LOWER TEPEE CREEK

RIVERSCAPE RESTORATION

80% DESIGN REPORT

Prepared by:

Anabranch Solutions, LLC

ANABRANCH SOLUTIONS

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April 2021

PREPARED FOR:

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PROJECT SUMMARY

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 strives to train a tribal workforce in LTPBR practices and increase engagement and traditional ecological knowledge (TEK) in watershed restoration. This document outlines the 80% restoration design for the lower 1.75 miles of Tepee Creek, a tributary to White Creek, located in the Klickitat River subbasin.

Tepee Creek is part of the White Creek Major Spawning Area (MaSA) for ESA-listed Mid-Columbia steelhead (*Oncorhynchus mykiss*). The White Creek drainage is considered one of the most significant spawning areas in the subbasin, accounting for approximately 41% of the observed steelhead spawning. Tepee Creek has accounted for up to 14% of spawning in the White Creek drainage in recent years (2002-2019).

Past land management activities including grazing, timber harvest, road construction, and the removal of wood from streams have decreased the quality and quantity of stream habitat within the Tepee Creek watershed including: reduced wood accumulations (e.g., large wood jams), geomorphic diversity (i.e., pool and off-channel habitat), channel-floodplain connectivity, riparian vegetation, and streamflow. Much of Tepee Creek is incised and the stream goes dry for substantial portions of the year (~5 months).

The overall goal of restoration on Tepee Creek is to improve the quality and quantity of habitat for threatened steelhead by promoting sustainable fluvial processes that result in a healthy and resilient riverscape. Within this broad management goal, objectives for restoration include: 1) increase the abundance of beaver dams and large wood accumulations, 2) increase in-channel geomorphic diversity, 3) Increase the proportion of the valley bottom composed of active channel and active floodplain, 3) increase wetland and riparian vegetation extent, diversity, and abundance, and 5) increase perennial surface flow extent during low flow periods.

The restoration design outlines Low-Tech Process-Based Restoration methods (Wheaton et al., 2019) in Tepee 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 Tepee 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, restoration design, adaptive management plan, and details regarding implementation and logistics.

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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 also strives to train a tribal workforce in LTPBR practices and increase engagement and traditional ecological knowledge (TEK) in watershed restoration.

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This document provides an 80% design report for the lower 1.75 miles of Tepee 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

Tepee Creek is a tributary to White Creek in the Klickitat River subbasin in south-central Washington (Figure 1). The Tepee Creek watershed encompasses 21.4 mi^2 with a maximum elevation of 3,980 feet near Simon Butte and a minimum elevation of 2,580 feet at its confluence with White Creek (Figure 2). Annual precipitation averages 31 inches and vegetation consists of ponderosa pine parkland and mixed conifer forests in the uplands and mixed deciduous and wetland species in riparian areas within valley bottoms. The entire watershed is part of the Yakama Reservation and managed by the Yakama Nation.

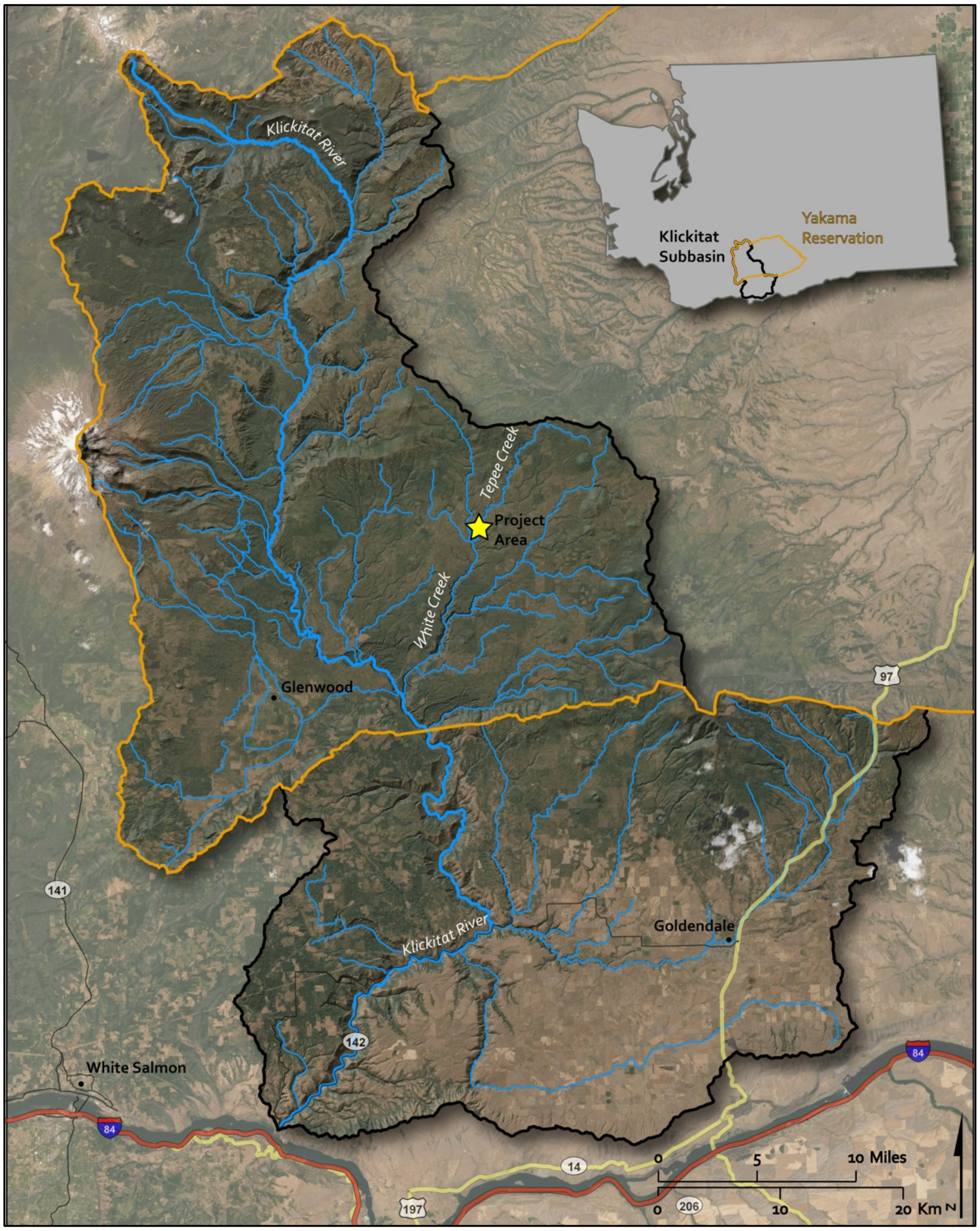

Figure 1. Project area location within the White Creek drainage and Klickitat River subbasin in south-central Washington.

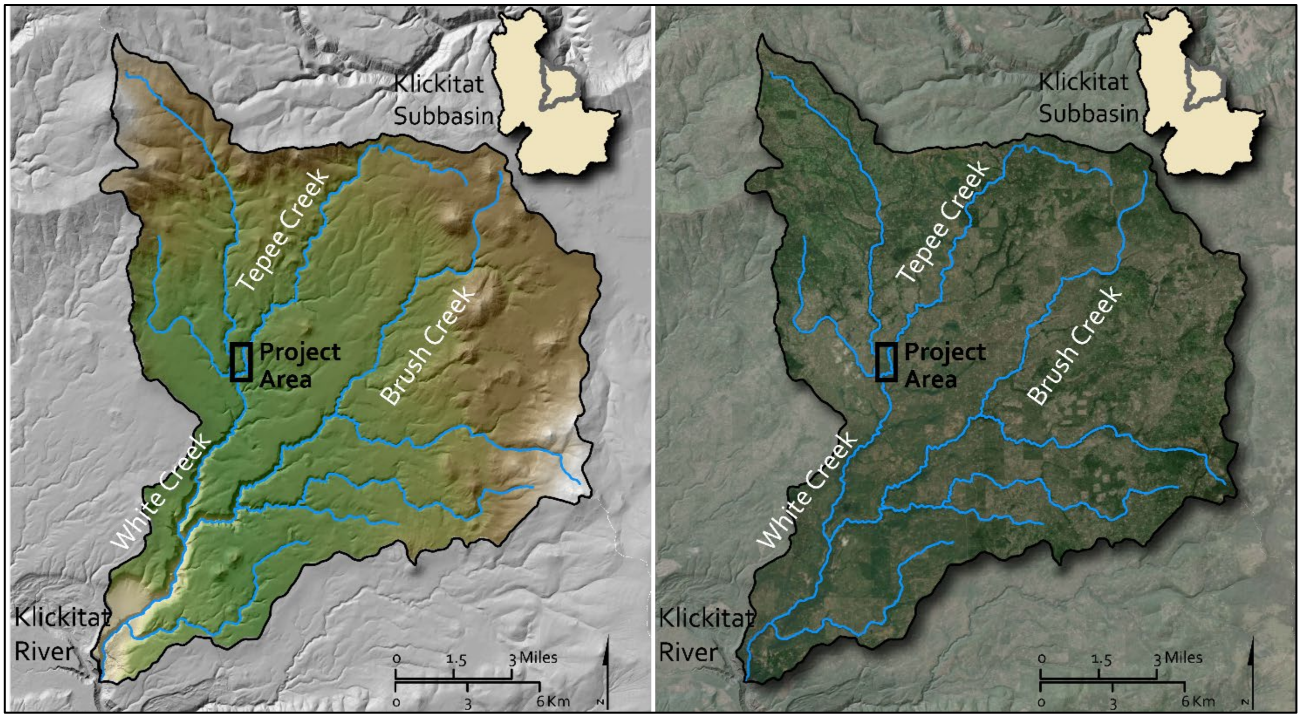

Figure 2. Project area location on Tepee Creek within the White Creek drainage: left panel provide elevation and right panel provides Google aerial imagery. The project area extends approximately 1.75 miles upstream from the confluence with White Creek.

The project area begins at the confluence of Tepee Creek and White Creek and extends approximately 1.75 miles upstream (Figure 3). Within the project area, the valley bottom averages approximately 180 feet and consists of two meadows interspersed between sections with more narrow valleys that have small discontinuous pockets of floodplain. The stream gradient is relatively low throughout (e.g., approximately 1%) except for a short, steeper section (up to 2.5%) near the confluence with White Creek.

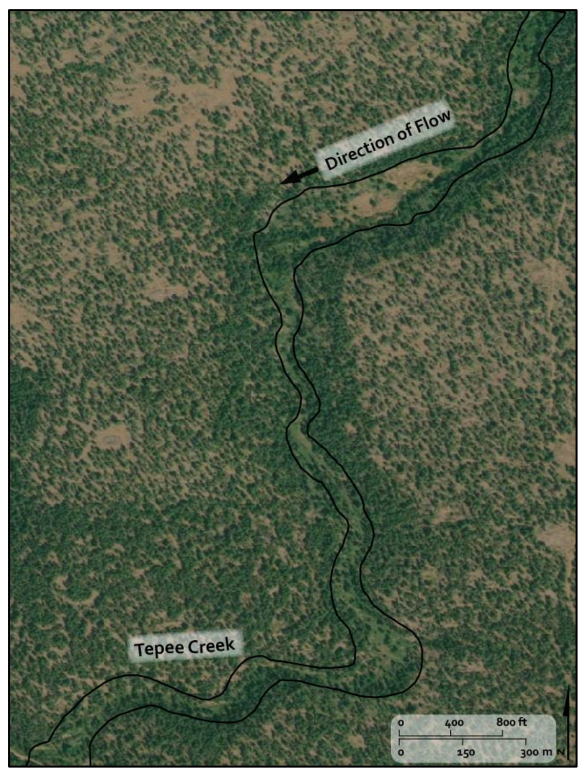

Figure 3. Overview map of the Tepee Creek project area. Black lines represent valley bottom margins.

