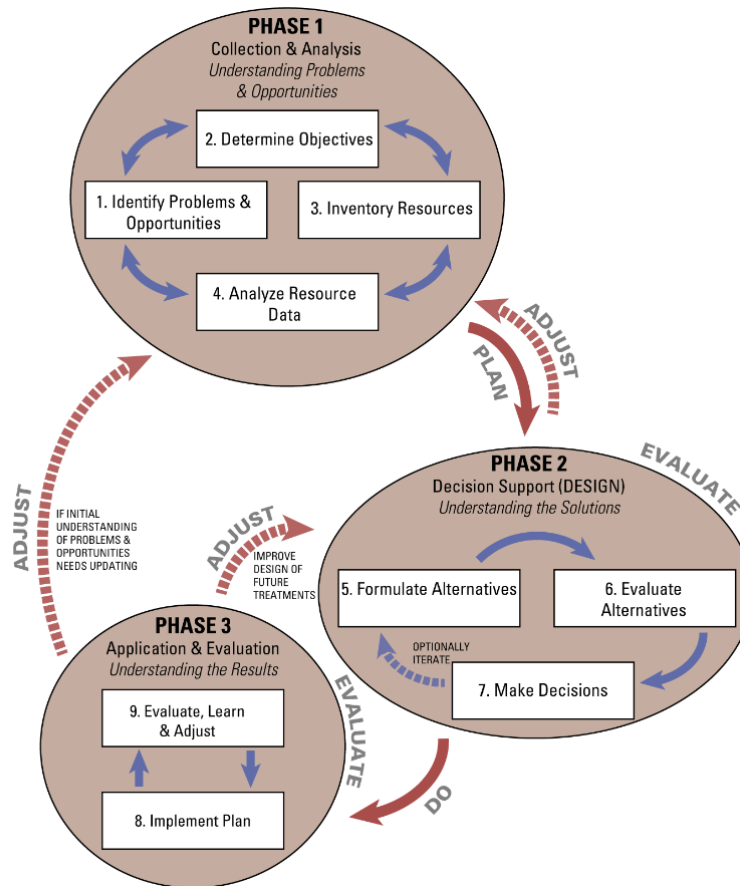


Figure 4. Outline depicting an adaptation of NRCS’s Conservation Planning Process used to guide the lower Swale Creek restoration planning and design process (from Wheaton et al. 2019).

LOW-TECH PROCESS-BASED RESTORATION

LTPBR is based on a set of riverscape and restoration principles that are applied based on the characteristics and limitations set by individual riverscapes (Appendix A). The first question we seek to answer before developing a LTPBR design is “is the riverscape structurally starved?”. Structural-starvation (i.e., the absence of wood, beaver dams, and/or dense vegetation) in riverscapes is one of the most common impairments affecting riverscape health. Generally, a structurally-starved riverscapes drains quickly, has limited lateral connectivity, is more prone to incision, and has simple and homogenous habitat. By contrast, a riverscape with a natural amount of structure has obstructions to flow leading to structurally-forced hydraulic diversity and geomorphic diversity resulting in a more resilient riverscape that provides diverse habitat and a suite of ecosystem services (Bisson et al., 1987; Roni et al., 2015; Wohl et al., 2019).

LTPBR approaches use the addition of structural elements to mimic, promote, and sustain natural riverscape processes. Rather than trying to create a specific channel form, LTPBR relies on stream power (and/or beaver) to “do the work”. LTPBR explicitly acknowledges that one treatment of structural elements is unlikely to reverse decades or longer of management impacts and that successful restoration is likely to include multiple treatments (i.e., phases) Therefore, LTPBR designs include phases, and work best when projects are monitored in order to determine when new phases or maintenance are required. The following design is presented within an adaptive management framework to incorporate monitoring and phased implementation in a transparent and structured plan (Figure 4).

RATIONALE FOR DESIGN

Several alternative channel and floodplain restoration approaches have been considered for riverscape recovery on lower Swale Creek. In general, these alternatives are characteristic of traditional engineered plans for valley bottom regrading and channel realignment. Given the design, permitting, implementation costs, and potential disturbance caused by machine access associated with engineered restoration over larger spatial extents, LTPBR approaches were selected as the proposed design alternative.

There are a number of project area characteristics that make Swale Creek well-suited for implementing LTPBR designs. Furthermore, LTPBR projects are well suited to the Yakama Nation’s vision to engage tribal members with stewardship of their natural resources.

Site characteristics – The climatic, topographic, and hydrologic conditions within Swale Creek support reliable flood events, a recovering riparian area, and a high potential for proliferation of riparian vegetation and natural recruitment of large wood.

Lack of human infrastructure – There is limited human infrastructure such as buildings and roads in the project area. This characteristic of the project area offers a high potential for expansion of the active channel and floodplain while posing little risk.

Tribal member engagement – The implementation of LTPBR projects lends itself to creating a workforce of tribal members that provides economic and cultural incentives to improve riverscape health.

RESOURCE ASSESSMENT

The following section provides an assessment of fisheries resources and limiting factors, geomorphic, hydrologic, and riparian conditions, and potential risks within the project area. The results from these assessments were used to evaluate potential future conditions and pathways to riverscape recovery. We used desktop analyses, site visits, aerial imagery, existing data, and personal communication with Yakama Nation staff to address the following questions to assess resource conditions and recovery potential (from Wheaton et al. 2019):

- Are the channel and floodplain well-connected?
- Is the proportion of the valley bottom geomorphic surfaces indicative of a healthy riverscape?
- Is the flow regime sufficient to create geomorphic change if structure is present?
- Is there the potential for self-sustaining sources of woody vegetation to support:
 - The process of wood accumulation, and/or
 - The process of beaver dam activity
- Based on the condition assessment, risks, and mitigation of risks, what is the potential future condition(s)?
- What are the pathways of recovery?
- What are the expected timelines for recovery?

FISHERIES RESOURCES AND LIMITING FACTORS

The Swale Creek watershed is considered a Minor Spawning Area (MiSA) for ESA-listed Mid-Columbia steelhead (*Oncorhynchus mykiss*; NMFS 2009). In addition to steelhead, ESA-listed Coho (*Oncorhynchus kisutch*) and Chinook (*Oncorhynchus tshawytscha*) salmon also utilize lower Swale Creek for spawning and rearing (Conley 2015). Bridgelip suckers (*Catostomus columbianus*), an important “First Food” to the Yakama People are also found in Swale Creek. Swale Creek is listed as impaired on Washington’s DOE 303(d) list for temperature criteria (NMFS 2009). Likely and potential limiting factors in the Swale Creek watershed include (NMFS 2009):

High stream temperatures (likely), low stream flow (likely), degraded habitat quality and quantity (potential), altered sediment routing (potential), and degraded channel structure and complexity (potential). The restoration actions outlined in this design propose to address a number of these limiting factors including:

- high stream temperatures
- low stream flow
- degraded habitat quality and quantity, and
- degraded channel structure and complexity.

VALLEY SETTING (REACHES)

The project area represents a single valley setting that consists of a moderately wide valley bottom that ranges from 300-700 feet wide (average 460 feet). At the downstream end of the project area, the valley bottom becomes more confined due to an alluvial fan on valley left. Within the valley bottom, reach characteristics consist of a main channel with pockets of discontinuous floodplain separated by relic secondary channels that are disconnected from the main channel. An abandoned railway bed that has been converted into a recreational trail (Klickitat Trail) parallels the left valley bottom margin and reduces the accessible valley bottom up to approximately 125 feet in some locations.

We assess the general health of a riverscape by identifying the existing composition of the valley bottom which is comprised of the active channel, active floodplain and inactive floodplain. Valley bottom areas were delineated based on freely available aerial imagery (i.e. Google Earth) and freely available topographic data from the National Elevation Dataset. In general, intact riverscapes are comprised of 100% active channel or floodplain, and the more degraded a riverscape is the greater the proportion of inactive floodplain will be present. We define the valley and its components after Wheaton et al. (2015):

GEOMORPHIC ASSESSMENT

Valley Bottom Composition

We assess the general health of a riverscape by identifying the existing composition of the valley bottom which is comprised of the active channel, active floodplain and inactive floodplain (Figure 5). Valley bottom areas were delineated based on an evaluation of aerial imagery (i.e., Google Earth, drone imagery) and topographic data (i.e., LiDAR). In general, intact riverscapes are comprised of 100% active channel or floodplain, and the more degraded a riverscape is the greater the proportion of inactive floodplain will be present. We define the valley and its components after Wheaton et al. (2015):

Valley – relatively flat low-lying area between hills or mountains typically containing a watercourse. Contains the geomorphic units: channel(s), floodplain(s), terrace(s), and fan(s).

Valley Bottom – low-lying area in a valley containing the stream channel and contemporary (i.e., genetic) floodplain. The valley bottom represents the current maximum possible extent of channel movement and riparian areas. It may be bounded by hillslopes, terraces, and/or alluvial fans.

Active Channel - area between the top of banks that is geomorphically active during typical (i.e., 1-2 year) flows, and is characterized by sediment entrainment, deposition and transport. It is identified by open water and/or the presence of bare surfaces that are the result of scour or deposition, and have not been colonized by perennial vegetation.

Active Floodplain - area within the valley bottom that is inundated by 5 - 10-year recurrence interval flows (e.g., the 5-10-year floodplain), and is generally capable of recruiting and supporting riparian vegetation.

Inactive Floodplain - area which could flood under the current flow regime, but not hydrologically connected during 5 – 10-year recurrence intervals flows. We specifically identify this area as the inactive floodplain, rather than the commonly used term 'terrace' in order to differentiate valley bottom features that are the result of anthropogenic disturbances from those that are the product of historic climatic or geomorphic events and conditions that are different from contemporary process rates. Unlike the distinction between a terrace and floodplain, which are distinguished by differences in elevation, both the active floodplain and inactive floodplain may be present at the same elevation but are differentiated by their lateral displacement from the active channel.



Figure 5. Conceptual schematic of valley bottom geomorphic composition in the lower Swale Creek project area. Note that the target floodplain is limited by the old railway prism running parallel to the valley bottom on the right side of the photo.

Within the project area, the active channel and active floodplain comprise approximately 34% (13 of 38 acres) of the valley bottom. The inactive floodplain encompasses approximately 65% (25 acres) of the valley bottom. The former railway prism increases confinement in the project area limiting floodplain access. Of the 25 acres of inactive floodplain, approximately one-third of that area (7 acres) is on the hillslope (valley left) side of the railway prism and disconnected from the main channel.

Channel Characteristics

Channel characteristics in lower Swale Creek are indicative of a structurally starved riverscape (i.e., lack of structural elements such as large wood accumulations, beaver dams, or boulders). The channel is highly simplified and primarily consists of planar geomorphic units (e.g., runs and rapids) which are dominated by large cobbles and small boulders due to a lack of sediment sorting. A small inset floodplain is present where the stream has widened and the channel margins are lined with alders and banks consist of large cobble which make them resistant to erosion. Multiple secondary channels are present but are only accessed during high flow events. Data summaries from habitat surveys conducted in 2014 that covered the project area and extended approximately 3.5 miles upstream indicate 0.73 pools/100m with a large wood frequency of 3.9 pieces/100m and 0-1 large wood accumulations (e.g., jams)/100m (Kuhn and Romero 2020).



Figure 6. Examples of geomorphic conditions in lower Swale Creek. See Appendix B for additional project area photos.

HYDROLOGY

Swale Creek, at the project area drains approximately 120 square miles and experiences average annual precipitation of 19 inches. Peak flows tend to be rainfall driven and occur in winter and spring as rain on snow events (Liermann et al., 2012). Predicted streamflow for the 2, 5, 10, 25, 50 and 100-year recurrence intervals is shown in Figure 7. Low-flow statistics are not available for the project area, however field observations indicate that baseflows are typically < 1 cfs. Baseflows in lower Swale Creek are primarily influenced by the geologic nature of the watershed. The Warwick Fault that dissects the watershed upstream of the project area limits groundwater discharge to lower Swale Creek (WPN 2004). This historic lack of groundwater baseflow has likely not been influenced by land use change within the watershed. A table of the predicted streamflow values as well as a longer discussion of their utility in LTPBR planning and design can be found in Appendix C of this report.

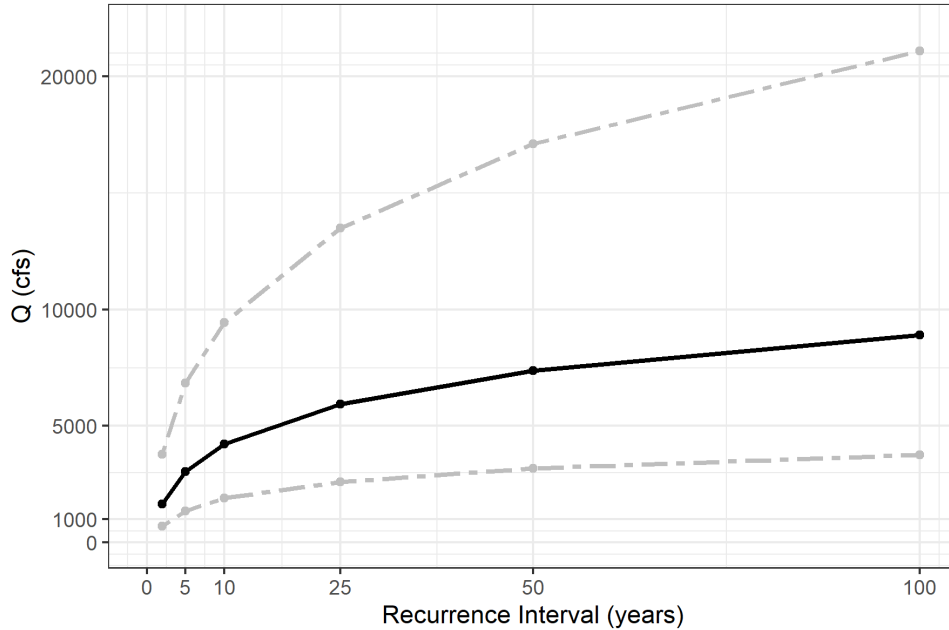


Figure 7. Predicted values of streamflow on Swale Creek for up to 100-year recurrence interval events. Solid black line represents the predicted value, dotted grey lines represent the upper and lower prediction interval. Data retrieved from Streamstats (<https://streamstats.usgs.gov/ss/>) Accessed 01/10/2021 and are based on Mastin et al. (2016).

RIPARIAN ASSESSMENT AND POTENTIAL TO SUPPORT BEAVER

The extent of woody riparian vegetation throughout the project area consists primarily of alder and willow which are limited to the channel margins. The dominant woody riparian species is alder, which are all of the approximate same age class. The inset floodplain is dominated by reed canary grass which gives way to alder and upland shrubs and grasses underneath a canopy of big leaf maple outside of the active channel and floodplain. Riparian canopy cover is estimated to be 39% in the main channel and 13% in secondary channels (Kuhn and Romero 2020). There is limited natural wood recruitment within the project area.

We used the Beaver Restoration Assessment Tool (BRAT; Macfarlane et al., 2017) to assess the current and historic capacity to support beaver dams across the Klickitat River subbasin. Importantly, BRAT relies on regional hydrological data when assessing whether flow conditions are conducive to, or will limit beaver dam activity. In lower Swale Creek, stream power in the main channel is the primary factor likely to limit the capacity/likelihood to support beaver dam activity. However, there are some locations on the main channel in the lower project area with higher channel-floodplain connectivity where unit stream power is reduced by the ability to access the floodplain, and opportunities may exist to build in secondary channels. Within the project area, Swale Creek currently has the capacity to support 1-5 dams. There are currently no beaver dams within the project area. As such there is the potential for moderate uplift if restoration activities can encourage the colonization of the project area by beaver and promotion of beaver dam activity by improving off-channel habitat and channel-floodplain connectivity. The results from BRAT suggests that encouraging beaver dam activity is a potential restoration strategy but given the high stream power in the project area, it should be coupled with additional strategies (e.g., large wood accumulations) to make the valley bottom more suitable for sustaining the persistence of dams.

RISK ASSESSMENT

Risks were assessed as the potential for impacts to infrastructure (road crossings, buildings, etc.) within and adjacent to the valley bottom. The Klickitat Trail, a former railway that is now a recreational trail is located within the valley bottom and runs parallel to the southern side (river left) of Swale Creek (Figure 8). The former railway prism is armored with ballast material. There are no road crossings within the project area. The nearest bridge is approximately 0.75 miles downstream from the bottom of the project area (. A few temporary structures (i.e., a yurt, small cabin) are present within the project area.