PRELIMINARY PROJECT GOALS AND OBJECTIVES

The overall goal of restoration on Tepee 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. Within this broad management goal, preliminary restoration objectives provided by Yakama Nation include:

- increasing the frequency of overbank flows
- enhancing in-channel habitat conditions
- increasing the duration of low flows
- reducing active channel hydraulic severity
- improving shallow aquifer storage/recharge
- increasing valley bottom suitability for culturally significant plants

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 Tepee 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).

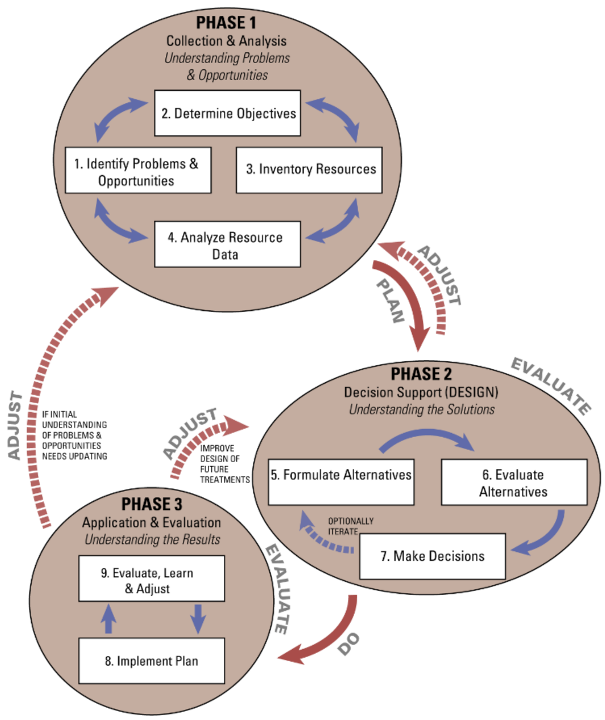

Figure 4. Outline depicting an adaptation of NRCS's Conservation Planning Process used to guide the lower Tepee Creek restoration planning and design process (from Wheaton et al. 2019).

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, implementation of LTPBR relies on stream power (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 Tepee 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, Low-Tech Process-Based Restoration (LTPBR) approaches were selected as the proposed design alternative.

There are a number of project area characteristics that make it 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 catchment conditions within Tepee Creek support reliable flood events, the presence of nearby beaver populations and suitability of Tepee Creek to support beaver, and a recovering riparian area and forested uplands.

Lack of human infrastructure – There is no human infrastructure such as houses, outbuildings, or equipment 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. Because of this, detailed engineering plans or hydraulic modeling are not required for the design and implementation of a successful restoration plan capable of meeting project goals and objectives.

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 connected?
  - Are the channel(s) and floodplain connected during both baseflow and high-flow conditions?
- Is the proportion of 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 associated with different recovery trajectories?

FISHERIES RESOURCES AND LIMITING FACTORS

Tepee Creek is part of the White Creek Major Spawning Area (MaSA) for ESA-listed Mid-Columbia steelhead (*Oncorhynchus mykiss)* which is considered one of the most significant spawning areas in the subbasin (Klickitat Lead Entity 2015). The distribution of steelhead extends approximately 10 miles upstream from the confluence with White Creek. There are no other ESA-listed species in Tepee Creek. On average, the White Creek drainage accounts for approximately 41% of the observed steelhead spawning in the subbasin and Tepee Creek itself has accounted for up to 14% in recent years (Yakama Nation staff, personal communication, 2020).

Limiting Factors in the White Creek drainage include (NMFS 2009):

Streamflow, habitat quality and quantity, impaired fish passage, altered sediment routing, degraded water quality (temperature), competition, and degraded channel structure and complexity. The restoration actions outlined in this design propose to address a number of limiting factors including:

- flow (low flows),
- habitat quality and quantity,
- degraded water quality (temperature),
- degraded channel structure and complexity, and
- floodplain connectivity.

VALLEY SETTING (REACHES)

Two distinct valley settings are present in the project area:1) confined reaches with relatively narrow valley bottoms (75-200 ft.) and 2) meadow reaches with wider valley bottoms (150-425 ft.; Figure 5).

Figure 5. Aerial imagery illustrating differences in valley setting between confined (left photo) and meadow (right photo) reaches.

GEOMORPHIC ASSESSMENT

Valley Bottom Geomorphic Composition

We assess the overall health of a riverscape by identifying the existing composition of geomorphic attributes within the valley bottom that include the active channel, active floodplain and inactive floodplain. Valley bottom attributes were delineated within the project area based on consideration of geomorphic and vegetative indicators during field visits, and through evaluation of orthoimagery and topographic data (Figure 6). The proportion and arrangement of floodplain varies depending on valley setting and reach type, but generally the greater the proportion of inactive floodplain the more degraded the riverscape. We define the valley and its components as (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., or 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 tops 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 (i.e., 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 is not hydrologically connected during 5 – 10-year recurrence interval 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 distinguished by their lateral displacement from the active channel.

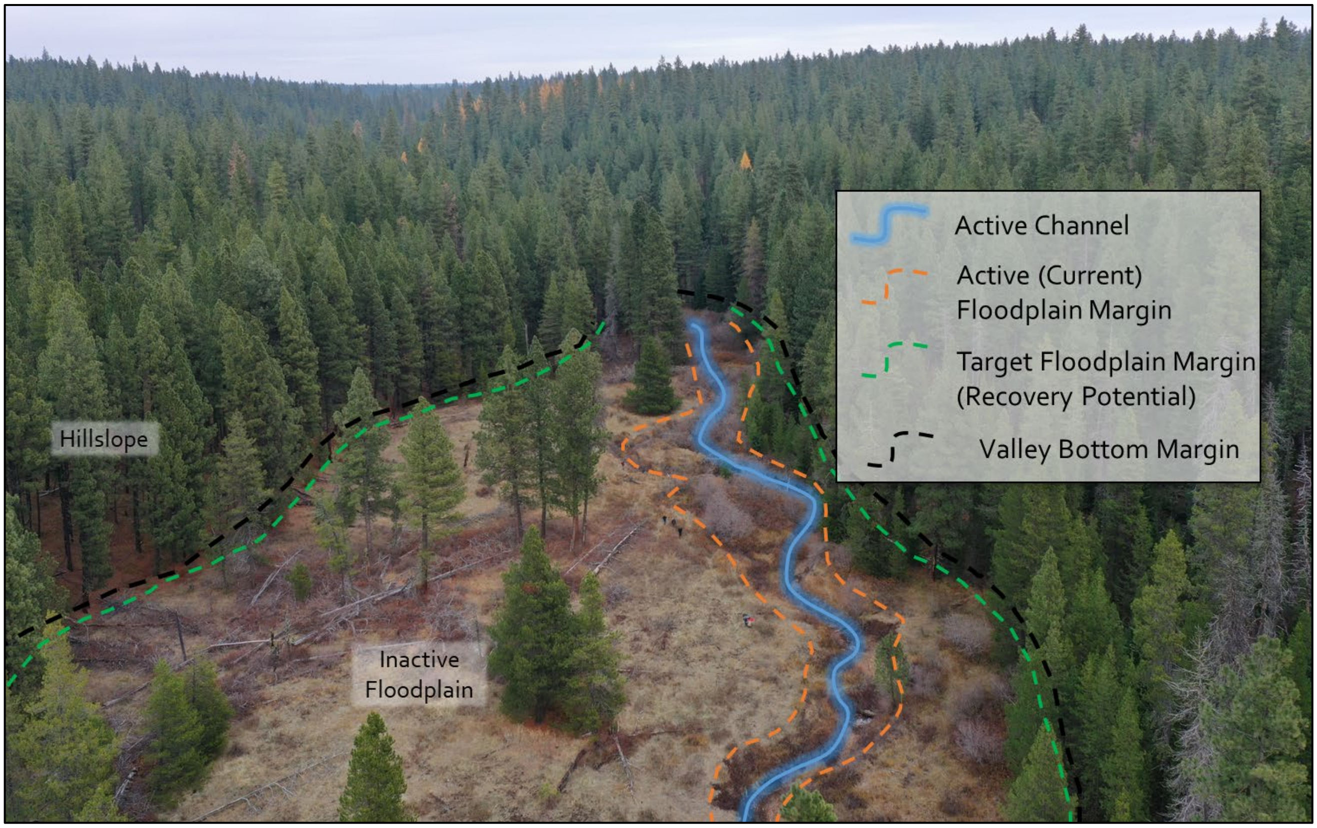

Figure 6. Schematic of valley bottom geomorphic composition for a meadow reach in the lower Tepee Creek project area. In this reach, there is potential to target 100% of the valley bottom given the lack of infrastructure.

Within the project area, the active channel and active floodplain comprise approximately 40% (14 of 34 acres) of the valley bottom. In general, the active channel and active floodplain comprise a greater proportion of the valley bottom in confined reaches than unconfined reaches which are wider and tend to have more incised channels.

Channel Characteristics

Channel characteristics in lower Tepee Creek vary between reach types. Within meadow reaches, the stream is deeply incised with highly erodible banks that are sparsely covered with riparian vegetation. Where the channel has widened, there is a small inset floodplain but a large proportion of the valley bottom is comprised of inactive floodplain (disconnected at 5 – 10 year flows). The stream channel has very little geomorphic diversity with few structural elements (e.g., LWD and/or beaver dams; Figure 7). In confined reaches, the channel is less incised, but still disconnected from the floodplain with low to moderate amounts of structural elements and limited geomorphic diversity. Habitat monitoring results in the lower project area estimate 1.7 pools/100m, 8.5 large wood pieces/100m, and no large wood accumulations (Yakama Nation staff, unpublished results). Substrate characteristics range from pockets of small and large gravels to accumulations of fines throughout.

Figure 7. Examples of geomorphic conditions in a meadow and confined reach of lower Tepee Creek. See Appendix B for additional project area photos.

HYDROLOGY

Tepee Creek, at the project area drains approximately 21 square miles, end experiences an average of 31 inches of precipitation annually. 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 8. Low-flow statistics are not available for the project area, however field observations indicate that baseflows are typically <1 cfs and the stream goes dry for approximately 5 months out of the year (Yakama Nation staff, personal communication, 2020).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 the Appendix C of this report.

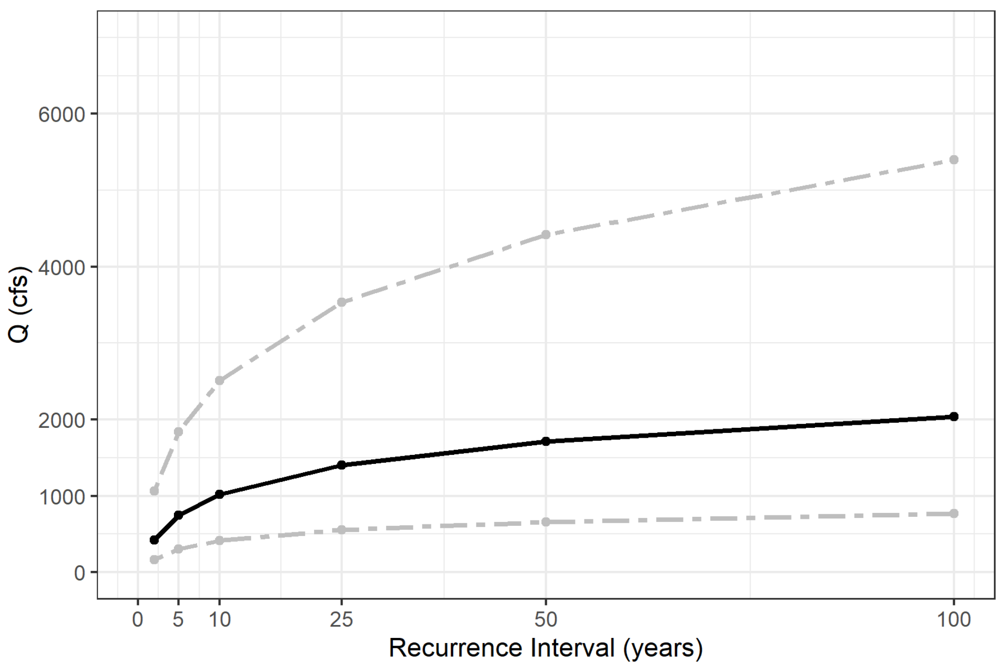

Figure 8. Predicted values of streamflow on Tepee Creek for up to 100-year recurrence interval events. Solid black line represents the predicted value, dotted grey lines represent the upper and lower prediction interval. Data retrieved from Streamstats (https://streamstats.usgs.gov/ss/) Accessed 01/10/2021 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 is limited to the margins of the incised channel and mostly consists of young alders. Where the floodplain is disconnected, vegetation consists of upland grasses and shrubs accompanied by lodgepole and ponderosa pine encroaching in some places from the valley margins.

Headwater streams in the Klickitat River subbasin generally have the capacity to support frequent to pervasive beaver dams. 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 Tepee Creek, dry streamflow conditions currently are likely to limit the capacity/likelihood to support beaver dam activity. However, beaver have been observed to extend the duration of streamflow in intermittent systems. It is with this understanding that we assessed the current capacity to support beaver dams in Tepee Creek, based on riparian and upland vegetation characteristics and channel gradient. Within the project area, Tepee Creek currently has the capacity to support 30-50 beaver dams. Historically, the project area could support 40 – 60 dams. Reductions in capacity are likely due to a decrease in the woody riparian vegetation preferred by beavers for forage and dam building. There are currently no beaver dams within the project area. As such there is the potential for significant uplift if restoration activities can encourage the colonization of the project area by beaver and promotion of beaver dam activity. The limited reduction in beaver dam capacity, relative to historic condition, suggests that encouraging beaver dam activity is an appropriate restoration strategy provided that forage and dam building resources become sufficient. Furthermore, the upper portions of Tepee Creek, as well as nearby streams have the capacity to support beaver dams. This capacity is important to creating realistic expectations for the likelihood of future beaver dam activity within the project area. Alternative sites may either provide a source of dispersing beaver (if or once established) or be areas that may be colonized at the expense of colonization within the project area.

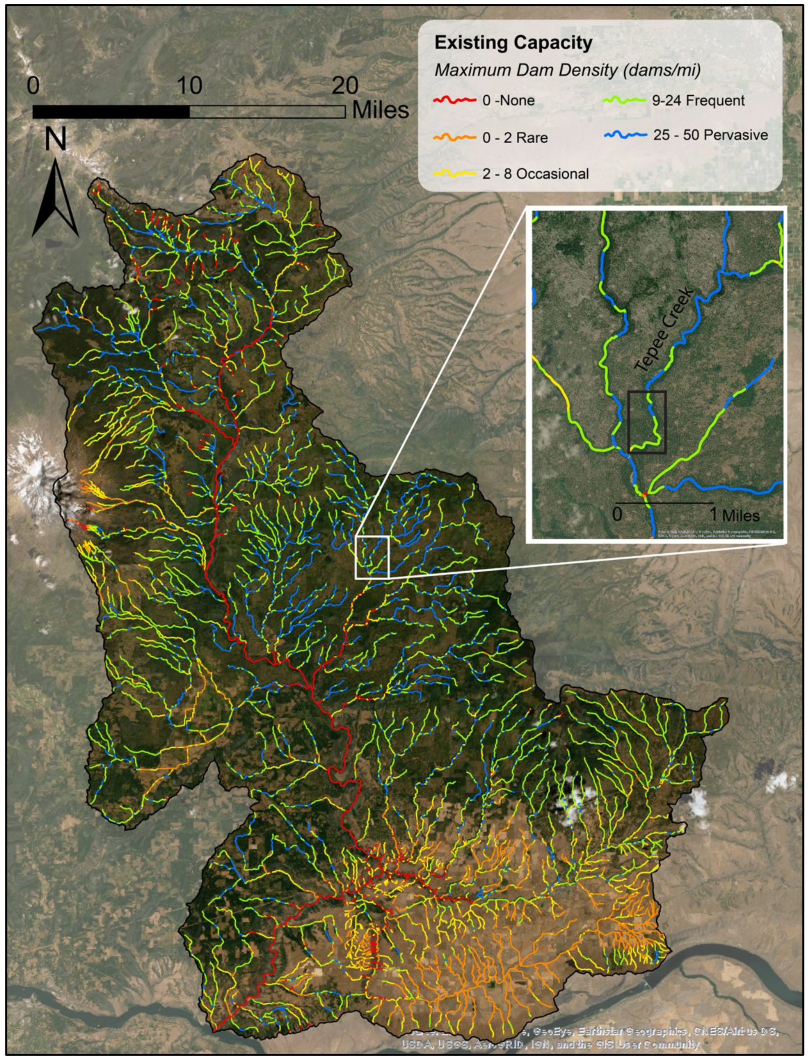

Figure 9. Existing capacity to support beaver dams within the Klickitat River subbasin and near the lower Tepee Creek project area. The surrounding area is shown in order to provide context regarding the future likelihood that beaver move into the project area based on the capacity of nearby streams.

RISK ASSESSMENT

Risks were assessed as the potential for impacts to infrastructure (road crossings, buildings, etc.) within and adjacent to the valley bottom. There are no roads, road crossings, or structures within the valley bottom of the project area. There is a potential risk to the road that parallels White Creek near its confluence with Tepee Creek if large amounts of wood move downstream from Tepee and aggregate in the channel. This risk is low due to the riparian and floodplain buffer that is present between the active channel on White Creek and the road prism. Risks and constraints will be further evaluated and managed using adaptive management.

POTENTIAL FUTURE CONDITION

Prior to human alteration, many riverscapes such as Tepee Creek (especially in meadow reaches) 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 10; Table 1). This concept, when applied to either meadow or confined reaches provides an overarching target for restoration and potential pathways of recovery.

Without active structural additions it will likely be decades before Tepee Creek naturally recovers to near Stage 0 conditions based on our assessment. With targeted restoration actions, there is potential to access the entire valley bottom throughout the project area based on the absence of infrastructure. In confined reaches, recovery potential may be recognized within short to medium time scales (years to decades). In meadow reaches, achieving full recovery potential may take longer due to the relatively degraded conditions and greater area of disconnected floodplain, but when recognized, provide a greater amount of ecosystem benefits and uplift such as flow attenuation, groundwater storage, and more diverse habitat for steelhead. Ultimately, self-sustaining riverscape conditions may not be recognized without the processes of natural wood recruitment or beaver activity, which restoration can help to kick-start.

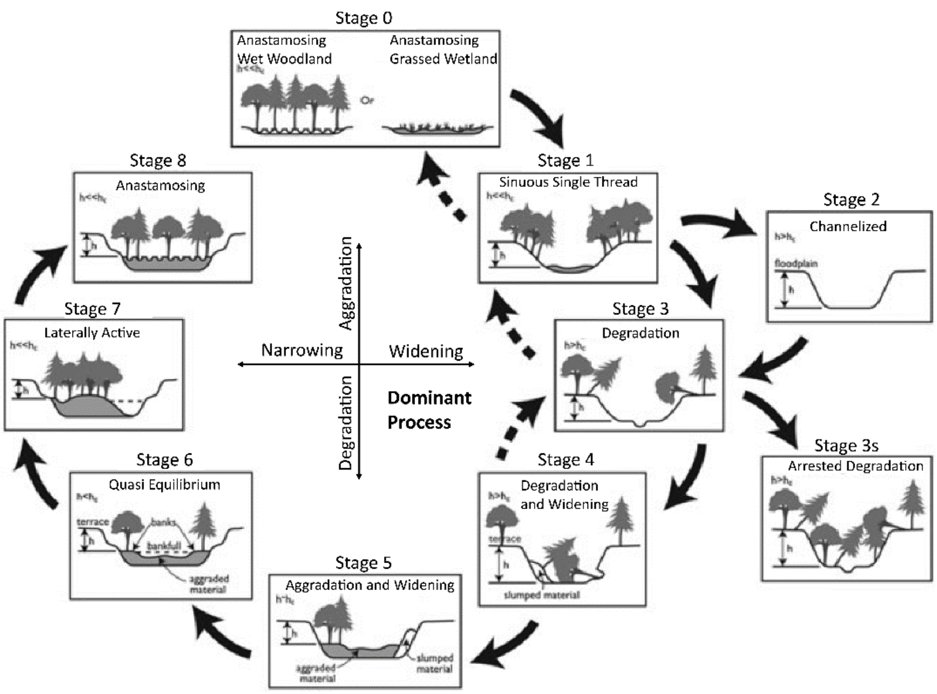

Figure 10. Stream evolution model (SEM) proposed by Cluer and Thorne (2014) illustrating approximate stages and pathways associated with recovery to Stage 0. Restoration in Tepee Creek is intended to accelerate recovery trajectories.

Table 1. Description of dominant hydrologic, hydraulic, substrate, and morphological characteristics of Stage 0 channels. 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 Tepee 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 the Klickitat River Subbasin including low flows, high water temperatures, lack of instream complexity, and floodplain connectivity (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 of current conditions and recovery potential (Table 2).

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

Objective	Description	Link to Restoration Goals
1	Increase the abundance of beaver dams and large wood accumulations.	Both artificial and natural beaver dams along with large wood accumulations (e.g., large wood jams) increase in-channel habitat diversity and help to accelerate recovery. An expanding beaver population is indicative of self – sustaining riverscape processes.
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.
5	Increase perennial surface flow extent during low flow periods.	Surface flow creates conditions that support woody riparian vegetation establishment, steelhead habitat quantity, and suggests efforts to attenuate flow are successful.

RESTORATION INDICATORS

There is a high potential for restoration success in lower Tepee Creek due to the lack of infrastructure and grazing pressure in the valley bottom, the application of best management practices and minimal disturbance in the uplands, 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 ability to widen incised 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 in response to 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.

Perennial Surface Flow Percent – Percent of channel length with persistent surface flow during low flow periods. Surface flow should be recognized if present in any channel (i.e., primary or secondary channels). Expected to increase in response to flow attenuation, temporary storage, and increased surface – groundwater exchange.

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 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 habitat data collected in the lower project area (Yakama Nation, unpublished data).