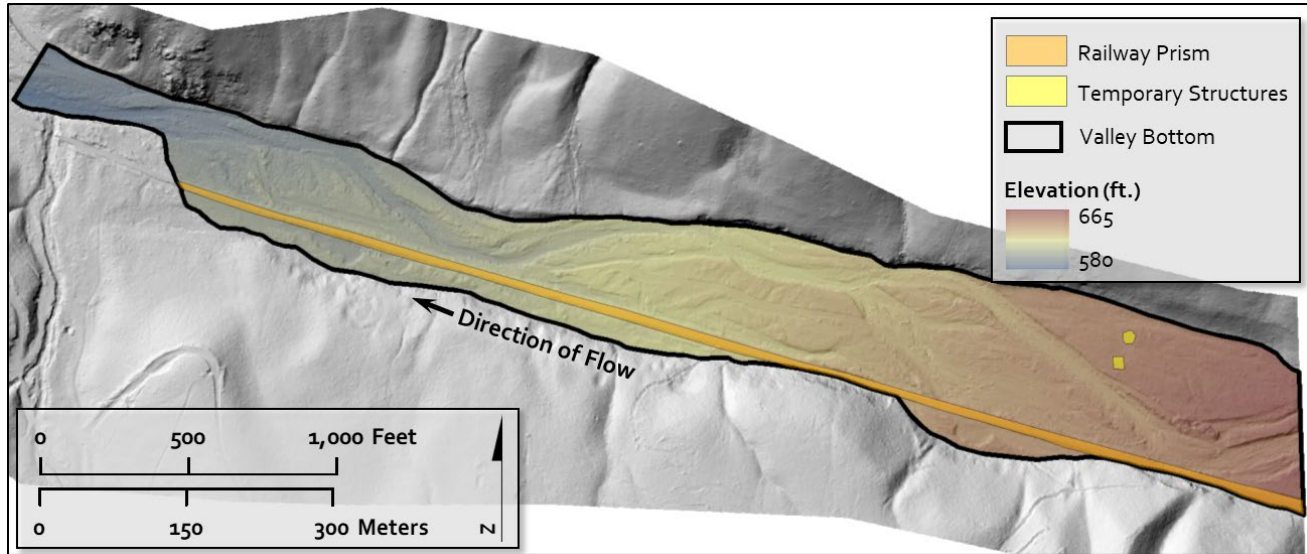


Figure 8. Project area map showing the locations of infrastructure (Klickitat Trail and temporary structures) within the valley bottom.



Figure 9. Horseshoe Bend Road bridge over Swale Creek is located approximately 0.75 miles downstream from the project area.

POTENTIAL FUTURE CONDITION

Prior to human alteration, many riverscapes such as Swale Creek were characterized by multiple channels and high channel-floodplain connectivity, and were also more resilient to disturbance. The stream evolution model presented by Cluer and Thorne (2014) describes valley bottoms characterized by multiple channels and high channel-floodplain connectivity as “Stage 0”, and describes how the hydrologic, hydraulic, substrate, geomorphic, and ecological benefits

of this stage are greater than other stages in the stream evolution cycle (Figure 9; Table 1). This concept, when applied to lower Swale Creek provides an overarching target for restoration and potential pathways of recovery.

Without active restoration, it will likely be decades before lower Swale Creek naturally recovers to near Stage 0 conditions based on our assessment. Furthermore, the railway prism, a confining feature that dissects the valley bottom limits full recovery to Stage 0. Without removal of the railway prism and access to the entire valley bottom, Stage 8 conditions are a more appropriate target. Stage 8 conditions would possess many of the same characteristics as Stage 0 but be limited to only a portion of the valley bottom. With targeted restoration actions, there is potential to access a large portion of the valley bottom throughout the project area based on limited infrastructure. The potential to improve in-channel geomorphic diversity and channel-floodplain connectivity may be recognized in short to medium timescales. If realized, these improvements will provide immediate ecosystem and habitat benefits for steelhead and other species. Full recovery to full Stage 8 conditions may take longer and require multiple structural interventions. Ultimately, self-sustaining riverscape conditions may not be recognized without the processes of natural wood recruitment and/or beaver activity.

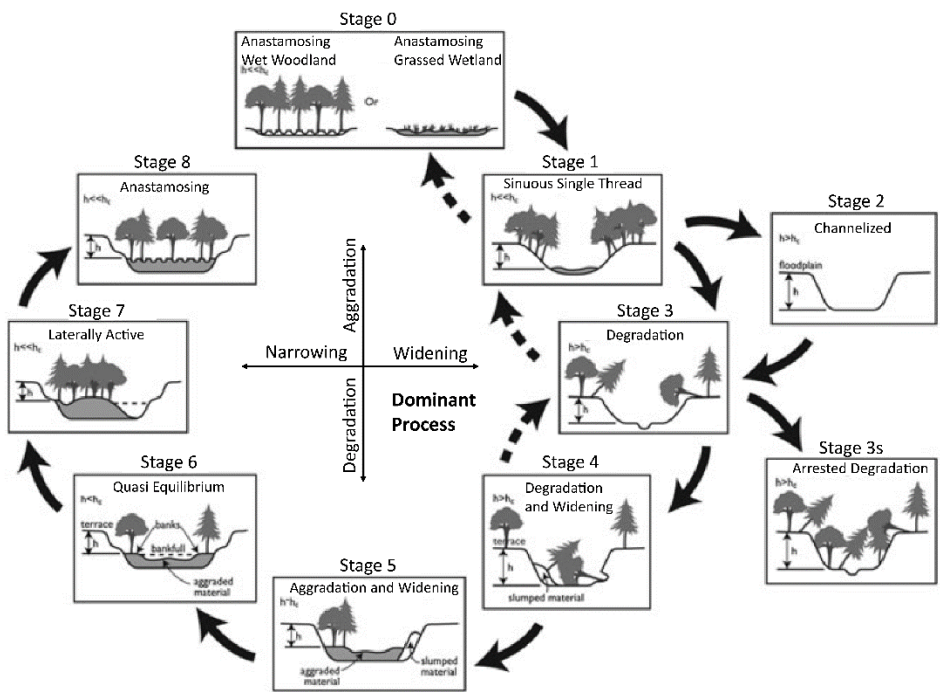


Figure 10. Stream evolution model (SEM) proposed by Cluer and Thorne (2014) illustrating approximate stages and pathways associated with recovery to Stage 0. Restoration in Swale Creek is intended to accelerate recovery trajectories.

Table 1. Description of dominant hydrologic, hydraulic, substrate, and morphological characteristics of Stage 0 channels. Realization of Stage 0 in lower Swale Creek is limited by the railway prism that dissects the valley bottom. Therefore Stage 8 may be a more appropriate target. Adapted from Cluer and Thorne (2014).

Stage 0 Description	Hydrologic Regime	Hydraulics and Substrate	Morphology
Dynamically meta-stable network of anabranching channels with vegetated islands	Floods cover width of floodplain; Maximum flood attenuation; High water table	Maximum in-channel hydraulic diversity; Wide range of depth/velocity combinations; Wide range of substrate sizes in well-sorted patches	Multiple channels; Low bank height; Fully connected floodplain; High capacity to store sediment and wood

REVISED PROJECT OBJECTIVES

The preliminary project objectives are revisited and modified here to ensure they are consistent with riverscape restoration goals and reflect the current conditions and potential for recovery in the project area. The lower Swale Creek restoration goals and objectives support recovery planning actions aimed at improving the quality and quantity of habitat and address several factors limiting steelhead production in Swale Creek including low flows, high water temperatures, degraded habitat quality and quantity, and degraded channel structure and complexity (NMFS 2009).

RESTORATION OBJECTIVES

Restoration goals are also directly supported by S.M.A.R.T (Specific, Measurable, Achievable, Relevant, Time bound, from Skidmore et al. 2011) restoration objectives that have been developed to create expectations for project outcomes, establish restoration indicators, and guide adaptive management. The revised restoration objectives were developed based on initial project objectives provided by Yakama Nation and the assessment (Table 2).

Table 2. Restoration objectives and their link to broader management goals.

Objective	Description	Link to Restoration Goals
1	Increase the abundance of large wood accumulations.	Both artificial and natural large wood accumulations (e.g., large wood jams) increase in-channel habitat diversity and help to accelerate recovery.
2	Increase in-channel geomorphic diversity.	Geomorphically diverse streams provide higher quality habitat for adult and juvenile steelhead.
3	Increase the proportion of the valley bottom composed of active channel and active floodplain.	Increased active channel and floodplain area contributes to the expansion of wetland and riparian vegetation and increasing steelhead habitat quantity.
4	Increase wetland and riparian vegetation extent, diversity, and abundance.	Riparian vegetation is essential to support wood accumulation, as forage and building material for beaver, and suitability for culturally significant plants.

RESTORATION INDICATORS

There is definite potential for restoration success in lower Swale Creek due to the lack of infrastructure and indications that riparian conditions have begun to recover. However, restoration success may be limited by a number of factors including: a flashy hydrograph, the availability of sediment to aggrade the channel, and the cohesion of banks which can influence the stream's ability to widen channels and provide local sources of sediment.

In keeping with SMART project objectives, a series of restoration targets and indicator metrics are recommended for evaluating the effectiveness of restoration. For each indicator, estimates of current and potential (i.e., target) values have been developed that correspond to broad recovery timelines (Table 3). All metrics are intended to be summarized through monitoring efforts using methods such as those described within the LTPBR Implementation and Monitoring Protocol (Weber et al. 2020). These methods allow quantification of indicator metrics via orthoimagery acquisition using a consumer level drone, or through measurements taken during rapid field habitat surveys.

Restoration Indicator Metrics

Pool Frequency – Frequency (count/100m) of in-channel concave geomorphic units (Wheaton et al. 2015; e.g., pools) created by erosion, and/or damming. Expected to increase resulting from the structural treatments. Pool habitat provides refuge for juvenile steelhead during periods of drought and high temperatures, and velocity refuge during high – flow periods.

Bar Frequency – Frequency (count/100m) of in-channel convex geomorphic units created through deposition (Wheaton et al. 2015; e.g., point bars, mid-channel bars, riffles). Expected to increase resulting from the structural intervention as a function of increased in-channel hydraulic diversity. Bars are indicative of spawning habitat used by adult steelhead.

Active Valley Bottom Area – Percent and area of the valley bottom functioning as part of the active channel and active floodplain. Expected to increase resulting from structural intervention due to overbank flows, pond creation, floodplain connectivity, and creation of multi-threaded channels.

Wetland and Riparian Vegetation Extent – Percent and area of the valley bottom in which the community is composed of wetland and/or riparian plant species. Expected to increase with an expanding active channel and floodplain, floodplain inundation frequency, groundwater elevation, as well as due to grazing management and riparian vegetation planting treatments.

Beaver Dam and Large Wood Accumulation Abundance – Count of natural beaver dams, artificial dams, and large wood accumulations within the project area. Artificial dams and large wood accumulations will increase immediately after restoration treatments. Natural beaver dams and self-sustaining beaver populations have the potential to increase over short to longer time periods with the creation of deep-water cover from restoration treatments and over longer time periods following the creation of off-channel habitat and side channels and expansion of riparian vegetation communities.

Table 3. Current and target indicator metrics and their link to specific project objectives for the project area. Target metrics are estimated for the As-Built project occurring just after the first phase of implementation and short, medium, and long-term time periods following subsequent phases. Ranges in future target metrics indicate uncertainty in the timeline and outcomes from the restoration treatment. Current pool and large wood accumulation metrics were derived from Kuhn and Romero (2020).

Indicator	Status		Target Metrics		
	Current	As-Built	Short-Term 2 – 5 years	Medium-Term 5 – 10 years	Long-Term 10-20 years
Pool Habitat Frequency (count/100m) ¹	0-1 / 100m	1-3 / 100m	2-4 / 100m	2-5 / 100m	3-6 / 100m
Bar Habitat Frequency (count/100m) ¹	0-2 / 100m	0-2 / 100m	2-4 / 100m	2-5 / 100m	3-6 / 100m
Active Valley Bottom (% & acres)	30-40%	30-45%	30-50%	35-60%	40-80*%
	11-15 acres	11-16 acres	11-20 acres	15-25 acres	15-30 acres
Wetland and Riparian Vegetation Extent (% & area) ²	15-20%	15-20%	15-25%	20-30%	25-40%
	6-8 acres	6-8 acres	6-10 acres	8-11 acres	10-15 acres
Natural Beaver Dams (count) ³	0 dams	0 dams	0-3 dams	0-6 dams	4-8 dams
Artificial Beaver Dams (count)	0 dams	1-3 dams	0-3 dams	3-6 dams	2-4 dams
Large Wood Accumulations (count) ⁴	0 - 1 jams	40-60 jams	20-70	20-80	30-80

1: Assumes treatments will form pools and bars after flood events.

2: Primarily based on expectations for expansion of the active floodplain and planting treatment.

3: Assumes natural colonization by beavers and dams primarily located in side channels.

4: Assumes a combination of natural and artificial large wood accumulations in the project area.

*: Assumes maximum valley bottom extent if railway prism is not removed.

RESTORATION DESIGN

The LTPBR restoration design consists of the following components used to guide the implementation of treatments over time:

Temporal Design – The temporal design is used to guide initial and subsequent implementation phases (i.e., temporally punctuated structural treatments including new structures and maintenance).

Spatial Design – Reach Delineation – Restoration reach delineation based on valley setting. The delineation of reaches is used to set specific objectives and adjust restoration expectations according to limitations set by the riverscape.

Structural Elements and Complex Design – Description of structure types and their organization, distribution, and function within structure complexes (i.e., groups of multiple structures).

TEMPORAL DESIGN

Temporal design should take into consideration both the expectations for flood events of a given magnitude, as well as rates of vegetative, geomorphic, and hydrologic recovery. Therefore the restoration design takes a phased approach to implementation in order to help facilitate the adaptive management process. We recommend a pilot restoration treatment followed by implementation in the entire project area (Phase 1). A second structural treatment (Phase 2) would follow after at least 1-2 typical (2-year return interval) flow events. A third treatment phase would take place after several moderate floods and at least one large flow (>5-year year return interval). Additional phases could be added based on progress towards restoration targets and/or establishing self-sustaining process. Additional benefits of a phased approach include the advantages of enabling implementers to work out initial logistics at a smaller scale and scale up restoration more efficiently while in the meantime training and building a local workforce. The phased approach also fits an iterative process that can be applied to multiple ongoing restoration projects over large spatial scales. Importantly, the specific timing of additional treatments, while likely to correspond to the timeframes listed above are in practice driven by adaptive management, and progress towards meeting restoration objectives.

Table 4. Estimated time table for phased implementation in lower Swale Creek. Structure estimates are approximations. The number of new structures and those that need maintenance in subsequent phases will be assessed through the adaptive management process.

Phase	Year(s)	Restoration Actions	Structure Estimate
1	1	<ul style="list-style-type: none"> ▪ Pilot restoration in select project area locations ▪ Evaluate pilot restoration 	New: 20-30
	2	<ul style="list-style-type: none"> ▪ Implement restoration throughout project area ▪ Structure maintenance and additions in areas of pilot restoration ▪ Riparian planting within pilot restoration reaches 	New and maintained: 30-60
2	2-5	<ul style="list-style-type: none"> ▪ Evaluate Phase 1 restoration ▪ Structure maintenance and additions within project area ▪ Riparian planting throughout project area 	0-25
3	5-10	<ul style="list-style-type: none"> ▪ Evaluate Phase 2 restoration ▪ Structure maintenance and additions within project area ▪ Additional riparian plantings (if necessary) 	0-25
Additional	10+	<ul style="list-style-type: none"> ▪ Evaluate the establishment of self-sustaining processes ▪ Structure maintenance and additions if necessary 	0-25

SPATIAL DESIGN - REACH DELINEATION

Identifying and delineating distinct reaches allows for better management of project expectations given the differences in valley bottom characteristics and helps guide where more restoration effort may be invested. Management reaches

also provide the setting for complex level designs (i.e., groups of structures designed to work together for specific objectives) and establishing complex objectives. As part of the resource assessment, one reach type was identified within the project area. Therefore the design contains one management reach that encompasses the entire project area.

STRUCTURAL ELEMENTS AND COMPLEX DESIGN

Structural Elements

Structural elements proposed in the design include Beaver Dam Analogues (BDAs), Post-Assisted Log Structures (PALS), and unsecured trees/wood accumulations. These structure types can be constructed using a variety of locally sourced material (from adjacent floodplains and hillslopes or forest management activities) and installed using manual labor that will result in minimal impact to existing riparian vegetation and habitat. Appendix D provides details on BDA and PALS construction methods, different structure types, how different structure types should be used to promote specific responses, and design schematics.

Post-Assisted Log Structures (PALS)

PALS are composed of woody material of various sizes secured with untreated wooden posts driven into the substrate and positioned to mimic natural wood accumulations. PALS are generally designed to increase geomorphic diversity, force lateral channel migration, force overbank flows, and encourage widening, and encourage aggradation and channel avulsion (Figure 11; Appendix D). However, PALS can also be built on the floodplain and disconnected side-channels in anticipation of floodplains being reactivated. There are three basic types of PALS: bank-attached, mid-channel, and channel spanning. Bank-attached PALS are used to widen channels, recruit sediment, promote scour pools, and build bank-attached bars. Mid-channel PALS are used to split flows, build mid-channel bars, scour pools, and recruit sediment. Channel-spanning PALS are used to force aggradation, promote overbank flow during high flow, and promote plunge and dam pools. Different types of PALS are often used in combination with beaver dam analogues to produce a variety of localized geomorphic affects. PALS are typically built in high densities (3-5 PALS/100m) such that if a PALS is blown out woody material is likely to be captured by downstream structures (i.e., safety in numbers restoration principle; Appendix A).



Figure 11. Example of a mid-channel post-assisted log structure (PALS) designed to mimic woody debris accumulations.

Beaver Dam Analogues (BDAs)

Beaver dam analogues (BDAs) mimic the form and function of natural beaver dams. BDAs are temporary, permeable structures built with or without posts using a combination of locally available woody material and sediment (Figure 12; Appendix D). The design and implementation of BDAs is a simple and cost-effective method to restore the processes

that are responsible for physically complex channel and floodplain habitat. They can be used to support existing populations of beaver by increasing the stability of existing dams; create immediate deep-water habitat for beaver translocation or naturally dispersing beaver, or to promote many of the same processes affected by natural beaver dams such as increased channel-floodplain connectivity during both high and low flow conditions, increased groundwater recharge, expansion of riparian vegetation and wetland areas, increased hydraulic diversity including deep-slow water habitat, and incision recovery through channel-widening and aggradation.



Figure 12. Example of beaver dam analogue (BDA) reinforced with posts.