	Status	Target Metrics			
Indicator	**Current**	**As-Built**	**Short-Term 2 – 5 years**	**Medium-Term 5 – 10 years**	**Long-Term 10-20 years**
Objective 1: Increase In-Channel Habitat Complexity					
Pool Habitat Frequency (count/100m)[1]	1-2 / 100m	1-2 / 100m	1-3 / 100m	2-6 / 100m	4-8 / 100m
Bar Habitat Frequency (count/100m)[1]	0-2 / 100m	0-2 / 100m	1-4 / 100m	3-8 / 100m	4-10 / 100m
Objective 2: Increase Percent and Area of Active Valley Bottom					
Active Valley Bottom (% & acres)	35-45% 11-15 acres	35-50% 11-17 acres	35-60% 11-20 acres	40-75% 14-26 acres	50-90% 17-31 acres
Objective 3: Increase Perennial Surface Flow Extent					
Perennial Surface Flow Length (% and length)	0-5%, 0-150 meters	0-5%, 0-150 meters	0-7%, 0-210 meters	2-20%, 60-600 meters	5-75%, 150-2250 meters
Objective 4: Increase Wetland and Riparian Vegetation Extent					
Wetland and Riparian Vegetation Extent (% & area)[2]	10 - 25%, 3-8 acres	10 - 25%, 3-8 acres	15-30%, 5-10 acres	20-40%, 7-14 acres	25-45%, 8-15 acres
Objective 5: Increase Abundance and Distribution of Beaver Dams and Large Wood Accumulations					
Natural Beaver Dam Frequency (count)	0 dams	0 dams	0-5 dams	0-20 dams	15-30 dams
Artificial Beaver Dam Frequency (count)	0 dams	10-25 dams	0-25 dams	5-30 dams	20-30 dams
Large Wood Accumulation Frequency (count)[3]	0 - 6 jams	60-100 jams	40-120 jams	60-150 jams	80-150 jams

1: Assumes treatments will form pool and bar complexes after flood events.
2: Primarily based on expectations for expansion of the active floodplain and planting treatment.
3: Assumes a combination of natural and artificial large wood accumulations in the project area.

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 inclusive of new structures, maintenance, and structure enhancement).

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 in select reaches 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 Tepee 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	▪ Pilot restoration in select reaches (one meadow and one confined)	New: 50-100
	2	▪ Evaluate pilot restoration ▪ Implement restoration throughout project area ▪ Structure maintenance and additions in areas of pilot restoration ▪ Riparian planting within pilot restoration reaches	New and maintained: 50-100
2	2-5	▪ Evaluate Phase 1 restoration ▪ Structure maintenance and additions within project area ▪ Riparian planting throughout project area	0-50
3	5-10	▪ Evaluate Phase 2 restoration ▪ Structure maintenance and additions within project area ▪ Additional riparian plantings (if necessary)	0-50
Additional	10+	▪ Evaluate the establishment of self-sustaining processes ▪ Potential beaver reintroduction	0-50

SPATIAL DESIGN - REACH DELINEATION

As part of the resource assessment, two distinct reach types were identified within the project area. These types include reaches with relatively narrow valley bottoms (i.e., confined) and meadow reaches with wider valley bottoms. The spatial orientation of these reach types lead to the delineation of five management reaches within the project area. 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. For example, given the larger area of potential floodplain in meadow reaches, and the higher capacity to store water and attenuate flows, more effort and resources may be invested in these areas. Also, to meet certain objectives in downstream reaches (i.e., aggradation), specific actions upstream may be required (e.g., building numerous bank-attached structures designed to mobilize sediment that can be captured in downstream channel spanning structures). 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.

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 to no 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 used 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.

Figure 13. Utilizing a griphoist to move large wood from the adjacent floodplain into the stream channel (left photo) and example of high densities of large wood left unanchored in the channel and placed on the floodplain to add roughness (right photo). Photo examples are from restoration on a tributary to the upper Grande Ronde River in Oregon.

Complimentary Restoration Priorities

Although not specifically addressed within this design document, woody riparian plantings are an integral component of riverscape restoration within lower Tepee 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.

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 (e.g., BDAs) or a mix of structure types (i.e., PALS and BDAs) and be composed of as few as two structures or as many as 10s of structures. Individual PALS and BDAs that are part of a complex help to increase the stability of any given structure within the complex. We have identified a series of five complexes (corresponding to reach delineations) designed to meet multiple objectives. Figure 14 provides an overview of complex locations along with the restoration design including structure types and locations within each complex. Table 5 provides a list of objectives for each 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. A more detailed mapview of complex designs and a table of structure locations for the project area can be found in Appendix F. The number, type, and location of structures is subject to change based on ground conditions.

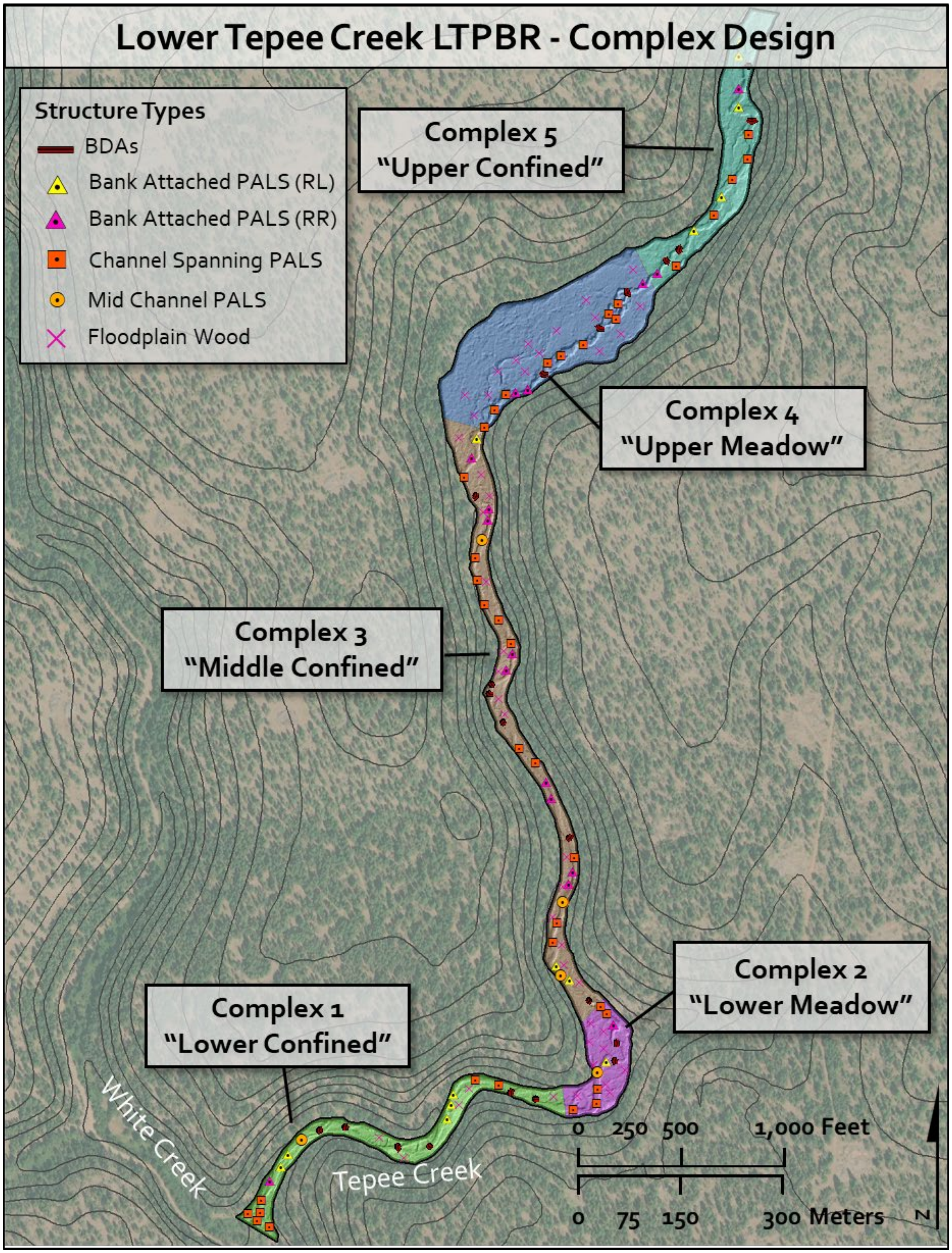

Figure 14. Restoration design illustrating complex locations and structure types and locations within the lower Tepee Creek project area. Complex "names" refer to reach types and location in the project area. Table 5 provides a description of specific objectives for each complex. A more refined mapview of complex designs and a list of structures and locations can be found in Appendix F.

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

Complex (length) Reach Name	Reach	Risk	Complex Objectives	Description	PALS	BDAs
1 (2200 ft.)	Lower Confined	Limited risk; Road present along White Cr. near confluence	Increase Geomorphic Diversity Force Overbank Flows (floodplain connection)	Bank-attached PALS to promote erosion and lateral migration; Channel-spanning PALS and BDAs to capture sediment, aggrade the channel, promote overbank flows and connect discontinuous floodplains; Whole trees or PALS on floodplain surfaces to provide roughness	20-30	5-10
2 (840 ft.)	Lower Meadow	Limited risk; No infrastructure	Increase Geomorphic Diversity Force Overbank Flows (floodplain connection) Pond/Wetland Creation	Bank-attached PALS to promote erosion and lateral migration; Channel-spanning PALS and BDAs to capture sediment, aggrade the channel, promote overbank flows and reconnect side channels and floodplain; Mid-channel PALS to split flow in wide-shallow areas; BDAs to pond water at low flow; Whole trees or PALS on floodplain surfaces to provide roughness	15-20	5-10
3 (3300 ft.)	Middle Confined	Limited risk; No infrastructure	Increase Geomorphic Diversity Force Overbank Flows (floodplain connection)	Bank-attached PALS to promote erosion and lateral migration; Channel-spanning PALS and BDAs to capture sediment, aggrade the channel, promote overbank flows and connect discontinuous floodplains; Whole trees or PALS on floodplain surfaces to provide roughness	20-50	5-10
4 (1200 ft.)	Upper Meadow	Limited risk; No infrastructure	Widening and Aggradation (incision recovery) Increase Geomorphic Diversity Force Overbank Flows (floodplain connection) Pond/Wetland Creation	Bank-attached and channel-spanning PALS to promote widening through erosion and lateral channel migration; Channel-spanning PALS and BDAs to capture sediment, aggrade the channel, and promote overbank flows onto the inset floodplain; Mid-channel PALS to split flow in wide-shallow areas; BDAs to pond water at low flow; Whole trees or PALS on floodplain surfaces to provide roughness	15-25	5-10
5 (1700 ft.)	Upper Confined	Limited risk; No infrastructure	Increase Geomorphic Diversity Force Overbank Flows (floodplain connection)	Bank-attached PALS to promote erosion and lateral migration; Channel-spanning PALS and BDAs to capture sediment, aggrade the channel, promote overbank flows and connect discontinuous floodplains; Whole trees or PALS on floodplain surfaces to provide roughness	15-25	5-10
				Totals:	**75-150**	**25-50**

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 Tepee 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.