Other Structural Additions

Additional approaches to adding structural elements to the stream and floodplain include direct felling of trees into the channel or onto the floodplain to provide roughness, or using a griphoist to move large wood from adjacent hillslopes or floodplains (Figure 13). The trees can be used as a base for building PALS, used without posts and anchored into existing vegetation, or kept whole to limit their movement in the channel or on the floodplain (Carah et al. 2014; Figure 13). These structural additions also provide additional source material to recruit into natural wood jams and PALS. In some locations in and adjacent to the channel, there are boulders that can be moved to form low rock structures that increase channel roughness, trap and sort sediment, promote overbank flow, and increase complexity (Maestas et al., 2018).



Figure 13. Example of natural wood (alder) recruitment leading to channel aggradation and increased complexity. Felling trees directly into the channel and leaving them unanchored has the potential to promote similar processes in lower Swale Creek. Photo from Tenmile Creek in southeast Washington.

Complimentary Restoration Priorities

Although not specifically addressed within this design document, woody riparian plantings could be used to supplement riverscape restoration within lower Swale Creek. The structural interventions themselves will complement riparian vegetation treatments by supporting their survival and expansion through flow attenuation, increased water tables, and an increase in the frequency and spatial extent of floodplain inundation. In addition, the railway prism which is a confining feature in the valley bottom could potentially be removed to allow access to the entire valley bottom during high flows.

COMPLEX DESIGN

While individual structures (PALS and BDAs) may have local influence, they are unlikely to achieve project restoration objectives unless they are coordinated in a larger reach-scale effort. Thus, individual structures are designed to work together in complexes. A complex may be composed of a single structure type (i.e., BDAs) or a mix of structure types (i.e., different PALS and BDAs) and be composed of as few as two structures or as many as 10's of structures. Individual PALS and BDAs that are part of a complex help to increase the stability of any given structure within the complex. For the lower Swale Creek design, the project area contains one complex designed to meet multiple objectives. Table 5 provides a list of objectives for the complex along with a description and estimate of structure numbers and types. A more detailed description of complex objectives and their intended physical and biological responses can be found in Appendix E. The overall goal of restoration in this complex is to promote natural fluvial processes that accelerate the recovery trajectory toward a more healthy and resilient riverscape and improve the quality and quantity of habitat for steelhead and other species. See Figure 14 for an example of a conceptual restoration design outlining structure types and locations in the lower portion of the project area.

Table 5. Complex descriptions outlining risk, objectives, and an estimate of structure types and numbers.

Complex (length)	Risk	Primary Objectives	Description	PALS	BDAs
1 (4630 ft.)	Limited risk; Railway prism near valley margin; temporary structures on inactive floodplain near top of project	<ul style="list-style-type: none"> Increase Geomorphic Diversity Force Overbank Flows 	<ul style="list-style-type: none"> Bank-attached PALS to promote erosion and lateral migration Channel-spanning PALS and BDAs to promote overbank flows, capture sediment, aggrade the channel, and connect/create side channels BDAs mainly on secondary channels to pond water Whole trees or PALS on floodplain surfaces to provide roughness 	40-60	2-8

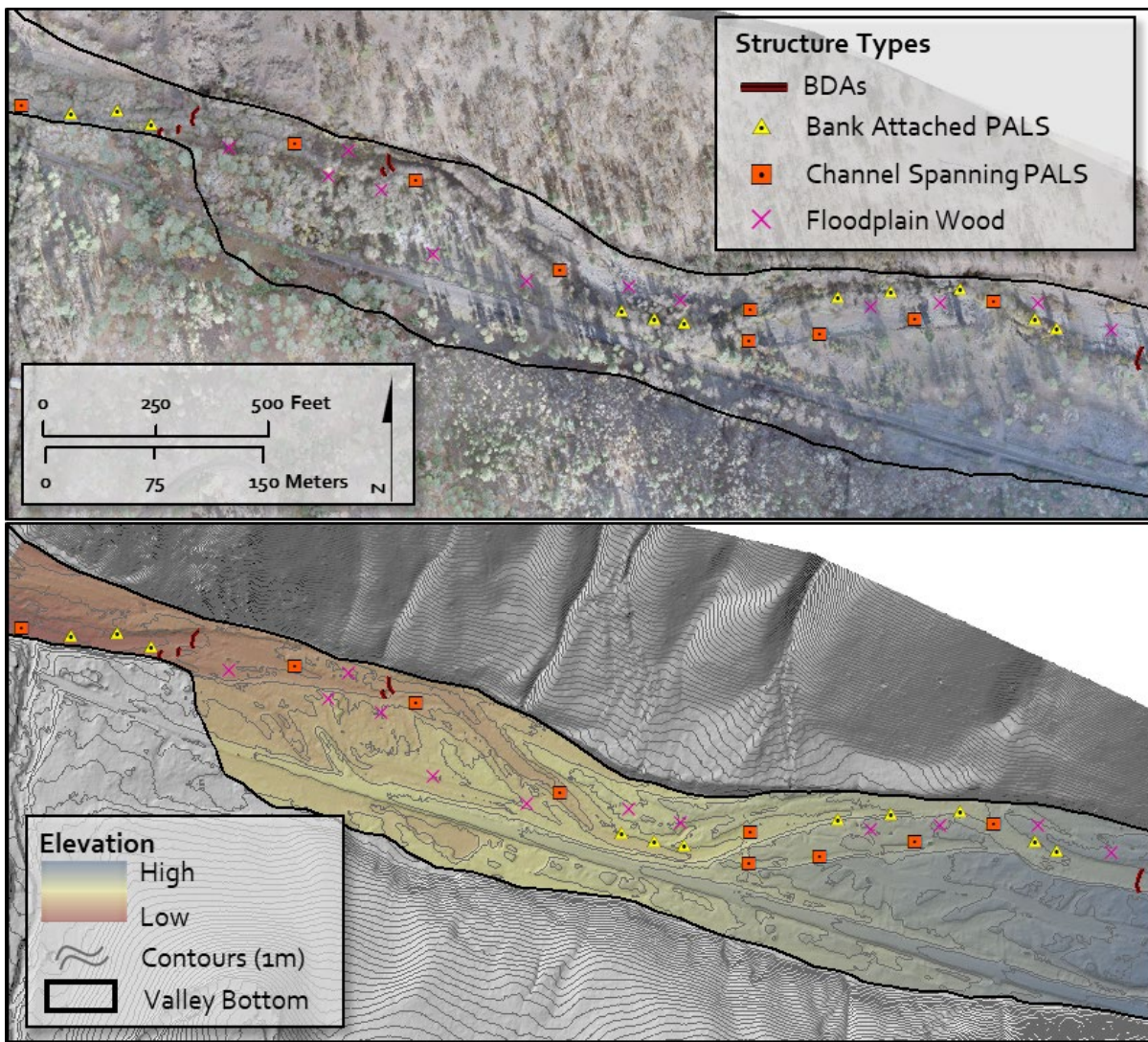


Figure 14. Conceptual restoration design outlining structure type and location for the lower portion of the project area on lower Swale Creek.

ADAPTIVE MANAGEMENT

LTPBR is more appropriately thought of as an ongoing-process of restoration and management than a 'one-and-done' effort. Here we discuss how adaptive management can be used to guide future phases of restoration. We use the term 'phases' here to refer to any restoration action taken, rather than when a specific restoration objective has been met. Adaptive management plays a major role in 1) evaluating the response to restoration through monitoring and 2) determining how the response to restoration guides future restoration actions (Figure 15). LTPBR projects can be evaluated at multiple scales, ranging from the scale of an individual structure to the entire project area, which along Swale Creek covers almost two miles of stream, and 34 acres of valley bottom. Here we focus on the complex and project scale rather than the scale of individual structures, since project objectives are not met at the scale of individual structures.

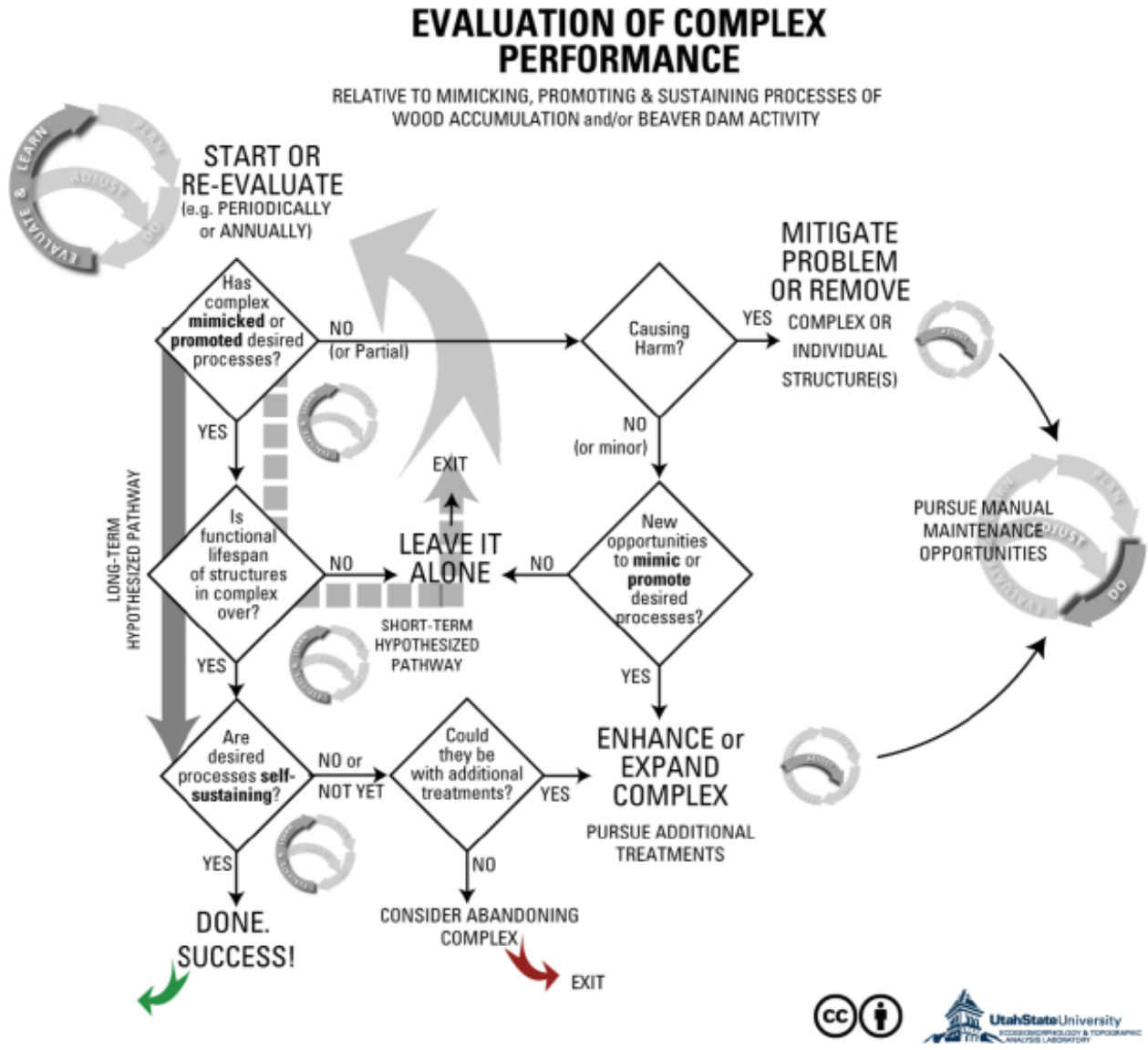


Figure 15. Adaptive management for monitoring and ongoing restoration of LTPBR complexes. Many of the concepts illustrated are also applicable at the scale of an individual structure or the entire project. From Chapter 6 of Wheaton et al. (2019; <http://lowtechpbr.restoration.usu.edu>).

Common maintenance or phased restoration actions which necessarily occur at the scale of individual structures within a complex include:

- Lateral extension of structures through adding wood
- Increase structure height through adding wood
- Plugging gaps through adding more wood
- Adding posts to existing structures
- Repair minor breaches
- Building new structures
- Removing structures if causing harm

The specific actions taken at an individual structure or location depend on the specific complex objectives and the specific structure objective within that complex.

An additional consideration in LTPBR projects is that streams may have different pathways to recovery, or recovery trajectories, for a given starting condition. Incised streams may recover by going through a widening phase, leading to aggradation and eventual reconnection, or by immediate aggradation and reconnection (Figure 16). It may be impossible to know what recovery trajectory is most likely for a given project area, or a specific reach within a project area. The goal of adaptive management is to be able to guide future management actions in the face of this uncertainty. Here we present two examples of potential recovery trajectories, taken from Figure 21 and how an adaptive management plan will guide restoration. These examples may be thought of as specific cases that fall under the broader adaptive management concepts outlined in Figure 15.

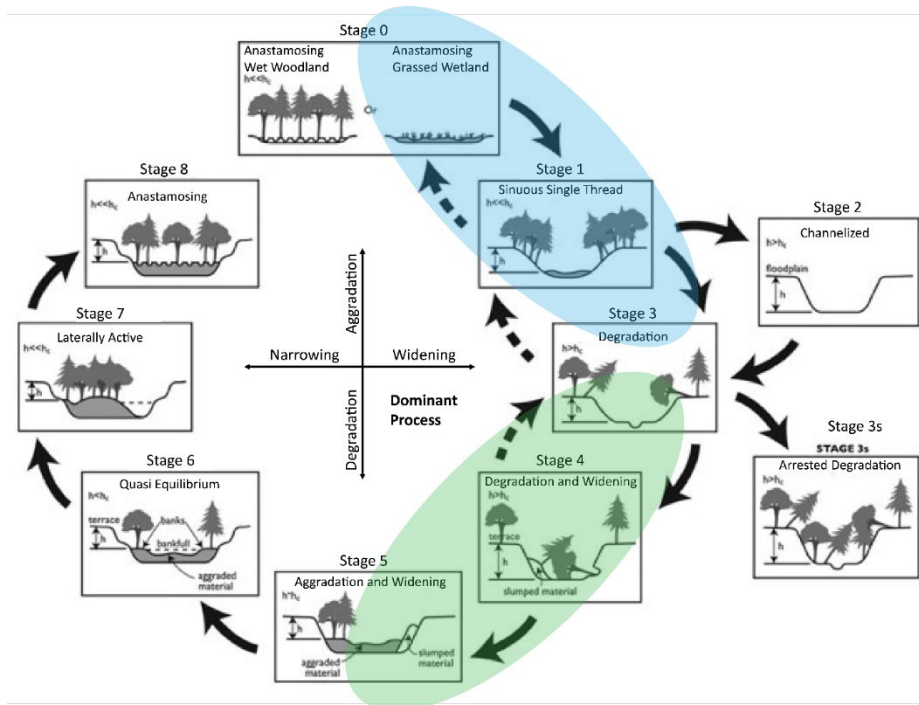


Figure 16. Stream evolution model (SEM) proposed by Cluer and Thorne (2014) illustrating possibility of multiple recovery trajectories. Two different recovery trajectories are highlighted by the blue and green polygons. The blue polygon highlights a counter-clockwise recovery trajectory, beginning with a stream in Stage 3, while the green polygon highlights a clockwise recovery trajectory beginning from the same starting condition. See text below for description of two potential recovery trajectories.

Counter-clockwise Recovery Trajectory

In this recovery trajectory, the incised stream (Stage 3) is dominated by aggradation which results in the reestablishment of channel-floodplain connectivity. Once established, subsequent phases of restoration can further increase the duration, frequency and extent of connectivity, pushing the stream from Stage 1 conditions into Stage 0 conditions. In practice, it may take multiple treatments to fully reconnect a highly incised stream to its floodplain. The time it takes will depend on the natural flow and sediment regime of the specific stream in question, factors which are often, as with Swale Creek poorly characterized prior to restoration.

Clockwise Recovery Trajectory

In this recovery trajectory, the incised stream is dominated by lateral erosion and consequent channel widening. Channel widening leads to the formation of increased instream complexity through the formation of bars, as well as a decrease in unit stream power as flows are spread out in a wider channel, further facilitating deposition (Stage 5). Once a wider channel is established an inset floodplain begins to develop which can support riparian vegetation, which can provide important benefits such as shading, as well as provide a source of woody material to be recruited to the stream naturally. In this trajectory the stream may reconnect to its historic floodplain, or it may simply create a new floodplain at a lower elevation (and more limited lateral extent) that provides much of the function provided by the historic floodplain.

The purpose of describing the two trajectories illustrated above is to draw attention to the nuance involved in formulating specific thresholds for adaptive management prior to restoration because both of the cases described represent positive outcomes of restoration. Adaptive management is intended to be able to address this uncertainty of outcomes, even when there are multiple positive outcomes to restoration. Importantly, the specific metrics and time tables associated with different recovery trajectories necessarily would require multiple indicator metrics and thresholds for each different recovery trajectory, and for each different complex of restoration structures. In short, a fully developed adaptive management plan would take the principles outlined in Figure 15, and need to develop multiple thresholds for multiple restoration trajectories. We contend that following the principles outlined in Figure 15 enables a more specific discussion following the first phase of restoration, once field observations can suggest the most likely recovery trajectory, which then enables the specific identification of thresholds and triggers for future work. Importantly, this process still enables the identification of harm done by restoration, and provides a mechanism for mitigating that harm.

MONITORING AND ADAPTIVE MANAGEMENT FRAMEWORK

To help facilitate the adaptive management framework on Swale Creek, Appendix F provides a framework to support adaptive management decision making based on requirements outlined in BPA's HIP Handbook.

CONSTRUCTION PLAN AND LOGISTICS

Implementation and logistical considerations are specific to material sourcing, site access, staging and refueling areas, and conservation measures that guide implementation and/or permitting of the restoration design.

MATERIAL SOURCING

To reduce costs and increase the efficiency of implementation, wood will be sourced from nearby forest thinning and/or fuels reduction projects and staged in select locations throughout the project area and/or sourced directly from adjacent floodplains and hillslopes. The size of individual wood pieces will vary but are not likely to exceed 12 inches dbh by 15 feet in length since they will be transported and placed by hand or small machinery (e.g., ATV, skidsteer; not to exceed 15,000 lbs.). Some wood exceeding 12 inches dbh by 15 feet in length may be used if directly sourced from the floodplain or adjacent hillslopes. It is anticipated that approximately 500-1000 pieces of wood will be needed for the first phase of implementation. Ongoing wood additions after the initial treatment phase will be assessed during subsequent phases.

SITE ACCESS, MATERIAL STAGING, AND FUELING/EQUIPMENT STORAGE

Road access to the project area is limited to the old railway/recreational trail along the left (southern) edge of the valley bottom margin which can support small trucks and UTVs/ATVs (Figure 17). Access to the stream channel will be limited to foot and small machinery (e.g. ATVs). Several staging areas, and fueling/equipment storage locations have been identified that will be used during implementation (Figure 17).

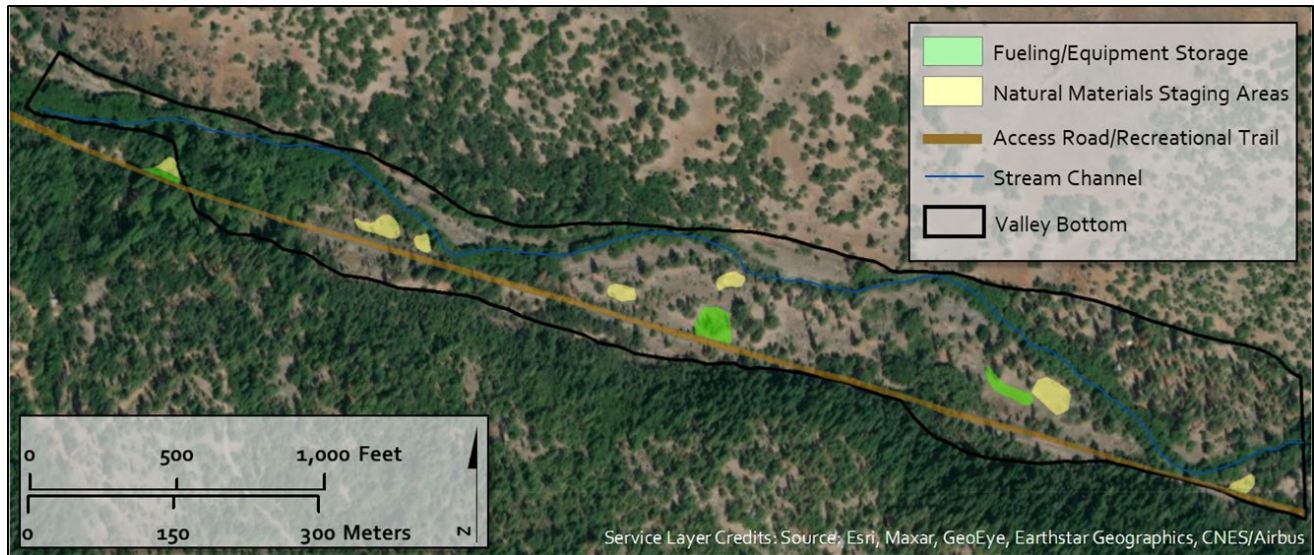


Figure 17. Overview of fueling/equipment storage locations, natural material staging areas, and road access for the lower Swale Creek project area.

IMPLEMENTATION

Equipment

The equipment requirements for installation of LTPBR structures (e.g., PALS and BDAs) consist of a hydraulic post pounder, chainsaws, loppers, shovels, picks, and 5-gallon buckets. The hydraulic power source for the pounder is mounted on a rolling frame that can be moved between structure locations by a 2-3 people. If access allows, an ATV will be used to transport the hydraulic post driver and power pack between structures during construction. A griphoist may also be used to transport larger wood pieces from the floodplain to the channel.

Construction

PALS are constructed by hand-placing the wood in the channel and then using the hydraulic post pounder to pound 2-4" diameter non-treated wooden posts into the channel to secure the wood. Posts are typically driven in 2-3' and cut off at approximately bank-full height. BDAs are built by using a variety of local materials including willow, alder, and conifer species that is woven in between wooden posts driven in the bed in the same manner as PALS. The main difference between BDAs and PALS is that BDAs are always channel spanning and local fill from the banks or bed is used to promote ponding of water during low flow conditions. The fill is typically sourced from the banks and bed upstream of the structure from the area that will be inundated by the pool formed by the BDA. The fill is placed on the upstream side of the BDA to slow water moving through the structure and increase ponding. Fill material will consist of sand, gravel, cobble, and sod. Material will be collected using shovels and picks and moved by hand using five gallon buckets. More detail on construction and design aspects of PALS and BDAs can be found in Appendix D.

CONSERVATION MEASURES

All activities will follow HIP General Conservation Measures (see Appendix G) and those outlined for small wood projects where applicable (see Appendix H). References to select conservation measures are provided below:

Fueling/Equipment Storage and Natural Material Staging Areas

Fueling and storage for equipment with gas tanks >5 gallons will take place at locations >150 feet from streams and wetlands while staging areas for wood and natural materials may be located <150 feet from streams and wetlands.

Timing of In-Water Work

Instream work will be conducted during the established work window determined by WDFW (likely July 15-September 30).

Work Area Isolation and Fish Salvage

The proposed design calls for minimal excavation within the wetted channel. During the construction of BDAs, some substrate will be excavated using hand tools (e.g., shovels) and transported using 5-gallon buckets. Therefore no work area isolation or fish salvage is expected.

Turbidity

The construction of PALS involves driving 2-4" wood posts into the streambed and adding wood, which creates little to no turbidity. The construction of BDAs involved driving wood posts, weaving woody material between the posts, and adding some substrate/fill to the upstream side of the structure which produces limited turbidity for a short-time. While small amounts of fine sediment may be introduced to the water column as substrate is disturbed during installation, the resulting increase in turbidity occurs at a small spatial scale (~10-20 m), for a short duration (1-2 hours), and at levels that are not thought to significantly impact salmonids.

Stream Crossings

Stream crossings within the project area will mostly be limited to foot traffic.

On-Site Harvest of Large Wood

Any large wood harvested from adjacent floodplains or hillslopes will follow best management practices and adhere to forest/riparian management guidelines.

REFERENCES

- Bisson PA, Bilby RE, Bryant MD, Dolloff CA, Grette GB, House RA, Murphy ML, Koski KV, and Sedell JR. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present, and future. Pages 143-190 in E. O. Salo and T.W. Cundy (eds.) Streamside management: forestry and fishery interactions. Contribution No. 57. Institute of Forest Resources, University of Washington, Seattle.
- Bouwes, N., Bennett, S., and Wheaton, J. 2016. Adapting Adaptive Management for Testing the Effectiveness of Stream Restoration: An Intensively Monitored Watershed Example. *Fisheries* 41(2): 84-91.
- Carah, J.K., Blencowe, C.C., Wright, D.W. and Bolton, L.A. 2014. Low-Cost Restoration Techniques for Rapidly Increasing Wood Cover in Coastal Coho Salmon Streams. *North American Journal of Fisheries Management* 34(5): 1003-1013.
- Cluer, B., & Thorne, C. (2014). A stream evolution model integrating habitat and ecosystem benefits. *River research and applications*, 30(2), 135-154.
- Jones, A., Legg, N., and Rudolph, J. 2019. Swale Creek Watershed and Trail Enhancement Prioritization Scheme. Prepared for The Confederated Tribes and Bands of the Yakama Nation by Wolf Water Resources. May 7, 2019.
- Klickitat Lead Entity. 2015. Klickitat Lead Entity Region Salmon Recovery Strategy. Prepared for the Washington State Recreation and Conservation Office, Olympia, WA.
- Kuhn, K.G. and Romero, N. 2020. Swale Creek (Klickitat River Subbasin, Washington) Rapid Aquatic Habitat Assessment Stream Report. Yakima/Klickitat Fisheries Project, Klickitat, Washington.
- Liermann, C.A., Olden, J.D., Beechie, T.J., Kennard, M.J., Skidmore, P.B., Konrad, C.P., and Imaki, H. 2012. Hydrogeomorphic Classification of Washington State Rivers to Support Emerging Environmental Flow Management Strategies. *River Research and Applications* 28(9): 1340-1358.
- Macfarlane, W.W., Wheaton, J.M., Bouwes, N., Jensen, M.L., Gilbert, J.T., Hough-Snee, N., and Shivik, J.A. 2017. Modeling the capacity of riverscapes to support beaver dams. *Geomorphology* 277: 72-99. doi:10.1016/j.geomorph.2015.11.019.
- Maestas, J.D., Conner, S., Zeedyk, B., Neely, B., Rondeau, R., Seward, N., Chapman, T., With, L., and Murph, R. 2018. Hand-built structures for restoring degraded meadows in sagebrush rangelands: Examples and lessons learned from the Upper Gunnison River Basin, Colorado. Range Technical Note No. 40. USDA-NRCS, Denver, CO.
- Mastin, M., Konrad, C., Veilleux, A., & Tecca, A. (2016). Magnitude, frequency, and trends of floods at gaged and ungaged sites in Washington, based on data through water year 2014 (ver 1.2, November 2017): US Geological Survey Scientific Investigations Report 2016-5118, 70 p.
- National Marine Fisheries Service (NMFS) 2009. Recovery Plan for the Klickitat River Population of the Middle Columbia River Steelhead Distinct Population Segment. September 2009.
- Roni P, Beechie T, Pess G, Hanson K, Jonsson B. 2015. Wood placement in river restoration: fact, fiction, and future direction. *Canadian Journal of Fisheries and Aquatic Sciences* 72: 466-478. DOI: 10.1139/cjfas-2014-0344
- Skidmore, P.B., Thorne, C.R., Cluer, B.L., Pess, G.R., Castro, J.M., Beechie, T.J. and Shea, C.C., 2011. Science base and tools for evaluating stream engineering, management, and restoration proposals, U.S. Department of Commerce, Seattle, WA. Available at: <https://repository.library.noaa.gov/view/noaa/4020>.
- Watershed Professionals Network (WPN), 2004. WRIA 30 Swale Creek Temperature Study; 2004. Appendix E to WRIA 30 Watershed Assessment. September 2004
- Weber, N., Wathen, G., and Bouwes, N. 2020. Low – Tech Process – Based Project Implementation and Monitoring Protocol. Available at: <http://fmltpbr.riverscapes.xyz>
- Wheaton, J.M., Bennett S.N., Bouwes, N., Maestas J.D. and Shahverdian S.M. (Editors). 2019. Low-Tech Process-Based Restoration of Riverscapes: Design Manual. Version 1.0. Utah State University Restoration Consortium. Logan, UT. Available at: <http://lowtechpbr.restoration.usu.edu/manual>

Wheaton, J.M., Fryirs, K.A., Brierley, G., Bangen, S.G., Bouwes, N. and O'Brien, G. 2015. Geomorphic mapping and taxonomy of fluvial landforms, *Geomorphology*, Volume 248, Pages 273-295, ISSN 0169-555X, <https://doi.org/10.1016/j.geomorph.2015.07.010>.

Wohl E, Kramer N, Ruiz-Villanueva V, Scott DN, Comiti F, Gurnell AM, Piegay H, Lininger KB, Jaeger KL, Walters DM, Fausch KD. 2019. The Natural Wood Regime in Rivers. *Bioscience* 69: 259-273. DOI: 10.1093/biosci/biz013

Yakama Nation Fisheries Program (YNFP). 2020. Southern Territories Habitat Strategy.

APPENDIX A - PRINCIPLES OF RIVERSCAPE HEALTH AND RESTORATION

RIVERSCAPE PRINCIPLES

1. **Streams need space.** Healthy streams are dynamic, regularly shifting position within their valley bottom, re-working and interacting with their floodplain. Allowing streams to adjust within their valley bottom is essential for maintaining functioning riverscapes.
2. **Structure forces complexity and builds resilience.** Structural elements, such as beaver dams and large woody debris, force changes in flow patterns that produce physically diverse habitats. Physically diverse habitats are more resilient to disturbances than simplified, homogeneous habitats.
3. **The importance of structure varies.** The relative importance and abundance of structural elements varies based on reach type, valley setting, flow regime and watershed context. Recognizing what type of stream you are dealing with (i.e., what other streams it is similar to) helps develop realistic expectations about what that stream should or could look (form) and behave (process) like.
4. **Inefficient conveyance of water is often healthy.** Hydrologic inefficiency is the hallmark of a healthy system. More diverse residence times for water can attenuate potentially damaging floods, fill up valley bottom sponges, and slowly release water, elevating baseflow and producing critical ecosystem services.

RESTORATION PRINCIPLES

5. **It's okay to be messy.** When structure is added back to streams, it is meant to mimic and promote the processes of wood accumulation and beaver dam activity. Structures are fed to the system like a meal and should resemble natural structures (log jams, beaver dams, fallen trees) in naturally 'messy' systems. Structures do not have to be perfectly built to yield desirable outcomes. Focus less on the form and more on the processes the structures will promote.
6. **There is strength in numbers.** A large number of smaller structures working in concert with each other can achieve much more than a few isolated, over-built, highly-secured structures. Using a lot of smaller structures provides redundancy and reduces the importance of any one structure. It generally takes many structures, designed in a complex (see Chapter 5: Shahverdian et al., 2019c), to promote the processes of wood accumulation and beaver dam activity that lead to the desired outcomes.
7. **Use natural building materials.** Natural materials should be used because structures are simply intended to initiate process recovery and go away over time. Locally sourced materials are preferable because they simplify logistics and keep costs down.
8. **Let the system do the work.** Giving the riverscape and/or beaver the tools (structure) to promote natural processes to heal itself with stream power and ecosystem engineering, as opposed to diesel power, promotes efficiency that allows restoration to scale to the scope of degradation.
9. **Defer decision making to the system.** Wherever possible, let the system make critical design decisions by simply providing the tools and space it needs to adjust. Deferring decision making to the system downplays the significance of uncertainty due to limited knowledge. For example, choosing a floodplain elevation to grade based on limited hydrology information can be a complex and uncertain endeavor, but deferring to the hydrology of that system to build its own floodplain grade reduces the importance of uncertainty due to limited knowledge.
10. **Self-sustaining systems are the solution.** Low-tech restoration actions in and of themselves are not the solution. Rather they are just intended to initiate processes and nudge the system towards the ultimate goal of building a resilient, self-sustaining riverscape.

APPENDIX B - PROJECT AREA PHOTOS



Figure 18. Aerial photos looking down (top photo) and up (bottom photo) valley illustrating valley bottom riparian and floodplain characteristics.



Figure 19. Aerial photos illustrating riparian, floodplain, and channel characteristics in the Swale Creek project area.

APPENDIX C - PREDICTED STREAMFLOW VALUES AND THEIR UTILITY

Table 6. Predicted streamflow intervals in the project area on lower Swale Creek.

Recurrence Interval (year)	Predicted Discharge (cfs)	Lower prediction interval (cfs)	Upper prediction interval (cfs)	Standard Error
2	1640	710	3790	52.5
5	3040	1350	6840	50.6
10	4230	1900	9430	50.5
25	5940	2610	13500	51.7
50	7380	3180	17100	52.9
100	8900	3760	21100	54.2
200	10500	4360	25300	55.5
500	13000	5200	32500	58

Characterizing streamflow characteristics is an important component of planning for LTPBR projects because it helps develop realistic expectations for what restoration may be able to achieve. It is not intended as an input for hydrologic modeling, or other computational exercises. Rather, it is meant to provide a more general background understanding of the magnitudes of flow experienced at the project area. For example, to make distinctions between project areas where 2-year peak flows are 30 cfs versus those where they are 300 cfs. Both sites may be appropriate for LTPBR, the question is one of which types of LTPBR strategies are most likely to be effective and how they relate to restoration objectives.

The values presented here are likely a relatively accurate representation of flows for Swale Creek (Yakama Nation staff, personal communication, 2021). Given the location of the watershed near the Columbia River Gorge, the hydrology is influenced by precipitation events that can move from the ocean to the eastern Gorge without much orographic obstruction, leading to some large snowfall events followed by rain. In addition, much of the watershed (especially in the lower watershed) is bedrock with limited infiltration capacity which contributes to higher peak flow events.

APPENDIX D - PALS AND BDA CONSTRUCTION METHODS, STRUCTURE TYPES, AND SCHEMATICS

This section outlines general construction methods, the different structure types, how different structure types should be used to promote specific hydraulic and geomorphic responses, and design schematics for Post-Assisted Log Structures (PALS) and Beaver Dam Analogs (BDA). More details can be found in Wheaton et al. 2019.

PALS CONSTRUCTION

POST-ASSISTED LOG STRUCTURES

HOW TO BUILD PALS

- 1** Decide location of PALS, configuration (e.g., orientation and type of PALS) as part of the design of a complex of structures (multiple structures working together).
- 2** Position larger logs on the base of the structure to make the general shape of structure.
- 3** Limb branches from one side of the logs so that much of the log comes in contact with the bed to increase interaction between the flow and the structure, even at low flows.
- 4** Pin large pieces in place with posts; drive posts at angles and downstream to help hold wood in place at high flows.
- 5** Add more logs, and pack and wedge smaller material to fill spaces in the structure.
- 6** Build up the structure to desired crest elevation, but crest elevation need not be uniform.