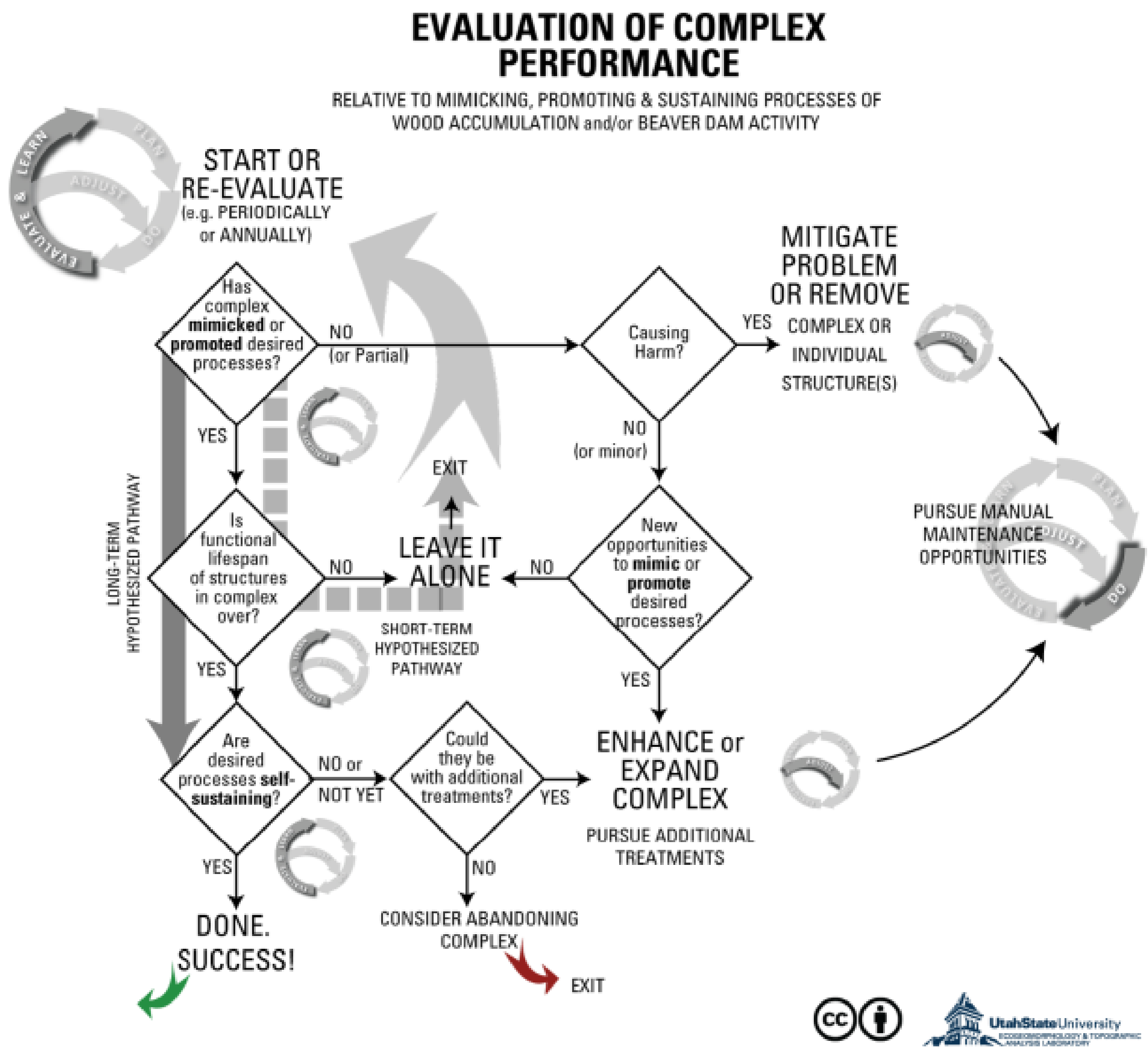

Figure 15. Adaptive management for monitoring and ongoing restoration of LTPBR complexes. Many of the concepts illustrated are also applicable at the scale of an individual structure or the entire project. From Chapter 6 of Wheaton et al. (2019; http://lowtechpbr.restoration.usu.edu).

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 20 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.

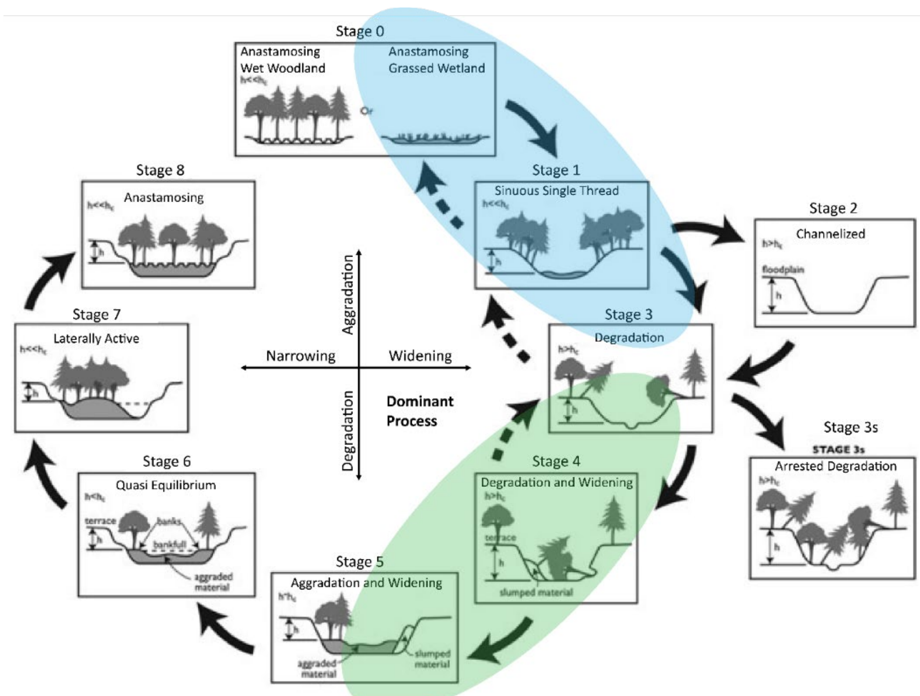

Figure 16. Stream evolution model (SEM) proposed by Cluer and Thorne (2014) illustrating possibility of multiple recovery trajectories. Two different recovery trajectories are highlighted by the blue and green polygons. The blue polygon highlights a counter-clockwise recovery trajectory, beginning with 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 Tepee 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 Tepee Creek, Appendix G provides a framework to support adaptive management decision making based on requirements outlined in BPA's HIP Handbook.

CONSTRUCTION PLAN AND LOGISTICS

Construction 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 (Figure 17). 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 1500-2000 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

Site access and travel within the project area will be limited to foot and small machinery (e.g. ATVs). There are no maintained roads that lead directly to the valley bottom but old skid paths and decommissioned roads are present from past forest management activities. These existing pathways will be used to access the project area and transport wood from upslope staging areas. Several access pathways, staging areas, and fueling/equipment storage locations have been identified that will be used during implementation (Figure 17). Prior to the construction of instream structures, wood and posts will be transported from designated staging areas and placed near structure locations by hand or small machinery.

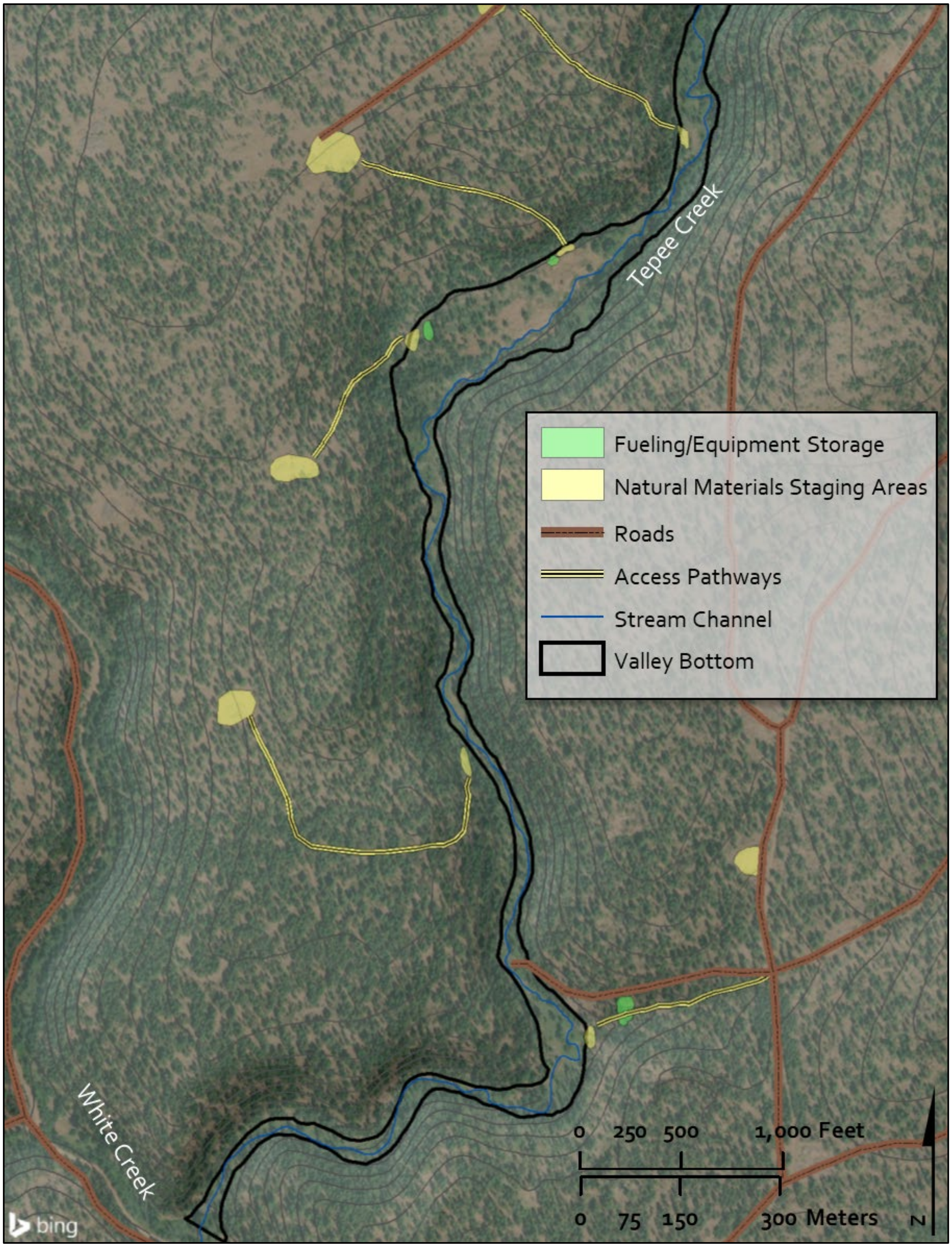

Figure 17. Overview of fueling/equipment storage locations, natural material staging areas, roads, and access pathways for the lower Tepee Creek project area.

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 untreated 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 5-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 H) and those outlined for small wood projects where applicable (see Appendix I). 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 Yakama Nation staff (likely July-October 15). Work outside this window may occur in dry portions of the stream channel upon approval from Yakama Nation staff.

Construction timing and noise limits will adhere to conservation measures outlined for northern spotted owls (Appendix J).

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. The channel is also dry for a majority of the year. 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. If stream crossing is found to be necessary for small machinery (e.g., ATVs, skidsteer), it will be done in the dry portion of the channel.

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 set forth by the Yakama Nation and guidelines outlined in the conservation measures for northern spotted owls (*Strix occidentalis caurina*) when applicable *(*Appendix J).

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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. Photos illustrating channel and riparian conditions in meadow reaches.