PALS STRUCTURE TYPES AND SCHEMATICS

BANK-ATTACHED PALS

VARIATION 1: TO FORCE A CONSTRICTION JET

- Creates convergent jet of flow between bank- or margin-attached structure and a resistant feature (e.g., bedrock bank, roots, wood) on opposite bank.
- Forces more variable hydraulics, which typically create a backwater eddy upstream of the structure, a large eddy in the wake of the structure, and divergent flow paths where the jet weakens.
- Promotes structurally-forced pool, riffle growth at the divergent jet, and eddy bar formation in the eddies. Upstream deposition stabilizes and grows the structures.
- Promotes further processes of wood accumulation.

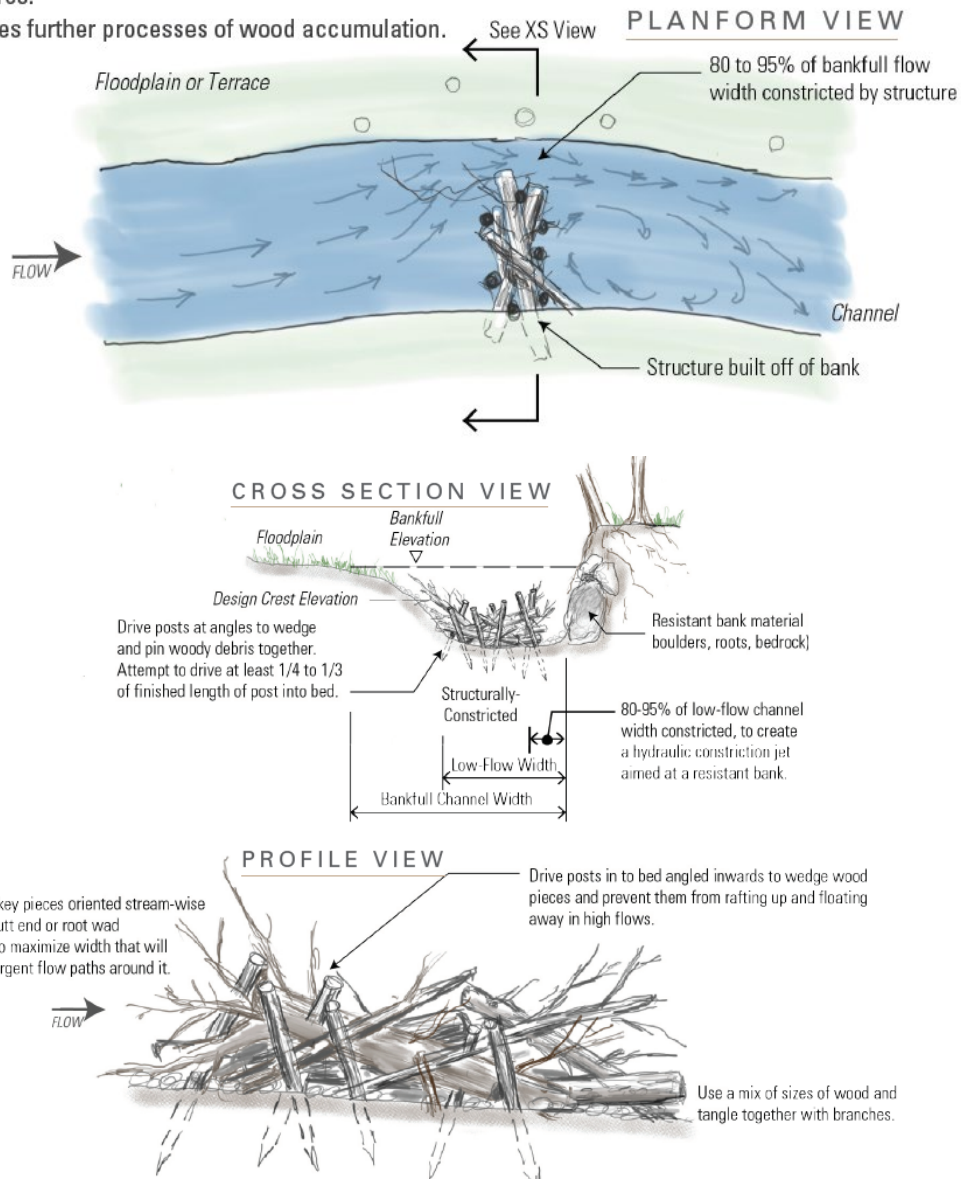


Figure 20. Typical schematic sketches of a bank-attached PALS intended to cause lateral channel migration through deposition of material on point and diagonal bars and erosion of high bank features. From Chapter 4 of Wheaton et al. (2019: <http://lowtechpbr.restoration.usu.edu>).

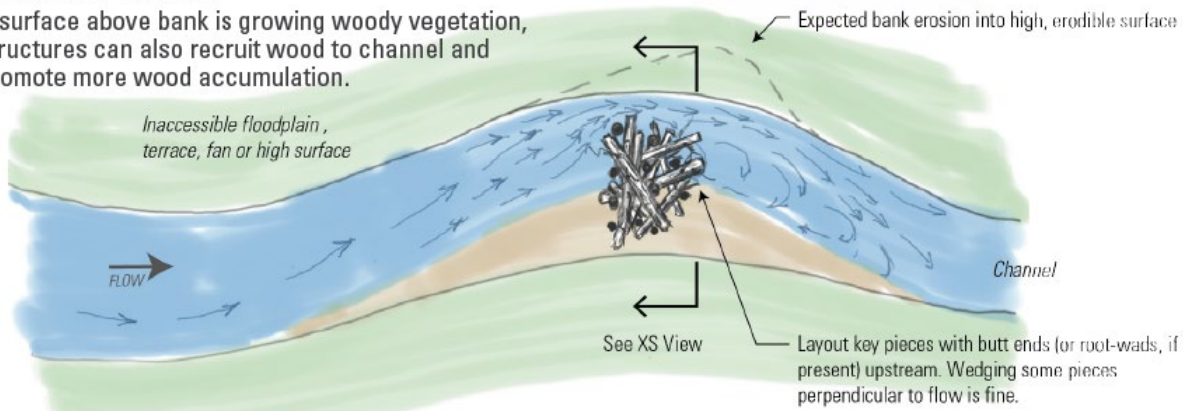
BANK-ATTACHED PALS:

VARIATION 2: BANK BLASTER

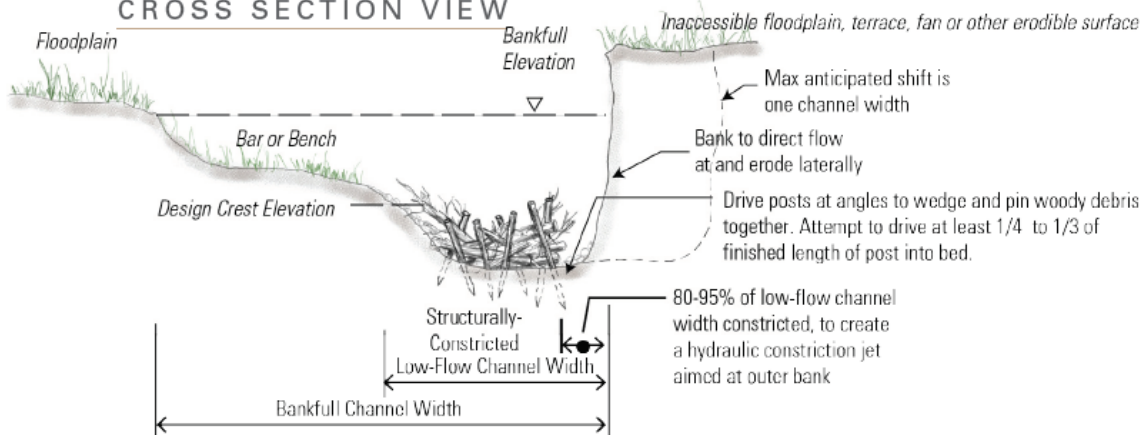
- Accelerates lateral widening via bank erosion of an erodible bank opposite of the structure.
- Shunting of flow forces more variable hydraulics, which typically create a backwater eddy upstream of the structure, an eddy downstream of structure, and temporary jet aimed at opposite erodible bank.
- Leads to lateral shift of channel (no more than one channel width typically). Further lateral migration occurs if bar growth continues on inside bend, further natural woody debris accumulates on structure, or subsequent treatment is extended off structure.
- If surface above bank is growing woody vegetation, structures can also recruit wood to channel and promote more wood accumulation.



PLANFORM VIEW

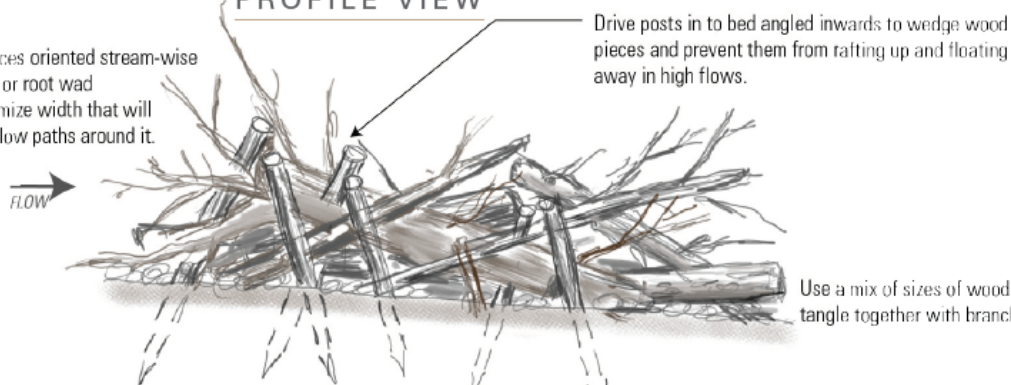


CROSS SECTION VIEW



PROFILE VIEW

Start with key pieces oriented stream-wise and face butt end or root wad upstream to maximize width that will create divergent flow paths around it.

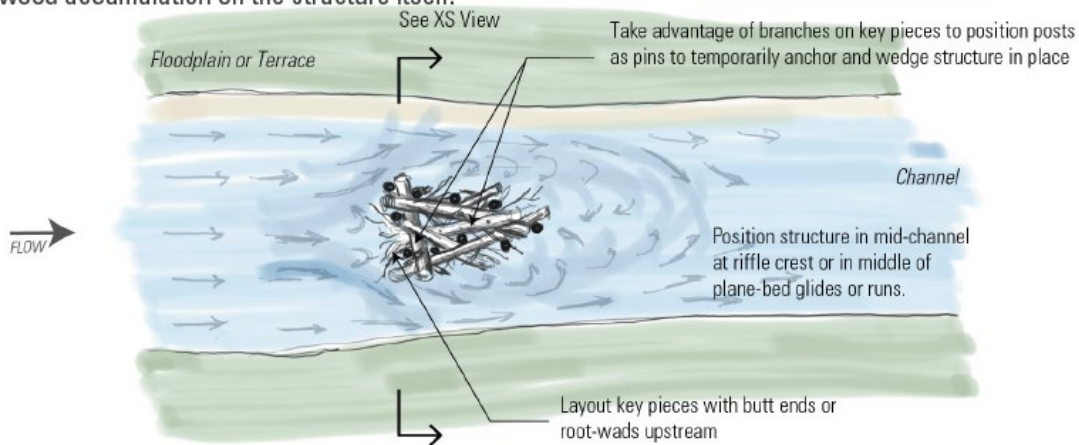


MID-CHANNEL PALS

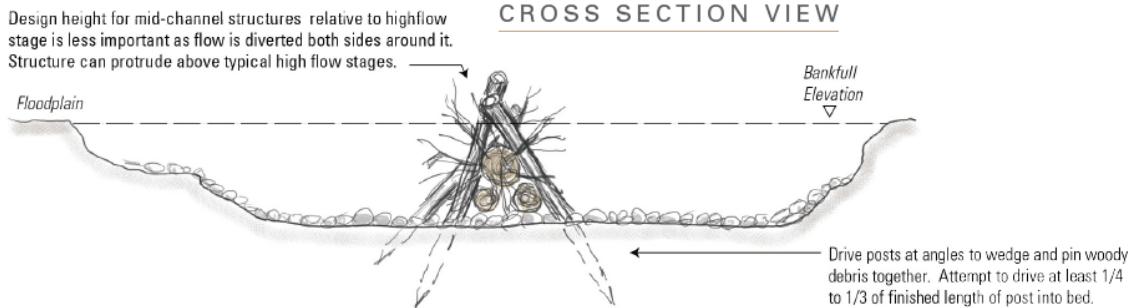
- Installed mid-channel to split flow around the structure.
- Forces more variable hydraulics, which creates an eddy downstream of structure.
- Can promote mid-channel bar development in place of planebed morphologies, encourage or promote diffluences, convert riffles into mid-channel bars and and/or to dissipate flow energy.
- In larger channels, multiple mid-channel PALS can be used in close proximity and are often more effective than a single large structure.
- In all cases, the mid-channel PALS can promote the process of wood accumulation on the structure itself.



PLANFORM VIEW



CROSS SECTION VIEW



PROFILE VIEW

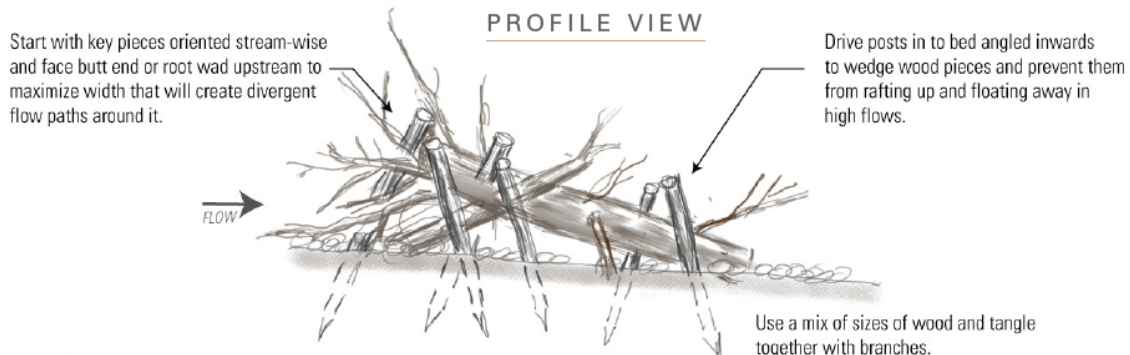


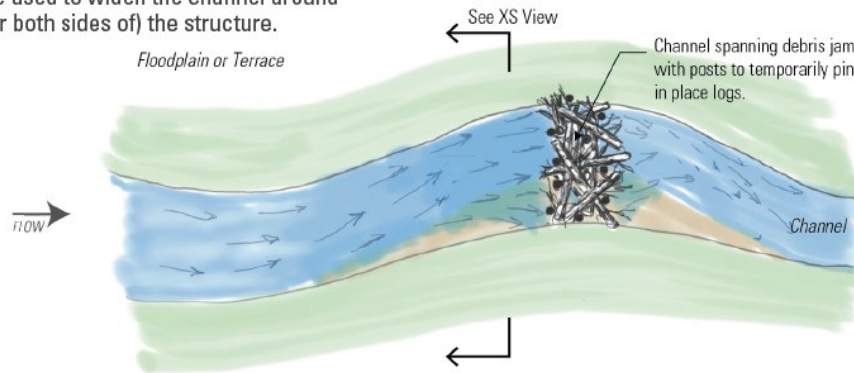
Figure 21. Typical schematics of a mid-channel PALS designed to induce channel complexity, encourage mid-channel deposition, and encourage channel avulsion. From Chapter 4 of Wheaton et al. (2019): <http://lowtechpbr.restoration.usu.edu>.

CHANNEL-SPANNING PALS

- Bank-attached on both sides, such that even at low-flow there is some hydraulic purchase across most of the channel, acting to back-water flow behind it. Unlike a beaver dam (with a uniform crest elevation), channel-spanning PALS can have a variable crest elevation and rougher finish, and are generally built with much greater porosity.
- Over time, increased water depth and decreased velocity upstream of PALS encourages more wood accumulation, organic accumulation and sediment deposition, all of which can act to stabilize the structure.
- If crest elevations are higher than adjacent floodplain(s), it can increase frequency of floodplain inundation, force new diffluences, and/or promote avulsions.
- Can be used to widen the channel around (one or both sides of) the structure.

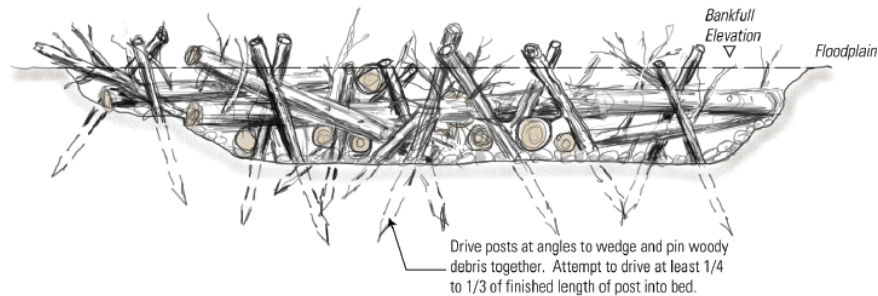


PLANFORM VIEW



Design height for channel-spanning structures is important. If it is intended Structure can protrude above typical high flow stages.

CROSS SECTION VIEW



PROFILE VIEW

Start with key pieces oriented stream-wise and face butt end or root wad upstream to maximize width that will create divergent flow paths around it.

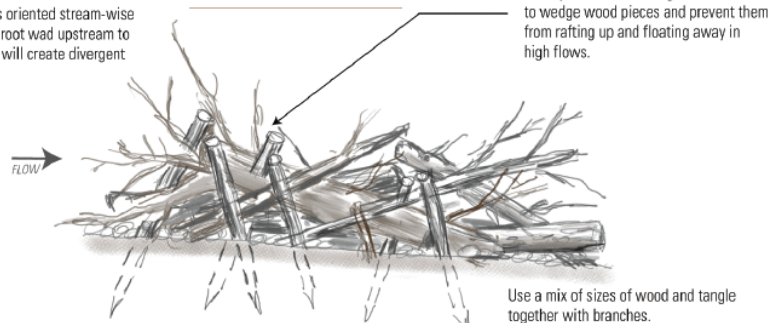


Figure 22. Typical schematics of a channel-spanning PALS. Channel spanning PALS are designed to be passable by fish at all flows. From Chapter 4 of Wheaton et al. (2019: <http://lowtechpbr.restoration.usu.edu>).



Figure 23. Example of PALS evolution over the course of one year promoting processes of wood accumulation. A and B show a mid-channel PALS becoming a bank-attached PALS, C and D show a bank-attached PALS becoming a debris jam, and E and F show a bank-attached PALS becoming a mid-channel PALS. The geomorphic changes imposed by the presence of the PALS in each example shows clear alterations to the channel bed and hydraulics. From Chapter 4 of Wheaton et al. (2019: <http://lowtechpbr.restoration.usu.edu>).

BDA CONSTRUCTION

HOW TO BUILD BDAs

- 1** Decide location of BDA dam crest orientation, configuration (e.g., straight or convex downstream), and crest elevation (use landscape flags if necessary). Position yourself with your eye-level at the proposed crest elevation of the dam (make sure it is < 5' in height). Look upstream to find where the pond will backwater to. Adjust crest elevation as necessary to achieve desired size of pond, inundation extent, and overflow patterns. If concerned about head drop (water surface elevation difference) over BDA, build a secondary BDA downstream with a crest elevation set to backwater into base of this BDA (and lessen head drop or elevation difference between water surface in pond and water surface downstream of BDA).
- 2** Build up first layer or course by widening base upstream and downstream of crest to flat height of 6 to 12" above existing water surface, and make sure it holds back water.
 - a.** If larger key pieces (i.e., larger logs, cobble or small boulders) are locally abundant, these can be used to lay out the crest position across the channel. Optionally, they can be 'keyed' in by excavating a small trench (no need to be deeper than ~1/3 of the height of key piece diameter) and place key pieces in and pack with excavated material.
 - b.** Lay out first layer of larger fill material, being careful not to go to higher than 6" to 12" above existing water surface. The first layer should be just high enough to backwater a flat water surface behind it.
 - c.** Using mud, bed material & turf (typically sourced from backwater area of pond) as fine fill material to plug up leaks, combine with sticks and branches of various sizes to build a wide base. Make sure base is wide enough to accommodate anticipated dam height (most dams will have a 1.5:1 to 3:1 (horizontal : vertical) proportions).
 - d.** Build up first layer only to top of key pieces from first layer. Make sure the crest is level across the channel and water is pooling to this temporary crest elevation.
- 3** Build up subsequent layer(s) in 6" to 12" lifts, packing well with fine fill material until ponding water to its next temporary crest elevation.
 - > Repeat step 3 as many times as necessary to build up to design crest elevation.
 - > Work a overflow mattress (laying branches parallel to flow) into dam on downstream side and build to provide energy dissipation to overtopping flows.
 - > If desired, and time permits, attempt to plug up BDA with mud and organic material (small sticks and turf) to flood pond to crest elevation. Optionally, you can leave this for maintenance by beaver or for infilling with leaves, woody debris and sediment.



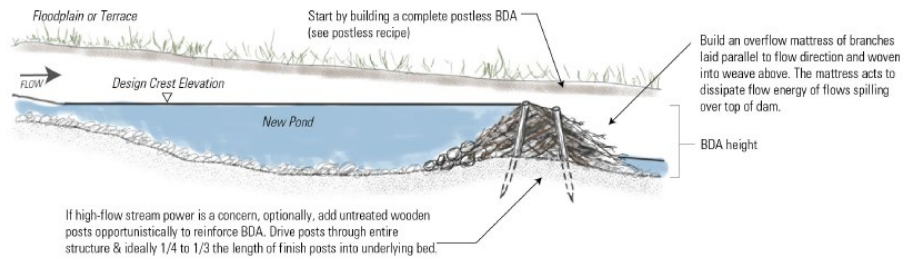
BDA STRUCTURE TYPES AND SCHEMATICS

POST-ASSISTED BDA

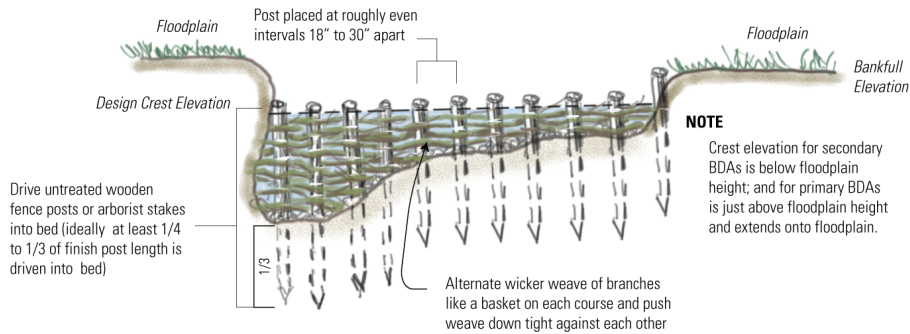
- Posts can provide some temporary anchoring and stability to help with initial dam stability during high flows in systems with flashier flow regimes or that produce larger magnitude floods.
- For situations where additional support during high flows is deemed necessary, our suggested practice is to start out following the instructions to build a postless BDA, and then simply add posts as extra reinforcement after the fact.



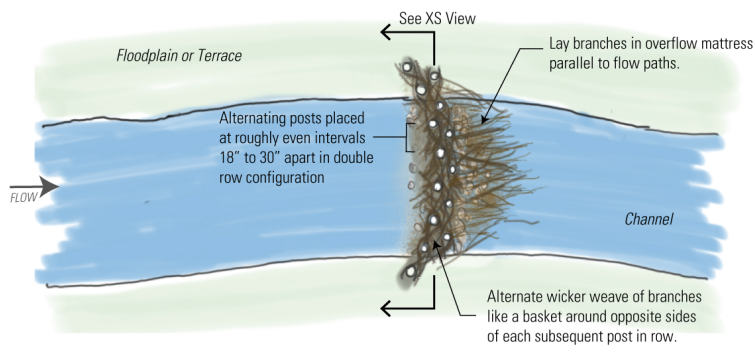
PROFILE VIEW WITH POSTS



X-SECTION VIEW



PLANFORM VIEW



NOT-TO-SCALE

Figure 24. Profile schematic of post-assisted BDA. Given the potential flashy hydrograph within Tenmile Creek, BDAs will primarily be reinforced with posts. From Chapter 4 of Wheaton et al. (2019: <http://lowtechpbr.restoration.usu.edu>).

APPENDIX E - COMPLEX OBJECTIVES

Table 7. Description of general process-based complex objectives and intended physical and biological responses.

Complex Objective	Function Overview	Physical Response	Biological Response
Force overbank Flow (Channel-Floodplain Connectivity)	Addition of structural elements to increase the frequency, duration, and extent of overbank flows.	Creation of multi-threaded channels as a result of headcut progression across floodplain. Newly formed channels may also serve to recruit existing woody vegetation material as new roughness elements.	Creation of off-channel juvenile salmonid rearing habitat. Increase connection of flow to the valley bottom also allows expansion of riparian vegetation communities.
Increase Geomorphic Diversity	Structural elements to promote complex patterns of erosion and deposition leading to heterogeneity in geomorphic form and geomorphic units (i.e., pools and bars).	Creation of a patchwork of geomorphic units that includes scour pools accompanied by the formation of bars.	Provides more diverse habitat for utilization by salmonids including pools for rearing and bars for spawning.

APPENDIX F - ADAPTIVE MANAGEMENT FRAMEWORK

1. & 2. Introduction and Responsible Parties Involved

The following monitoring and adaptive management plan will be used by the Yakama Nation to assess the effectiveness of LTPBR and guide the implementation of future implementation and maintenance. Monitoring will take place at intervals after project implementation and complement ongoing monitoring efforts in the subbasin.

3. Assessment Protocols			4. Adaptive Management Triggers	
Assessment Element	Performance Question	Monitoring Method	AM Trigger(s)	Potential AM Actions
Complex Function	Is the Complex promoting desired responses?	Assessment of complex function.	The complex is not contributing to improved riverscape processes (e.g., sediment sorting and transport, channel development, water routing, vegetation establishment/growth, etc.).	Improve existing structures (e.g., add wood, add posts) or build new structures to achieve desired response.
Structure Integrity & Function	Is the structure intact and achieving desired responses?	Assessment of structure function.	a) The structure is not intact and achieving the desired process OR promoting another desired process. b) The structure needs modification in order to continue achieving or improving process based benefits?	Improve/extend structure (e.g., add wood), relocate structure, or modify function by installing adjacent structures to produce a beneficial function.
Risk to Infrastructure	Are structures causing a risk to infrastructure?	Assessment of damage or potential damage to infrastructure.	The structure is causing harm to or at risk of causing harm to infrastructure?	Remove or modify structure to stop or avoid damage to infrastructure.
Risk to Riverscape Function	Are complexes and structures creating a risk to riverscape or ecological function?	Assessment of damage to riverscape and ecological processes.	The structure is causing harm to riverscape or ecological function?	Remove or modify the structure to mimic or promote desired process.
Risk to Fish Passage	Are structures inhibiting fish passage?	Assessment of fish passage.	The structure is preventing the upstream passage of fish during seasons of migration.	Remove or modify the structure to allow for passage.
Restoration Indicators	What is the current status of restoration indicators?	Remote or field-based surveys.	Target metrics for select indicators are not met.	Use assessment elements to determine factors inhibiting success and recommended AM actions.

5. Assessment Frequency, Timing, and Duration

a) Baseline Pre-Project Survey: refer to design report for current conditions.

b) As-built Survey: an as-built survey will be completed after initial implementation.

c) Site Layout Photo Documentation and Visual Inspection: Photos will be taken for documentation and during visual inspections post implementation.

d) Fish Passage Qualitative Narrative: Project area will be monitored to ensure that project actions do not negatively impact fish passage.

6 & 7. Data Storage and Quality Assurance Plan

All photos and survey data collected will be stored by the Yakama Nation and their contractor(s). The Yakama Nation and contractor(s) will be responsible for insuring that the design and monitoring plan is followed.