APPENDIX C - PREDICTED STREAMFLOW VALUES AND THEIR UTILITY

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

Recurrence Interval (year)	Predicted Discharge (cfs)	Lower prediction interval (cfs)	Upper prediction interval (cfs)	Standard Error
2	419	165	1060	52.5
5	747	303	1840	50.6
10	1020	415	2510	50.5
25	1400	555	3530	51.7
50	1710	661	4420	52.9
100	2040	770	5400	54.2
200	2380	878	6460	55.5
500	2900	1020	8210	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 overestimates of flows along Tepee Creek (David Lindley, personal communication, 2020) that are the product of the manner in which geographic regions are delineated in order to develop streamflow regression equations across the state of Washington. In short, the project area is located near the margin of three different regions, and is grouped with an area that encompasses the spine of the Cascades, which experiences significantly different precipitation patterns.

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

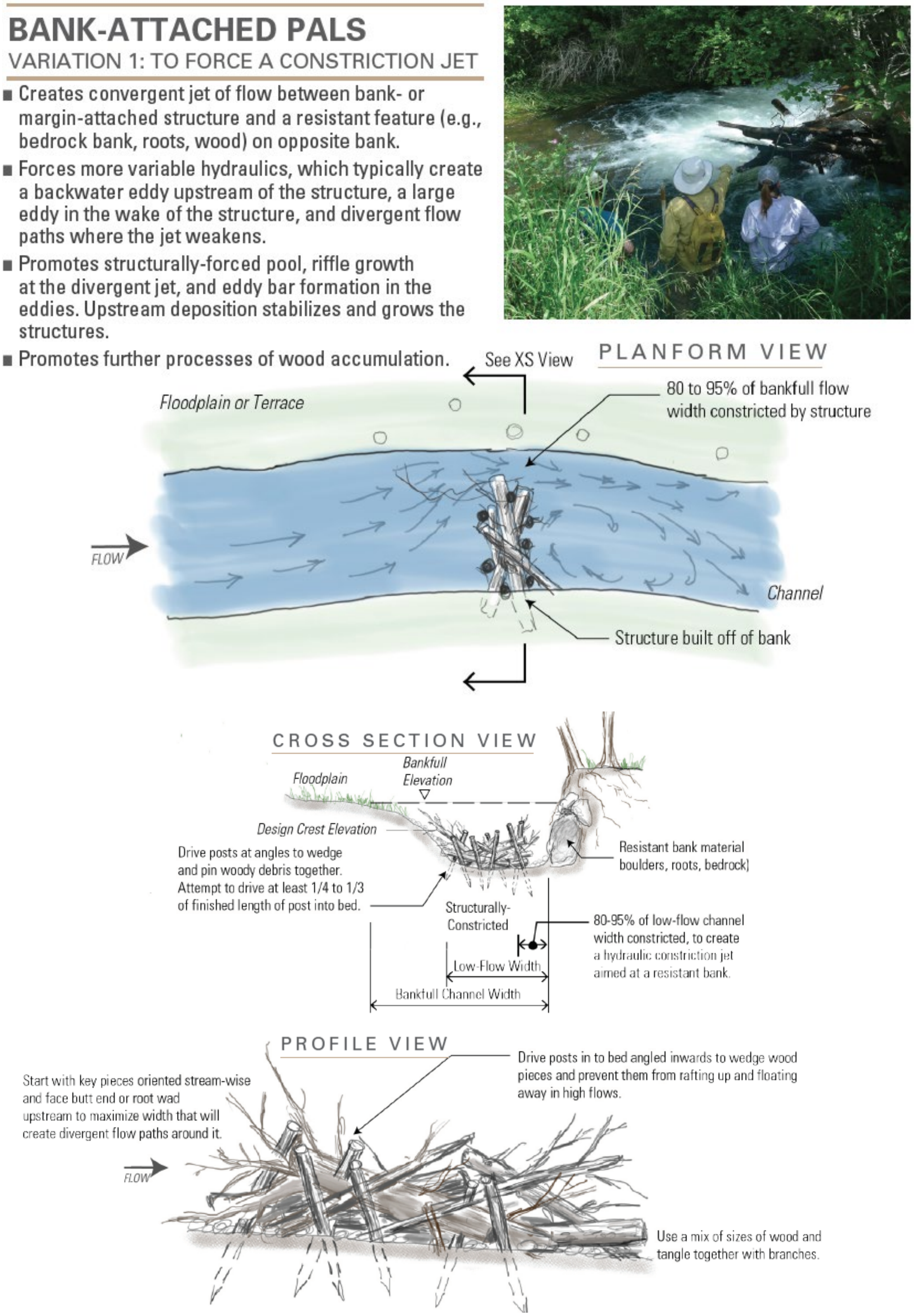
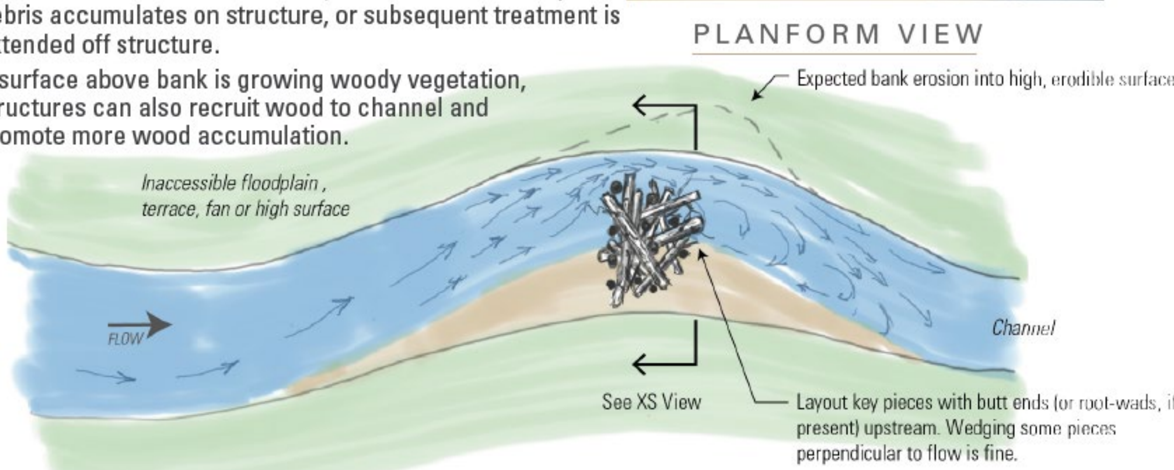


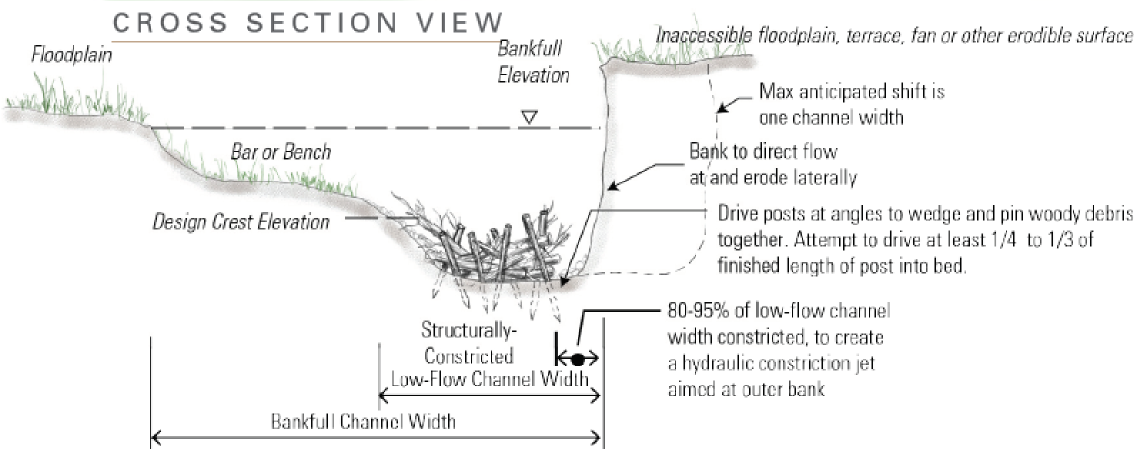
Figure 19. Typical schematic sketches of a bank-attached PALS intended to cause lateral channel migration through deposition of material on point and diagonal bars and erosion of high bank features. From Chapter 4 of Wheaton et al. (2019: http://lowtechpbr.restoration.usu.edu).

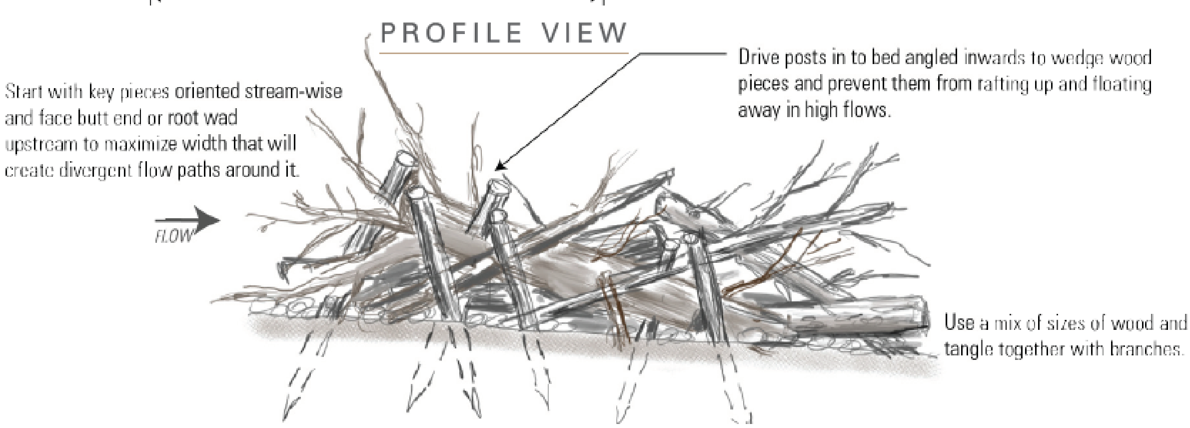
BANK-ATTACHED PALS:

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.