APPENDIX G - HIP GENERAL CONSERVATION AND IMPLEMENTATION MEASURES

<p>HIP 3 GENERAL AQUATIC CONSERVATION MEASURES APPLICABLE TO ALL ACTIONS</p> <p>THE ACTIVITIES COVERED UNDER THE HIP III ARE INTENDED TO PROTECT AND RESTORE FISH AND WILDLIFE HABITAT WITH LONG-TERM BENEFITS TO ESA-LISTED SPECIES. TO MINIMIZE THESE SHORT-TERM ADVERSE EFFECTS AND MAKE THEM PREDICTABLE FOR THE PURPOSES OF PROGRAMMATIC ANALYSIS, BPA WILL INCLUDE IN ALL PROJECTS IMPLEMENTED UNDER THIS HIP III PROPOSED ACTION THE FOLLOWING GENERAL CONSERVATION MEASURES (DEVELOPED IN COORDINATION WITH USFWS AND NMFS).</p> <p>PROJECT DESIGN AND SITE PREPARATION.</p> <p>1) STATE AND FEDERAL PERMITS. ALL APPLICABLE REGULATORY PERMITS AND OFFICIAL PROJECT AUTHORIZATIONS WILL BE OBTAINED BEFORE PROJECT IMPLEMENTATION. THESE PERMITS AND AUTHORIZATIONS INCLUDE, BUT ARE NOT LIMITED TO, NATIONAL ENVIRONMENTAL POLICY ACT, NATIONAL HISTORIC PRESERVATION ACT, AND THE APPROPRIATE STATE AGENCY REMOVAL AND FILL PERMIT, USACE CLEAN WATER ACT (CWA) 404 PERMITS, AND CWA SECTION 401 WATER QUALITY CERTIFICATIONS.</p> <p>2) TIMING OF IN-WATER WORK. APPROPRIATE STATE (OREGON DEPARTMENT OF FISH AND WILDLIFE (ODFW), WASHINGTON DEPARTMENT OF FISH AND WILDLIFE (WDFW), IDAHO DEPARTMENT OF FISH AND GAME (IDFG), AND MONTANA FISH WILDLIFE AND PARKS (MFWP)) GUIDELINES FOR TIMING OF IN-WATER WORK WINDOWS WILL BE FOLLOWED.</p> <p>A) BULL TROUT - WHILE UTILIZING THE APPROPRIATE STATE DESIGNATED IN-WATER WORK PERIOD WILL LESSEN THE RISK TO BULL TROUT, THIS ALONE MAY NOT BE SUFFICIENT TO ADEQUATELY PROTECT LOCAL BULL TROUT POPULATIONS. THIS IS ESPECIALLY TRUE IF WORK IS OCCURRING IN SPAWNING AND REARING AREAS BECAUSE EGGS, ALEVIN, AND FRY ARE IN THE SUBSTRATE OR CLOSELY ASSOCIATED HABITATS NEARLY YEAR ROUND. SOME AREAS MAY NOT HAVE DESIGNATED IN-WATER WORK WINDOWS FOR BULL TROUT OR IF THEY DO, THEY MAY CONFLICT WITH WORK WINDOWS FOR SALMON AND STEELHEAD. IF THIS IS THE CASE, OR IF PROPOSED WORK IS TO OCCUR WITHIN BULL TROUT SPAWNING AND REARING HABITATS, PROJECT PROponents WILL CONTACT THE APPROPRIATE USFWS FIELD OFFICE TO INSURE THAT ALL REASONABLE IMPLEMENTATION MEASURES ARE CONSIDERED AND AN APPROPRIATE IN-WATER WORK WINDOW IS BEING USED TO MINIMIZE PROJECT EFFECTS.</p> <p>B) LAMPREY - THE PROJECT SPONSOR AND/OR THEIR CONTRACTORS WILL AVOID WORKING IN STREAM OR RIVER CHANNELS THAT CONTAIN PACIFIC LAMPREY FROM MARCH 1 TO JULY 1 IN LOW TO MID ELEVATION REACHES (<5,000 FEET), IN HIGH ELEVATION REACHES (>5,000 FEET), THE PROJECT SPONSOR WILL AVOID WORKING IN STREAM OR RIVER CHANNELS FROM MARCH 1 TO AUGUST 1. IF EITHER TIMEFRAME IS INCOMPATIBLE WITH OTHER OBJECTIVES, THE AREA WILL BE SURVEILLED FOR NESTS AND LAMPREY PRESENCE, AND AVOIDED IF POSSIBLE. IF LAMPREYS ARE KNOWN TO EXIST, THE PROJECT SPONSOR WILL UTILIZE DEWATERING AND SALVAGE PROCEDURES OUTLINED IN US FISH AND WILDLIFE SERVICE BEST MANAGEMENT PRACTICES TO MINIMIZE ADVERSE EFFECTS TO PACIFIC LAMPREY (2010).</p> <p>C) EXCEPTIONS TO ODFW, WDFW, MFWP, OR IDFG IN-WATER WORK WINDOWS WILL BE REQUESTED THROUGH THE VARIANCE PROCESS (PAGE 2).</p> <p>3) CONTAMINANTS. THE PROJECT SPONSOR WILL COMPLETE A SITE ASSESSMENT WITH THE FOLLOWING ELEMENTS TO IDENTIFY THE TYPE, QUANTITY, AND EXTENT OF ANY POTENTIAL CONTAMINATION FOR ANY ACTION THAT INVOLVES EXCAVATION OF MORE THAN 20 CUBIC YARDS OF MATERIAL:</p> <p>A) A REVIEW OF AVAILABLE RECORDS, SUCH AS FORMER SITE USE, BUILDING PLANS, AND RECORDS OF ANY PRIOR CONTAMINATION EVENTS;</p> <p>B) A SITE VISIT TO INSPECT THE AREAS USED FOR VARIOUS INDUSTRIAL PROCESSES AND THE CONDITION OF THE PROPERTY;</p> <p>C) INTERVIEWS WITH KNOWLEDGEABLE PEOPLE, SUCH AS SITE OWNERS, OPERATORS, AND OCCUPANTS, NEIGHBORS, OR LOCAL GOVERNMENT OFFICIALS; AND</p> <p>D) A SUMMARY, STORED WITH THE PROJECT FILE THAT INCLUDES AN ASSESSMENT OF THE LIKELIHOOD THAT CONTAMINANTS ARE PRESENT AT THE SITE, BASED ON ITEMS 4(A) THROUGH 4(C).</p> <p>4) SITE LAYOUT AND FLAGGING, PRIOR TO CONSTRUCTION. THE ACTION AREA WILL BE CLEARLY FLAGGED TO IDENTIFY THE FOLLOWING:</p> <p>A) SENSITIVE RESOURCE AREAS, SUCH AS AREAS BELOW ORDINARY HIGH WATER, SPAWNING AREAS, SPRINGS, AND WETLANDS;</p> <p>B) EQUIPMENT ENTRY AND EXIT POINTS;</p> <p>C) ROAD AND STREAM CROSSING ALIGNMENTS;</p> <p>D) STAGING, STORAGE, AND STOCKPILE AREAS; AND</p> <p>E) NO-SPRAY AREAS AND BUFFERS.</p> <p>5) TEMPORARY ACCESS ROADS AND PATHS.</p> <p>A) EXISTING ACCESS ROADS AND PATHS WILL BE PREFERENTIALLY USED WHENEVER REASONABLE, AND THE NUMBER AND LENGTH OF TEMPORARY ACCESS ROADS AND PATHS THROUGH RIPARIAN AREAS AND FLOODPLAINS WILL BE MINIMIZED TO LESSEN SOIL DISTURBANCE AND COMPACTION, AND IMPACTS TO VEGETATION.</p> <p>B) TEMPORARY ACCESS ROADS AND PATHS WILL NOT BE BUILT ON SLOPES WHERE GRADE, SOIL, OR OTHER FEATURES SUGGEST A LIKELIHOOD OF EXCESSIVE EROSION OR FAILURE, IF SLOPES ARE STEEPER THAN 30%. THEN THE ROAD WILL BE DESIGNED BY A CIVIL ENGINEER WITH EXPERIENCE IN STEEP ROAD DESIGN.</p> <p>C) THE REMOVAL OF RIPARIAN VEGETATION DURING CONSTRUCTION OF TEMPORARY ACCESS ROADS WILL BE MINIMIZED, WHEN TEMPORARY VEGETATION REMOVAL IS REQUIRED, VEGETATION WILL BE CUT AT GROUND LEVEL (NOT GRUBBED).</p>	<p>D) AT PROJECT COMPLETION, ALL TEMPORARY ACCESS ROADS AND PATHS WILL BE OBLITERATED, AND THE SOIL WILL BE STABILIZED AND REVEGETATED, ROAD AND PATH OBLITERATION REFERS TO THE MOST COMPREHENSIVE DEGREE OF DECOMMISSIONING AND INVOLVES DECOMPACTING THE SURFACE AND DITCH, PULLING THE FILL MATERIAL ONTO THE RUNNING SURFACE, AND RESHAPING TO MATCH THE ORIGINAL CONTOUR.</p> <p>E) TEMPORARY ROADS AND PATHS IN WET AREAS OR AREAS PRONE TO FLOODING WILL BE OBLITERATED BY THE END OF THE IN-WATER WORK WINDOW.</p> <p>6) TEMPORARY STREAM CROSSINGS.</p> <p>A) EXISTING STREAM CROSSINGS WILL BE PREFERENTIALLY USED WHENEVER REASONABLE, AND THE NUMBER OF TEMPORARY STREAM CROSSINGS WILL BE MINIMIZED.</p> <p>B) TEMPORARY BRIDGES AND CULVERTS WILL BE INSTALLED TO ALLOW FOR EQUIPMENT AND VEHICLE CROSSING OVER PERENNIAL STREAMS DURING CONSTRUCTION. TREATED WOOD SHALL NOT BE USED ON TEMPORARY BRIDGE CROSSINGS OR IN LOCATIONS IN CONTACT WITH OR OVER WATER.</p> <p>C) EQUIPMENT AND VEHICLES WILL CROSS THE STREAM IN THE WET ONLY WHERE:</p> <p>I. THE STREAMBED IS BEDROCK OR</p> <p>II. MATS OR OFF-SITE LOGS ARE PLACED IN THE STREAM AND USED AS A CROSSING.</p> <p>D) VEHICLES AND MACHINERY WILL CROSS STREAMS AT RIGHT ANGLES TO THE MAIN CHANNEL WHEREVER POSSIBLE.</p> <p>E) THE LOCATION OF THE TEMPORARY CROSSING WILL AVOID AREAS THAT MAY INCREASE THE RISK OF CHANNEL RE-ROUTING OR AVULSION.</p> <p>F) POTENTIAL SPAWNING HABITAT (I.E., POOL TAIL-OUTS) AND POOLS WILL BE AVOIDED TO THE MAXIMUM EXTENT POSSIBLE.</p> <p>G) NO STREAM CROSSINGS WILL OCCUR AT ACTIVE SPAWNING SITES, WHEN HOLDING ADULT LISTED FISH ARE PRESENT OR WHEN EGGS OR ALEVINS ARE IN THE GRAVEL, THE APPROPRIATE STATE FISH AND WILDLIFE AGENCY WILL BE CONTACTED FOR SPECIFIC TIMING INFORMATION.</p> <p>H) AFTER PROJECT COMPLETION, TEMPORARY STREAM CROSSINGS WILL BE OBLITERATED AND THE STREAM CHANNEL, AND BANKS RESTORED.</p> <p>7) STAGING, STORAGE, AND STOCKPILE AREAS.</p> <p>A) STAGING AREAS (USED FOR CONSTRUCTION EQUIPMENT STORAGE, VEHICLE STORAGE, FUELING, SERVICING, AND HAZARDOUS MATERIAL STORAGE) WILL BE 150 FEET OR MORE FROM ANY NATURAL WATER BODY OR WETLAND, OR ON AN ADJACENT, ESTABLISHED ROAD AREA IN A LOCATION AND MANNER THAT WILL PRECLUDE EROSION INTO OR CONTAMINATION OF THE STREAM OR FLOODPLAIN.</p> <p>B) NATURAL MATERIALS USED FOR IMPLEMENTATION OF AQUATIC RESTORATION, SUCH AS LARGE WOOD, GRAVEL, AND BOULDERS, MAY BE STAGED WITHIN THE 100-YEAR FLOODPLAIN.</p> <p>C) ANY LARGE WOOD, TOPSOIL, AND NATIVE CHANNEL MATERIAL DISPLACED BY CONSTRUCTION WILL BE STOCKPILED FOR USE DURING SITE RESTORATION AT A SPECIFICALLY IDENTIFIED AND FLAGGED AREA.</p> <p>D) ANY MATERIAL NOT USED IN RESTORATION, AND NOT NATIVE TO THE FLOODPLAIN, WILL BE REMOVED TO A LOCATION OUTSIDE OF THE 100-YEAR FLOODPLAIN FOR DISPOSAL.</p> <p>8) EQUIPMENT. MECHANIZED EQUIPMENT AND VEHICLES WILL BE SELECTED, OPERATED, AND MAINTAINED IN A MANNER THAT MINIMIZES ADVERSE EFFECTS ON THE ENVIRONMENT (E.G., MINIMALLY-SIZED, LOW PRESSURE TIRES; MINIMAL HARD-TURN PATHS FOR TRACKED VEHICLES; TEMPORARY MATS OR PLATES WITHIN WET AREAS OR ON SENSITIVE SOILS), ALL VEHICLES AND OTHER MECHANIZED EQUIPMENT WILL BE:</p> <p>A) STORED, FUELED, AND MAINTAINED IN A VEHICLE STAGING AREA PLACED 150 FEET OR MORE FROM ANY NATURAL WATER BODY OR WETLAND OR ON AN ADJACENT, ESTABLISHED ROAD AREA;</p> <p>B) REFUELED IN A VEHICLE STAGING AREA PLACED 150 FEET OR MORE FROM A NATURAL WATERBODY OR WETLAND, OR IN AN ISOLATED HARD ZONE, SUCH AS A PAVED PARKING LOT OR ADJACENT, ESTABLISHED ROAD (THIS MEASURE APPLIES ONLY TO GAS-POWERED EQUIPMENT WITH TANKS LARGER THAN 5 GALLONS);</p> <p>C) BIODEGRADABLE LUBRICANTS AND FLUIDS SHALL BE USED ON EQUIPMENT OPERATING IN AND ADJACENT TO THE STREAM CHANNEL AND LIVE WATER.</p> <p>D) INSPECTED DAILY FOR FLUID LEAKS BEFORE LEAVING THE VEHICLE STAGING AREA FOR OPERATION WITHIN 150 FEET OF ANY NATURAL WATER BODY OR WETLAND; AND</p> <p>E) THOROUGHLY CLEANED BEFORE OPERATION BELOW ORDINARY HIGH WATER, AND AS OFTEN AS NECESSARY DURING OPERATION, TO REMAIN GREASE FREE.</p> <p>9) EROSION CONTROL. EROSION CONTROL MEASURES WILL BE PREPARED AND CARRIED OUT, COMMENSURATE IN SCOPE WITH THE ACTION, THAT MAY INCLUDE THE FOLLOWING:</p> <p>A) TEMPORARY EROSION CONTROLS.</p> <p>I. TEMPORARY EROSION CONTROLS WILL BE IN PLACE BEFORE ANY SIGNIFICANT ALTERATION OF THE ACTION SITE AND APPROPRIATELY INSTALLED DOWNSTREAM OF PROJECT ACTIVITY WITHIN THE RIPARIAN BUFFER AREA UNTIL SITE REHABILITATION IS COMPLETE.</p> <p>II. IF THERE IS A POTENTIAL FOR ERODED SEDIMENT TO ENTER THE STREAM, SEDIMENT BARRIERS WILL BE INSTALLED AND MAINTAINED FOR THE DURATION OF PROJECT IMPLEMENTATION.</p> <p>III. TEMPORARY EROSION CONTROL MEASURES MAY INCLUDE FIBER WATTLES, SILT FENCES, LITE MATTING, WOOD FIBER MULCH AND SOIL BINDER, OR GEOTEXTILES AND GEOSYNTHETIC FABRIC.</p>	<p>IV. SOIL STABILIZATION UTILIZING WOOD FIBER MULCH AND TACKIFIER (HYDRO-APPLIED) MAY BE USED TO REDUCE EROSION OF BARE SOIL IF THE MATERIALS ARE NOXIOUS WEED FREE AND NONTOXIC TO AQUATIC AND TERRESTRIAL ANIMALS, SOIL MICROORGANISMS, AND VEGETATION.</p> <p>V. SEDIMENT WILL BE REMOVED FROM EROSION CONTROLS ONCE IT HAS REACHED 1/3 OF THE EXPOSED HEIGHT OF THE CONTROL.</p> <p>VI. ONCE THE SITE IS STABILIZED AFTER CONSTRUCTION, TEMPORARY EROSION CONTROL MEASURES WILL BE REMOVED.</p> <p>B) EMERGENCY EROSION CONTROL. THE FOLLOWING MATERIALS FOR EMERGENCY EROSION CONTROL WILL BE AVAILABLE AT THE WORK SITE:</p> <p>I. A SUPPLY OF SEDIMENT CONTROL MATERIALS; AND</p> <p>II. AN OIL-ABSORBING FLOATING BOOM WHENEVER SURFACE WATER IS PRESENT.</p> <p>10) DUST ABATEMENT. THE PROJECT SPONSOR WILL DETERMINE THE APPROPRIATE DUST CONTROL MEASURES BY CONSIDERING SOIL TYPE, EQUIPMENT USAGE, PREVAILING WIND DIRECTION, AND THE EFFECTS CAUSED BY OTHER EROSION AND SEDIMENT CONTROL MEASURES. IN ADDITION, THE FOLLOWING CRITERIA WILL BE FOLLOWED:</p> <p>A) WORK WILL BE SEQUENCED AND SCHEDULED TO REDUCE EXPOSED BARE SOIL, SUBJECT TO WIND EROSION.</p> <p>B) DUST-ABATEMENT ADDITIVES AND STABILIZATION CHEMICALS (TYPICALLY MAGNESIUM CHLORIDE, CALCIUM CHLORIDE SALTS, OR LIGNINSULFONATE) WILL NOT BE APPLIED WITHIN 25 FEET OF WATER OR A STREAM CHANNEL AND WILL BE APPLIED SO AS TO MINIMIZE THE LIKELIHOOD THAT THEY WILL ENTER STREAMS. APPLICATIONS OF LIGNINSULFONATE WILL BE LIMITED TO A MAXIMUM RATE OF 0.5 GALLONS PER SQUARE YARD OF ROAD SURFACE, ASSUMING A 50:50 (LIGNINSULFONATE TO WATER) SOLUTION.</p> <p>C) APPLICATION OF DUST ABATEMENT CHEMICALS WILL BE AVOIDED DURING OR JUST BEFORE WET WEATHER, AND AT STREAM CROSSINGS OR OTHER AREAS THAT COULD RESULT IN UNFILTERED DELIVERY OF THE DUST ABATEMENT MATERIALS TO A WATERBODY (TYPICALLY THESE WOULD BE AREAS WITHIN 25 FEET OF A WATERBODY OR STREAM CHANNEL; DISTANCES MAY BE GREATER WHERE VEGETATION IS SPARSE OR SLOPES ARE STEEP).</p> <p>D) SPILL CONTAINMENT EQUIPMENT WILL BE AVAILABLE DURING APPLICATION OF DUST ABATEMENT CHEMICALS.</p> <p>E) PETROLEUM-BASED PRODUCTS WILL NOT BE USED FOR DUST ABATEMENT.</p> <p>11) SPILL PREVENTION, CONTROL, AND COUNTER MEASURES. THE USE OF MECHANIZED MACHINERY INCREASES THE RISK FOR ACCIDENTAL SPILLS OF FUEL, LUBRICANTS, HYDRAULIC FLUID, OR OTHER CONTAMINANTS INTO THE RIPARIAN ZONE OR DIRECTLY INTO THE WATER. ADDITIONALLY, UNCURED CONCRETE AND FORM MATERIALS ADJACENT TO THE ACTIVE STREAM CHANNEL MAY RESULT IN ACCIDENTAL DISCHARGE INTO THE WATER, THESE CONTAMINANTS CAN DEGRADE HABITAT, AND INJURE OR KILL AQUATIC FOOD ORGANISMS AND ESA-LISTED SPECIES. THE PROJECT SPONSOR WILL ADHERE TO THE FOLLOWING MEASURES:</p> <p>A) A DESCRIPTION OF HAZARDOUS MATERIALS THAT WILL BE USED, INCLUDING INVENTORY, STORAGE, AND HANDLING PROCEDURES WILL BE AVAILABLE ON-SITE.</p> <p>B) WRITTEN PROCEDURES FOR NOTIFYING ENVIRONMENTAL RESPONSE AGENCIES WILL BE POSTED AT THE WORK SITE.</p> <p>C) SPILL CONTAINMENT KITS (INCLUDING INSTRUCTIONS FOR CLEANUP AND DISPOSAL) ADEQUATE FOR THE TYPES AND QUANTITY OF HAZARDOUS MATERIALS USED AT THE SITE WILL BE AVAILABLE AT THE WORK SITE.</p> <p>D) WORKERS WILL BE TRAINED IN SPILL CONTAINMENT PROCEDURES AND WILL BE INFORMED OF THE LOCATION OF SPILL CONTAINMENT KITS.</p> <p>E) ANY WASTE LIQUIDS GENERATED AT THE STAGING AREAS WILL BE TEMPORARILY STORED UNDER AN IMPERVIOUS COVER, SUCH AS A TARPULIN, UNTIL THEY CAN BE PROPERLY TRANSPORTED TO AND DISPOSED OF AT A FACILITY THAT IS APPROVED FOR RECEIPT OF HAZARDOUS MATERIALS.</p> <p>12) INVASIVE SPECIES CONTROL. THE FOLLOWING MEASURES WILL BE FOLLOWED TO AVOID INTRODUCTION OF INVASIVE PLANTS AND NOXIOUS WEEDS INTO PROJECT AREAS:</p> <p>A) PRIOR TO ENTERING THE SITE, ALL VEHICLES AND EQUIPMENT WILL BE POWER WASHED, ALLOWED TO FULLY DRY, AND INSPECTED TO MAKE SURE NO PLANTS, SOIL, OR OTHER ORGANIC MATERIAL ADHERES TO THE SURFACE.</p> <p>B) WATERCRAFT, WADERS, BOOTS, AND ANY OTHER GEAR TO BE USED IN OR NEAR WATER WILL BE INSPECTED FOR AQUATIC INVASIVE SPECIES.</p> <p>C) WADING BOOTS WITH FELT SOLES ARE NOT TO BE USED DUE TO THEIR PROPENSITY FOR AIDING IN THE TRANSFER OF INVASIVE SPECIES.</p>	<p>Designed: _____ Date: April 18, 2016</p> <p>Drawn: S. B. B. Date: _____</p> <p>Checked: X</p> <p>Approved: _____</p> <p>Title: _____</p> <p>HIP III GENERAL CONSERVATION & IMPLEMENTATION MEASURES</p> <p>Bozelle Power Administration, Environment, Fish and Wildlife</p> <p>File Name: HIP III GCA</p> <p>Drawing No: 7</p> <p>Sheet 1 of 1</p>
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WORK AREA ISOLATION & FISH SALVAGE.

ANY WORK AREA WITHIN THE WETTED CHANNEL WILL BE ISOLATED FROM THE ACTIVE STREAM WHENEVER ESTABLISHED FISH ARE REASONABLY CERTAIN TO BE PRESENT, OR IF THE WORK AREA IS LESS THAN 300 FEET UPSTREAM FROM KNOWN SPAWNING HABITATS. WHEN WORK AREA ISOLATION IS REQUIRED, DESIGN PLANS WILL INCLUDE ALL ISOLATION ELEMENTS, FISH RELEASE AREAS, AND, WHEN A PUMP IS USED TO DEWATER THE ISOLATION AREA AND FISH ARE PRESENT, A FISH SCREEN THAT MEETS NMFS'S FISH SCREEN CRITERIA (NMFS 2011, OR MOST CURRENT), WORK AREA ISOLATION AND FISH CAPTURE ACTIVITIES WILL OCCUR DURING PERIODS OF THE COOLEST AIR AND WATER TEMPERATURES POSSIBLE, NORMALLY EARLY IN THE MORNING VERSUS LATE IN THE DAY, AND DURING CONDITIONS APPROPRIATE TO MINIMIZE STRESS AND DEATH OF SPECIES PRESENT.

- NATIONAL MARINE FISHERIES SERVICE, 2011, ANADROMOUS SALMONID PASSAGE FACILITY DESIGN, NORTHWEST REGION, AVAILABLE ONLINE AT:
[HTTP://WWW.NMWR.NOAA.GOV/SALMONID-HYDROPOWER/FERC/PLLOAD/FISH-PASSAGE-DESIGN.PDF](http://www.nmwr.noaa.gov/SALMONID-HYDROPOWER/FERC/PLLOAD/FISH-PASSAGE-DESIGN.PDF)

- U.S. FISH AND WILDLIFE SERVICE, 2010, BEST MANAGEMENT PRACTICES TO MINIMIZE ADVERSE EFFECTS TO PACIFIC LAMPREY.
[HTTP://WWW.FWS.GOV/OC/PA/CFB/2010/BEST%20MANAGEMENT%20PRACTICES%20FOR%20PACIFIC%20LAMPREY%20FINAL%2001%2008%2016%2010.pdf](http://www.fws.gov/oc/pa/cfb/2010/BEST%20MANAGEMENT%20PRACTICES%20FOR%20PACIFIC%20LAMPREY%20FINAL%2001%2008%2016%2010.pdf)

FOR SALVAGE OPERATIONS IN KNOWN BULL TROUT SPAWNING AND REARING HABITAT, ELECTROFISHING SHALL ONLY OCCUR FROM MAY 1 TO JULY 31. NO ELECTROFISHING WILL OCCUR IN ANY BULL TROUT OCCUPIED HABITAT AFTER AUGUST 15. BULL TROUT ARE VERY TEMPERATURE SENSITIVE AND GENERALLY SHOULD NOT BE ELECTROSHOCKED OR OTHERWISE HANDLED WHEN TEMPERATURES EXCEED 15 DEGREES CELSIUS. SALVAGE ACTIVITIES SHOULD TAKE PLACE DURING PERIODS OF THE COOLEST AIR AND WATER TEMPERATURES POSSIBLE, NORMALLY EARLY IN THE MORNING VERSUS LATE IN THE DAY, AND DURING CONDITIONS APPROPRIATE TO MINIMIZE STRESS TO FISH SPECIES PRESENT.

SALVAGE OPERATIONS WILL FOLLOW THE ORDERING, METHODOLOGIES, AND CONSERVATION MEASURES SPECIFIED BELOW IN STEPS 1 THROUGH 6. STEPS 1 AND 2 WILL BE IMPLEMENTED FOR ALL PROJECTS WHERE WORK AREA ISOLATION IS NECESSARY ACCORDING TO CONDITIONS ABOVE. ELECTROFISHING (STEP 3) CAN BE IMPLEMENTED TO ENSURE ALL FISH HAVE BEEN REMOVED FOLLOWING STEPS 1 AND 2, OR WHEN OTHER MEANS OF FISH CAPTURE MAY NOT BE FEASIBLE OR EFFECTIVE. DEWATERING AND REWATERING (STEPS 4 AND 5) WILL BE IMPLEMENTED UNLESS WETTED IN-STREAM WORK IS DEEMED TO BE MINIMALLY HARMFUL TO FISH, AND IS BENEFICIAL TO OTHER AQUATIC SPECIES. DEWATERING WILL NOT BE CONDUCTED IN AREAS KNOWN TO BE OCCUPIED BY LAMPREY, UNLESS LAMPREYS ARE SALVAGED USING GUIDANCE SET FORTH IN US FISH AND WILDLIFE SERVICE (2010).

1) ISOLATE.

A) BLOCK NETS WILL BE INSTALLED AT UPSTREAM AND DOWNSTREAM LOCATIONS AND MAINTAINED IN A SECURED POSITION TO EXCLUDE FISH FROM ENTERING THE PROJECT AREA.

B) BLOCK NETS WILL BE SECURED TO THE STREAM CHANNEL BED AND BANKS UNTIL FISH CAPTURE AND TRANSPORT ACTIVITIES ARE COMPLETE. BLOCK NETS MAY BE LEFT IN PLACE FOR THE DURATION OF THE PROJECT TO EXCLUDE FISH.

C) IF BLOCK NETS REMAIN IN PLACE MORE THAN ONE DAY, THE NETS WILL BE MONITORED AT LEAST DAILY TO ENSURE THEY ARE SECURED TO THE BANKS AND FREE OF ORGANIC ACCUMULATION. IF THE PROJECT IS WITHIN BULL TROUT SPAWNING AND REARING HABITAT, THE BLOCK NETS MUST BE CHECKED EVERY FOUR HOURS FOR FISH IMPINGEMENT ON THE NET, LESS FREQUENT INTERVALS MUST BE APPROVED THROUGH A VARIANCE REQUEST.

D) NETS WILL BE MONITORED HOURLY ANYTIME THERE IS INSTREAM DISTURBANCE.

2) SALVAGE. AS DESCRIBED BELOW, FISH TRAPPED WITHIN THE ISOLATED WORK AREA WILL BE CAPTURED TO MINIMIZE THE RISK OF INJURY, THEN RELEASED AT A SAFE SITE:

A) REMOVE AS MANY FISH AS POSSIBLE PRIOR TO DEWATERING.

B) DURING DEWATERING, ANY REMAINING FISH WILL BE COLLECTED BY HAND OR DIP NETS.

C) SEINES WITH A MESH SIZE TO ENSURE CAPTURE OF THE RESIDING ESTABLISHED FISH WILL BE USED.

D) MINNOW TRAPS WILL BE LEFT IN PLACE OVERNIGHT AND USED IN CONJUNCTION WITH SEINING.

E) IF BUCKETS ARE USED TO TRANSPORT FISH:

- I. THE TIME FISH ARE IN A TRANSPORT BUCKET WILL BE LIMITED, AND WILL BE RELEASED AS QUICKLY AS POSSIBLE;
- II. THE NUMBER OF FISH WITHIN A BUCKET WILL BE LIMITED BASED ON SIZE, AND FISH WILL BE OF RELATIVELY COMPARABLE SIZE TO MINIMIZE PREDATION;
- III. AERATORS FOR BUCKETS WILL BE USED OR THE BUCKET WATER WILL BE FREQUENTLY CHANGED WITH COLD CLEAR WATER AT 15 MINUTE OR MORE FREQUENT INTERVALS.
- IV. BUCKETS WILL BE KEPT IN SHADED AREAS OR WILL BE COVERED BY A CANOPY IN EXPOSED AREAS.

V. DEAD FISH WILL NOT BE STORED IN TRANSPORT BUCKETS, BUT WILL BE LEFT ON THE STREAM BANK TO AVOID MORTALITY COUNTING ERRORS.

F) AS RAPIDLY AS POSSIBLE (ESPECIALLY FOR TEMPERATURE-SENSITIVE BULL TROUT), FISH WILL BE RELEASED IN AN AREA THAT PROVIDES ADEQUATE COVER AND FLOW REFUGE, UPSTREAM RELEASE IS GENERALLY PREFERRED, BUT FISH RELEASED DOWNSTREAM WILL BE SUFFICIENTLY OUTSIDE OF THE INFLUENCE OF CONSTRUCTION.

G) SALVAGE WILL BE SUPERVISED BY A QUALIFIED FISHERIES BIOLOGIST EXPERIENCED WITH WORK AREA ISOLATION AND COMPETENT TO ENSURE THE SAFE HANDLING OF ALL FISH.

3) ELECTROFISHING. ELECTROFISHING WILL BE USED ONLY AFTER OTHER SALVAGE METHODS HAVE BEEN EMPLOYED OR WHEN OTHER MEANS OF FISH CAPTURE ARE DETERMINED TO NOT BE FEASIBLE OR EFFECTIVE. IF ELECTROFISHING WILL BE USED TO CAPTURE FISH FOR SALVAGE, THE SALVAGE OPERATION WILL BE LED BY AN EXPERIENCED FISHERIES BIOLOGIST AND THE FOLLOWING GUIDELINES WILL BE FOLLOWED:

- A) THE NMFS'S ELECTROFISHING GUIDELINES (NMFS 2000).
- B) ONLY DIRECT CURRENT (DC) OR PULSED DIRECT CURRENT (PDC) WILL BE USED AND CONDUCTIVITY MUST BE TESTED.
 - I. IF CONDUCTIVITY IS LESS THAN 100 MS, VOLTAGE RANGES FROM 800 TO 1100 WILL BE USED.
 - II. FOR CONDUCTIVITY RANGES BETWEEN 100 TO 300 MS, VOLTAGE RANGES WILL BE 500 TO 800.
 - III. FOR CONDUCTIVITY GREATER THAN 300 MS, VOLTAGE WILL BE LESS THAN 400.

C) ELECTROFISHING WILL BEGIN WITH A MINIMUM PULSE WIDTH AND RECOMMENDED VOLTAGE AND THEN GRADUALLY INCREASE TO THE POINT WHERE FISH ARE IMMOBILIZED.

D) THE ANODE WILL NOT INTENTIONALLY CONTACT FISH.

E) ELECTROFISHING SHALL NOT BE CONDUCTED WHEN THE WATER CONDITIONS ARE TURBID AND VISIBILITY IS POOR. THIS CONDITION MAY BE EXPERIENCED WHEN THE SAMPLER CANNOT SEE THE STREAM BOTTOM IN ONE FOOT OF WATER.

F) IF MORTALITY OR OBVIOUS INJURY (DEFINED AS DARK BANDS ON THE BODY, SPINAL DEFORMATIONS, DE-SCALING OF 25% OR MORE OF BODY, AND TORPIDITY OR INABILITY TO MAINTAIN UPRIGHT ATTITUDE AFTER SUFFICIENT RECOVERY TIME) OCCURS DURING ELECTROFISHING, OPERATIONS WILL BE IMMEDIATELY DISCONTINUED, MACHINE SETTINGS, WATER TEMPERATURE AND CONDUCTIVITY CHECKED, AND PROCEDURES ADJUSTED OR ELECTROFISHING POSTPONED TO REDUCE MORTALITY.

4) DEWATER. DEWATERING, WHEN NECESSARY, WILL BE CONDUCTED OVER A SUFFICIENT PERIOD OF TIME TO ALLOW SPECIES TO NATURALLY MIGRATE OUT OF THE WORK AREA AND WILL BE LIMITED TO THE SHORTEST LINEAR EXTENT PRACTICABLE.

A) DIVERSION AROUND THE CONSTRUCTION SITE MAY BE ACCOMPLISHED WITH A COPPER DAM AND A BY-PASS CULVERT OR PIPE, OR A LINED, NON-ERODIBLE DIVERSION DITCH. WHERE GRAVITY FEED IS NOT POSSIBLE, A PUMP MAY BE USED, BUT MUST BE OPERATED IN SUCH A WAY AS TO AVOID REPETITIVE DEWATERING AND REWATERING OF THE SITE. IMPOUNDMENT BEHIND THE COPPER DAM MUST OCCUR SLOWLY THROUGH THE TRANSITION, WHILE CONSTANT FLOW IS DELIVERED TO THE DOWNSTREAM REACHES.

B) ALL PUMPS WILL HAVE FISH SCREENS TO AVOID JUVENILE FISH IMPINGEMENT OR ENTRAPMENT, AND WILL BE OPERATED IN ACCORDANCE WITH NMFS'S CURRENT FISH SCREEN CRITERIA (NMFS 2011, OR MOST RECENT VERSION). IF THE PUMPING RATE EXCEEDS 3 CUBIC FEET SECOND (CFS), A NMFS HYDRO FISH PASSAGE REVIEW WILL BE NECESSARY.

C) DISSIPATION OF FLOW ENERGY AT THE BYPASS OUTFLOW WILL BE PROVIDED TO PREVENT DAMAGE TO RIPARIAN VEGETATION OR STREAM CHANNEL.

D) SAFE REENTRY OF FISH INTO THE STREAM CHANNEL WILL BE PROVIDED, PREFERABLY INTO POOL HABITAT WITH COVER, IF THE DIVERSION ALLOWS FOR DOWNSTREAM FISH PASSAGE.

E) SEEPAGE WATER WILL BE PUMPED TO A TEMPORARY STORAGE AND TREATMENT SITE OR INTO UPLAND AREAS TO ALLOW WATER TO PERCOLATE THROUGH SOIL OR TO FILTER THROUGH VEGETATION PRIOR TO REENTERING THE STREAM CHANNEL.

4 NATIONAL MARINE FISHERIES SERVICE, 2011, ANADROMOUS SALMONID PASSAGE FACILITY DESIGN, NORTHWEST REGION, AVAILABLE ONLINE AT:
[HTTP://WWW.NMWR.NOAA.GOV/SALMONID-HYDROPOWER/FERC/PLLOAD/FISH-PASSAGE-DESIGN.PDF](http://www.nmwr.noaa.gov/SALMONID-HYDROPOWER/FERC/PLLOAD/FISH-PASSAGE-DESIGN.PDF)

5) SALVAGE NOTICE. MONITORING AND RECORDING OF FISH PRESENCE, HANDLING, AND MORTALITY MUST OCCUR DURING THE DURATION OF THE ISOLATION, SALVAGE, ELECTROFISHING, DEWATERING, AND REWATERING OPERATIONS. ONCE OPERATIONS ARE COMPLETED, A SALVAGE REPORT WILL DOCUMENT PROCEDURES USED, ANY FISH INJURIES OR DEATHS (INCLUDING NUMBERS OF FISH AFFECTED), AND CAUSES OF ANY DEATHS.

CONSTRUCTION AND POST-CONSTRUCTION CONSERVATION MEASURES.

1) FISH PASSAGE. FISH PASSAGE WILL BE PROVIDED FOR ANY ADULT OR JUVENILE FISH LIKELY TO BE PRESENT IN THE ACTION AREA DURING CONSTRUCTION, UNLESS PASSAGE DID NOT EXIST BEFORE CONSTRUCTION OR THE STREAM IS NATURALLY IMPASSABLE AT THE TIME OF CONSTRUCTION. IF THE PROVISION OF TEMPORARY FISH PASSAGE DURING CONSTRUCTION WILL INCREASE NEGATIVE EFFECTS ON AQUATIC SPECIES OF INTEREST OR THEIR HABITAT, A VARIANCE CAN BE REQUESTED FROM THE NMFS BRANCH CHIEF AND THE FWS FIELD OFFICE SUPERVISOR. PERTINENT INFORMATION, SUCH AS THE SPECIES AFFECTED, LENGTH OF STREAM REACH AFFECTED, PROPOSED TIME FOR THE PASSAGE BARRIER, AND ALTERNATIVES CONSIDERED, WILL BE INCLUDED IN THE VARIANCE REQUEST.

2) CONSTRUCTION AND DISCHARGE WATER.

A) SURFACE WATER MAY BE DIVERTED TO MEET CONSTRUCTION NEEDS, BUT ONLY IF DEVELOPED SOURCES ARE UNAVAILABLE OR INADEQUATE.

B) DIVERSIONS WILL NOT EXCEED 10% OF THE AVAILABLE FLOW.

C) ALL CONSTRUCTION DISCHARGE WATER WILL BE COLLECTED AND TREATED USING THE BEST AVAILABLE TECHNOLOGY APPLICABLE TO SITE CONDITIONS.

D) TREATMENTS TO REMOVE DEBRIS, NUTRIENTS, SEDIMENT, PETROLEUM HYDROCARBONS, METALS AND OTHER POLLUTANTS LIKELY TO BE PRESENT WILL BE PROVIDED.

HIP III GENERAL CONSERVATION & IMPLEMENTATION MEASURES

Bonerville Power Administration - Environment, Fish and Wildlife

Designed	_____	April 18, 2018
Drawn	S. Smith, PE	_____
Checked	_____	_____
Approved	_____	_____
TITLE	_____	

File Name	HIP III GCA
Drawing No.	2
Sheet	1 of 2

APPENDIX H - HIP SMALL WOOD CONSERVATION MEASURES

- 1) Small wood placements shall be conducted by hand or small machinery not to exceed 15,000 lbs. operating weight. If heavy equipment is required, project shall adhere to Large Wood conservation measures.
- 2) Small wood placements shall be constructed for floodplain reconnection in stream systems less than 4% stream gradient.
- 3) Additional potential effects of structures may include channel aggradation and associated channel widening, bank erosion, increased channel meandering, and decreased channel depth. The Basis of Design Report must demonstrate how these potential impacts have been addressed.
- 4) Structures must be porous, must provide for a water surface differential of no more than one-foot at low flows, or otherwise provide a clear path for fish passage over, through or around the structure during low flows.
- 5) Structures shall have crest elevations that extend no more than 3 feet above the stream bed. Vertical posts (if utilized) shall be cut flush and not extend above the proposed crest elevation.
- 6) Vertical posts (if utilized) must be driven to a depth at least 1.5 times the expected scour depth of the waterway or a ratio of 2:1 for exposed – embedded length whichever is more conservative. A minimum 1.5-foot clear space is recommended between posts.
- 7) For incised channels, an adaptive management approach using lower elevation structures that trap sediment and aggrade the channel, with future and subsequent project phases is preferred over tall structures with excessive drop and increased risk of failure.
- 8) All primary materials used in small wood placements must consist of non- treated wood (e.g. fence posts) and must be constructed from a materials source collected outside the riparian area.
- 9) Placement of inorganic material is limited to the minimum quantity necessary to prevent under-scour of structure and manage pore flow sufficient to ensure adequate over-topping flow and side flow to facilitate fish passage where required.
- 10) No cabling, wire, mortar or other materials that serve to affix the structure to the bed, banks or upland is allowed.
- 11) Structures cannot unreasonably interfere with use of the waterway for navigation, fishing or recreation.