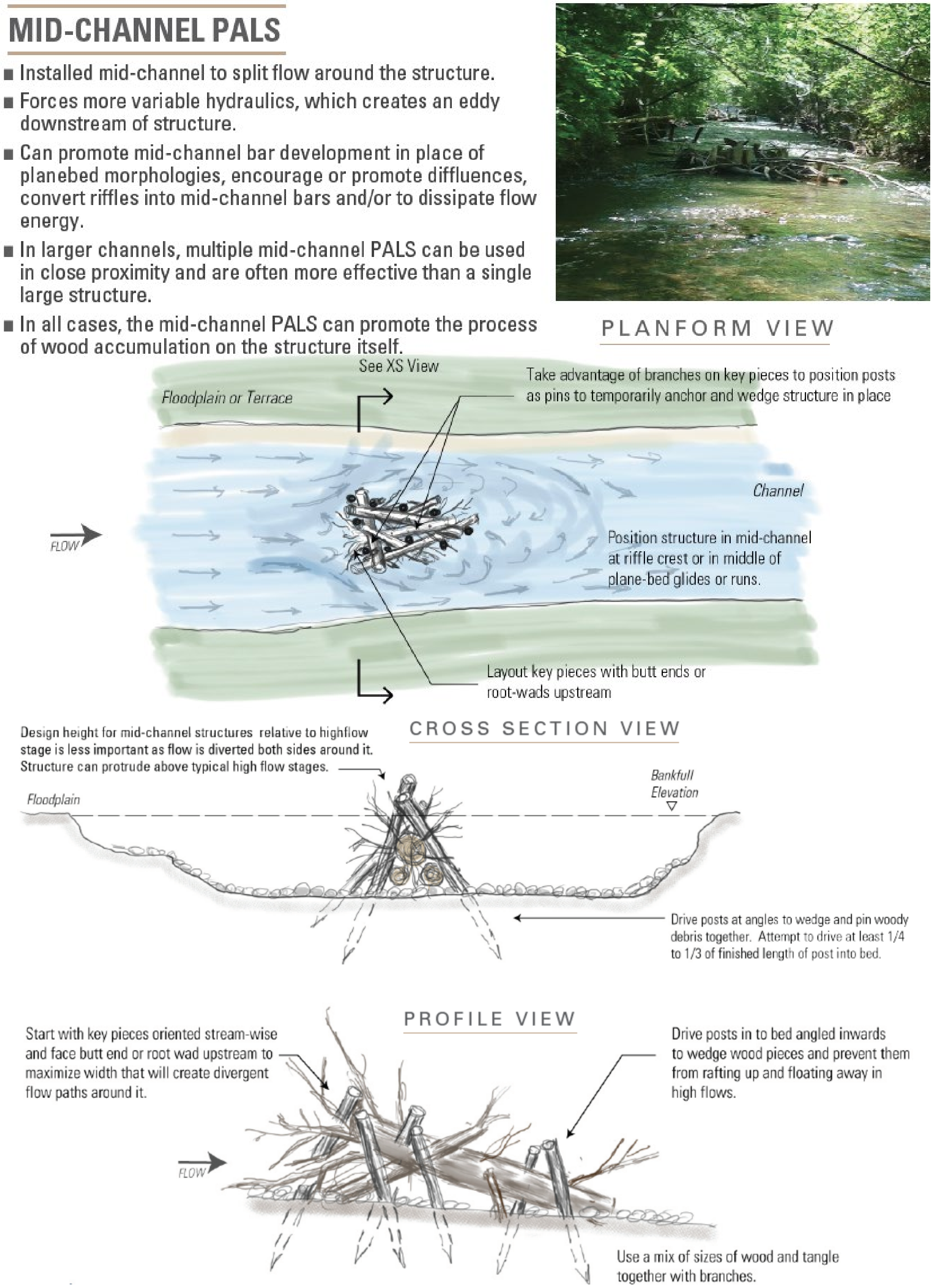


Figure 20. Typical schematics of a mid-channel PALS designed to induce channel complexity, encourage mid-channel deposition, and encourage channel avulsion. From Chapter 4 of Wheaton et al. (2019: http://lowtechpbr.restoration.usu.edu).

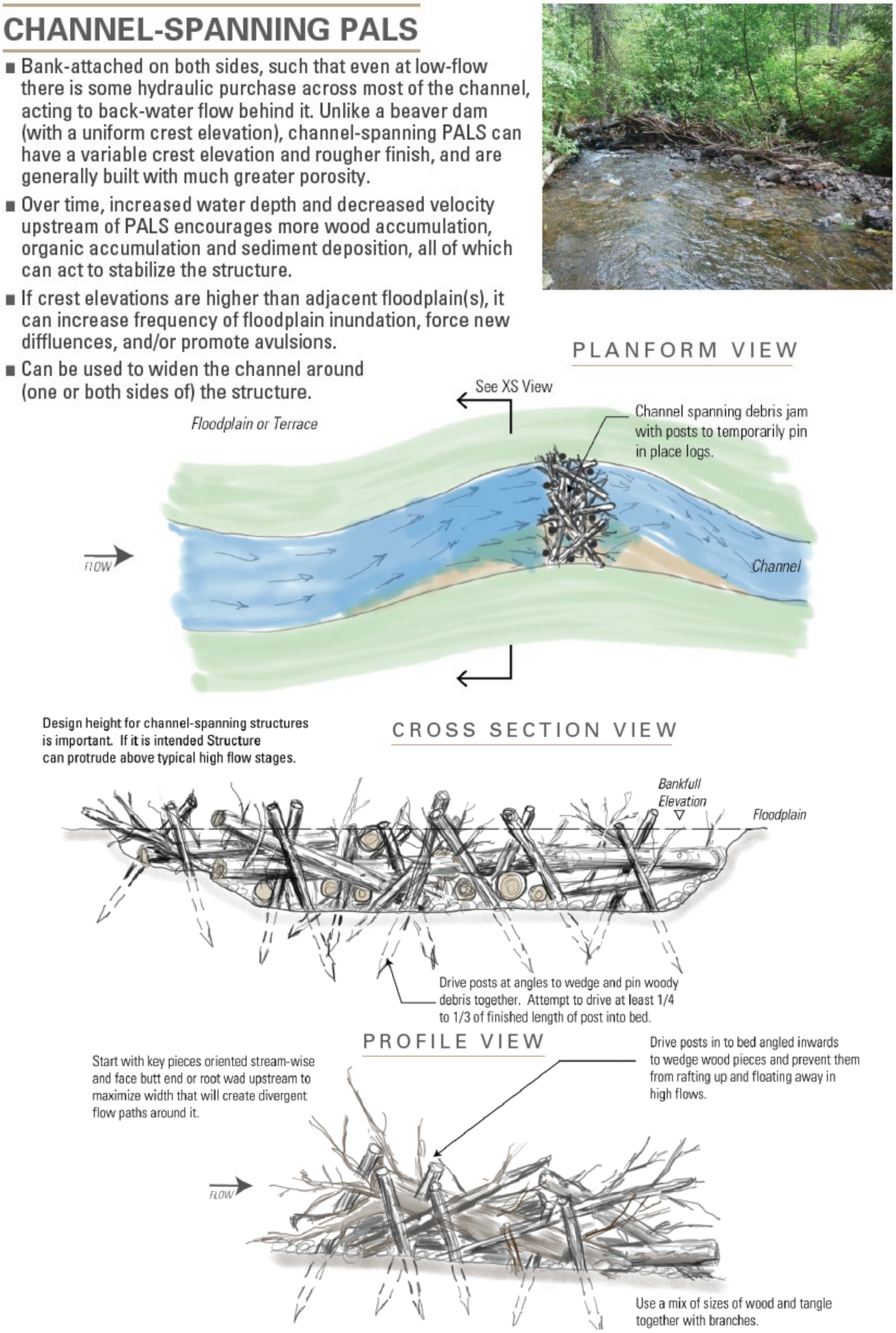


Figure 21. Typical schematics of a channel-spanning PALS. Channel spanning PALS are designed to be passable by fish at all flows. From Chapter 4 of Wheaton et al. (2019: http://lowtechpbr.restoration.usu.edu).

Figure 22. 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).

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

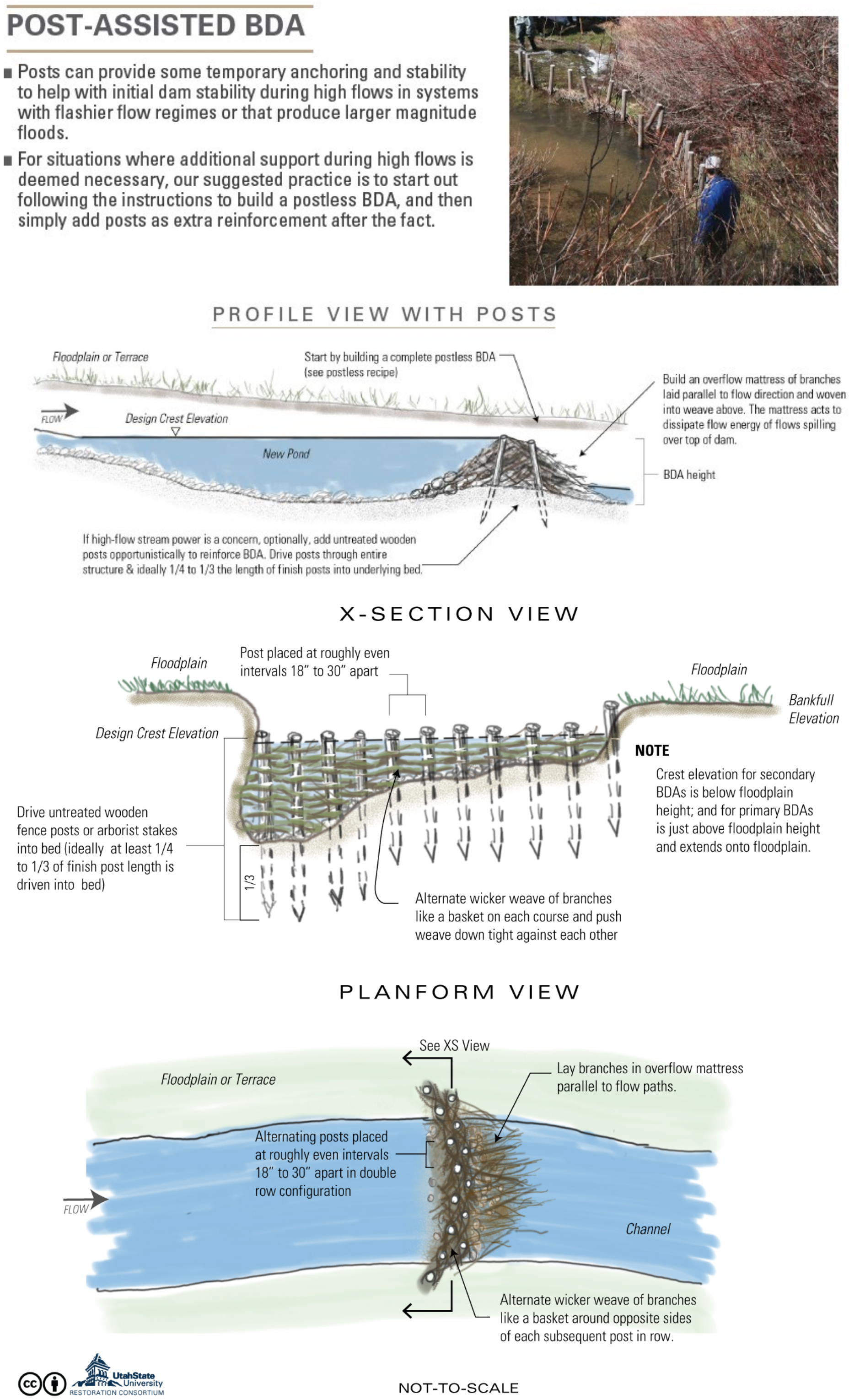


Figure 23. Profile schematic of post-assisted BDA. Given the potential flashy hydrograph within Tenmile Creek, BDAs will primarily be reinforced with posts. From Chapter 4 of Wheaton et al. (2019: http://lowtechpbr.restoration.usu.edu).

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.
Widening and Aggradation (Incision Recovery)	Generally a goal in straightened and/or incised reaches where overbank flow is difficult.	Sediment recruitment from incision trench walls. Roughness elements and channel widening decreases stream power and high flow velocity.	Widening when combined with roughness elements creates more available habitat for juvenile and adult salmonids.
Pond / Wetland Creation	Use of BDAs to force upstream ponding, creating slow, deep water habitat.	Ponded flow increases surface - groundwater exchange and water table elevation. Sediment deposition can often lead to channel aggradation and greater floodplain connectivity.	Water table elevation allows proliferation of riparian plant communities. Slow - water refugia creates ideal rearing conditions for early life-stages of many salmonid species and eventual beaver colonization. Deposition of fine sediment increases production of many invertebrate species.

APPENDIX F – DESIGN MAPS & STRUCTURE LOCATIONS

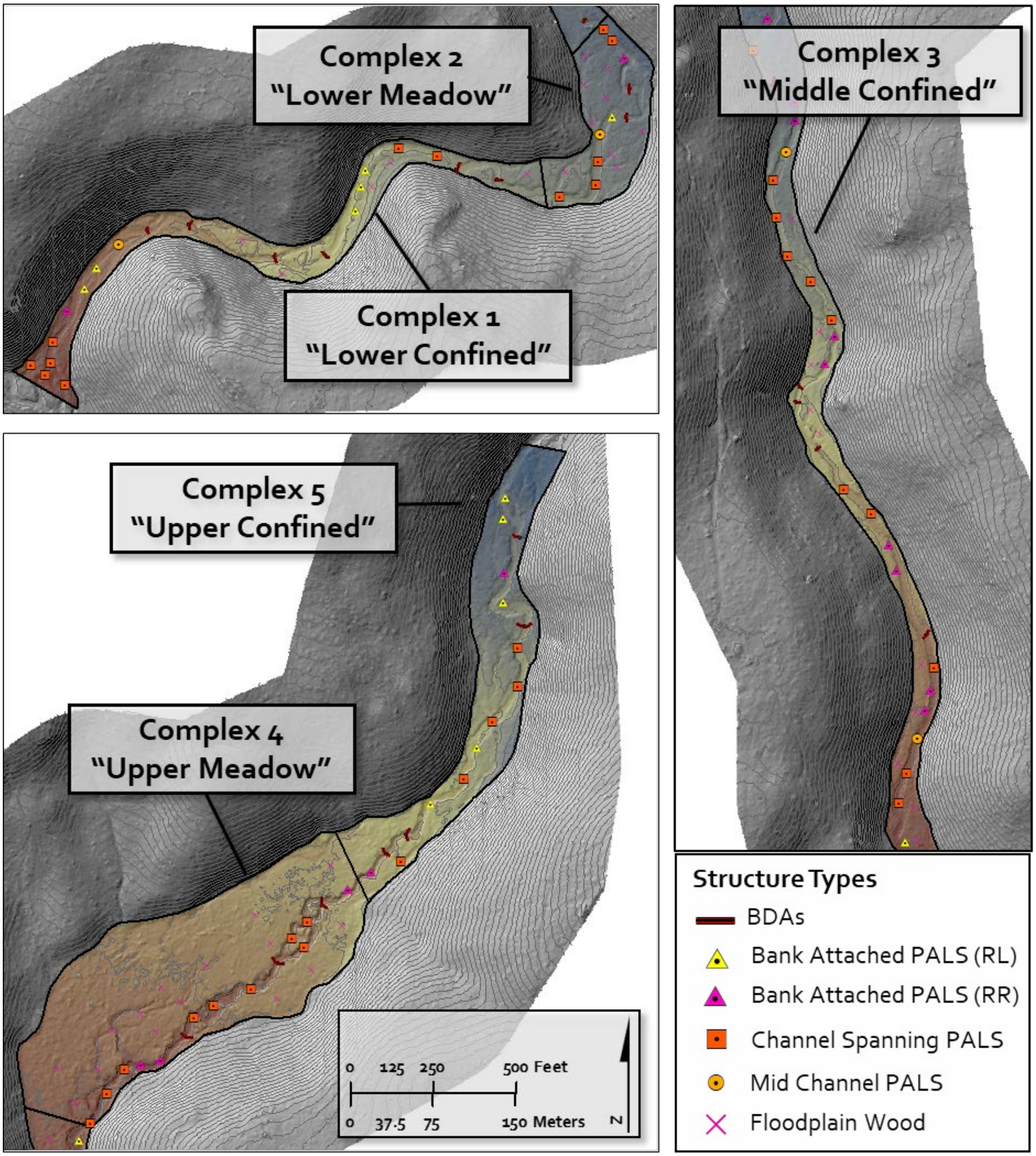


Figure 24. Restoration design outlining structure type and location for complexes on lower Tepee Creek. Structure coordinates can be found below in Table 8.

Table 8. List of individual structure type and location within each complex on Tepee Creek. All coordinates are for UTM Zone 10 N. The exact number, location, and type of individual structures is subject to change based on field conditions.

Complex Number	Structure ID	Structure Type	Easting	Northing
1	1	Channel Spanning PALS	648853	5109770
	2	Channel Spanning PALS	648836	5109779
	3	Channel Spanning PALS	648823	5109788
	4	Channel Spanning PALS	648841	5109790
	5	Channel Spanning PALS	648841	5109790
	6	Channel Spanning PALS	648843	5109809
	7	Channel Spanning PALS	648843	5109809
	8	Bank Attached PALS RR	648856	5109837
	9	Bank Attached PALS RL	648872	5109857
	10	Floodplain LWD	649050	5109871
	11	Bank Attached PALS RL	648882	5109875
	12	BDA	649042	5109886
	13	BDA	649089	5109886
	14	Mid Channel PALS	648903	5109897
	15	Floodplain LWD	649014	5109901
	16	BDA	648928	5109910
	17	BDA	648965	5109915
	18	Bank Attached PALS RL	649115	5109927
	19	Channel Spanning PALS	649299	5109940
	20	Floodplain LWD	649131	5109949
	21	Bank Attached PALS RL	649120	5109949
	22	Channel Spanning PALS	649332	5109950
2	23	BDA	649243	5109956
	24	Floodplain LWD	649270	5109960
	25	Floodplain LWD	649304	5109962
	26	Bank Attached PALS RL	649124	5109964
	27	BDA	649207	5109965
	28	Floodplain LWD	649352	5109966
	29	Channel Spanning PALS	649333	5109971
	30	Floodplain LWD	649147	5109972
	31	Channel Spanning PALS	649189	5109977
	32	Floodplain LWD	649346	5109978
	33	Channel Spanning PALS	649154	5109984
	34	Mid Channel PALS	649336	5109996
	35	Floodplain LWD	649374	5109999
	36	Floodplain LWD	649328	5110007
	37	Bank Attached PALS RL	649347	5110011
	38	BDA	649359	5110012
	39	Floodplain LWD	649342	5110030

Complex Number	Structure ID	Structure Type	Easting	Northing
	40	BDA	649362	5110038
	41	Floodplain LWD	649322	5110041
	42	Floodplain LWD	649342	5110056
	43	Bank Attached PALS RR	649357	5110065
	44	Floodplain LWD	649323	5110068
	45	Channel Spanning PALS	649347	5110082
	46	Channel Spanning PALS	649338	5110091
	47	BDA	649322	5110100
3	48	Floodplain LWD	649307	5110127
	49	Bank Attached PALS RL	649294	5110130
	50	Mid Channel PALS	649281	5110137
	51	Bank Attached PALS RL	649275	5110151
	52	Floodplain LWD	649285	5110153
	53	Floodplain LWD	649282	5110183
	54	Channel Spanning PALS	649268	5110186
	55	Channel Spanning PALS	649275	5110213
	56	Floodplain LWD	649268	5110223
	57	Mid Channel PALS	649285	5110244
	58	Floodplain LWD	649284	5110268
	59	Bank Attached PALS RR	649292	5110270
	60	Bank Attached PALS RR	649298	5110289
	61	Channel Spanning PALS	649300	5110309
	62	Floodplain LWD	649289	5110311
	63	BDA	649293	5110338
	64	Bank Attached PALS RR	649267	5110396
	65	Bank Attached PALS RR	649260	5110420
	66	Channel Spanning PALS	649243	5110448
	67	Channel Spanning PALS	649218	5110470
	68	BDA	649196	5110507
	69	Floodplain LWD	649197	5110521
	70	Floodplain LWD	649189	5110542
	71	BDA	649176	5110549
	72	BDA	649180	5110562
	73	Floodplain LWD	649190	5110582
	74	Bank Attached PALS RR	649201	5110584
	75	Bank Attached PALS RR	649211	5110608
	76	Floodplain LWD	649196	5110613
	77	Channel Spanning PALS	649207	5110623
	78	Channel Spanning PALS	649189	5110658
	79	Channel Spanning PALS	649169	5110680
	80	Floodplain LWD	649172	5110714

Complex Number	Structure ID	Structure Type	Easting	Northing
	81	Channel Spanning PALS	649158	5110716
	82	Channel Spanning PALS	649156	5110749
	83	Mid Channel PALS	649167	5110775
	84	Bank Attached PALS RR	649175	5110803
	85	Floodplain LWD	649166	5110816
	86	Bank Attached PALS RR	649175	5110820
	87	BDA	649156	5110839
	88	Floodplain LWD	649176	5110840
	89	Channel Spanning PALS	649138	5110866
	90	Floodplain LWD	649163	5110872
	91	Bank Attached PALS RR	649150	5110895
	92	Bank Attached PALS RL	649158	5110923
	93	Floodplain LWD	649131	5110924
4	94	Channel Spanning PALS	649169	5110939
	95	Floodplain LWD	649154	5110957
	96	Channel Spanning PALS	649183	5110965
	97	Floodplain LWD	649140	5110988
	98	Channel Spanning PALS	649199	5110988
	99	Floodplain LWD	649175	5110988
	100	Bank Attached PALS RR	649214	5110991
	101	Bank Attached PALS RR	649232	5110996
	102	BDA	649255	5111016
	103	Floodplain LWD	649228	5111021
	104	Floodplain LWD	649188	5111022
	105	Channel Spanning PALS	649261	5111034
	106	Floodplain LWD	649214	5111038
	107	Channel Spanning PALS	649280	5111045
	108	Floodplain LWD	649249	5111049
	109	Floodplain LWD	649337	5111051
	110	Channel Spanning PALS	649313	5111060
	111	Floodplain LWD	649232	5111062
	112	Floodplain LWD	649368	5111078
	113	Floodplain LWD	649274	5111082
	114	BDA	649337	5111083
	115	Channel Spanning PALS	649361	5111098
	116	Floodplain LWD	649331	5111101
	117	Channel Spanning PALS	649350	5111106
	118	Floodplain LWD	649396	5111117
	119	Channel Spanning PALS	649364	5111120
	120	Floodplain LWD	649317	5111126
	121	BDA	649377	5111136

Complex Number	Structure ID	Structure Type	Easting	Northing
	122	Bank Attached PALS RR	649401	5111150
	123	Bank Attached PALS RR	649421	5111165
	124	Floodplain LWD	649386	5111171
5	125	Channel Spanning PALS	649448	5111175
	126	BDA	649435	5111182
	127	BDA	649453	5111199
	128	Bank Attached PALS RL	649475	5111227
	129	Channel Spanning PALS	649504	5111250
	130	Bank Attached PALS RL	649516	5111277
	131	Channel Spanning PALS	649530	5111302
	132	Channel Spanning PALS	649553	5111333
	133	Channel Spanning PALS	649554	5111368
	134	BDA	649559	5111387
	135	Bank Attached PALS RL	649540	5111408
	136	Bank Attached PALS RR	649541	5111435
	137	BDA	649555	5111468
	138	Bank Attached PALS RL	649540	5111484
	139	Bank Attached PALS RL	649542	5111503

APPENDIX G - 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 H - HIP GENERAL CONSERVATION AND IMPLEMENTATION MEASURES

HIP GENERAL CONSERVATION MEASURES APPLICABLE TO ALL ACTIONS

THE ACTIVITIES COVERED UNDER THE HIP ARE INTENDED TO PROTECT AND RESTORE FISH AND WILDLIFE HABITAT WITH LONG-TERM BENEFITS TO ESA-LISTED SPECIES. THE FOLLOWING GENERAL CONSERVATION MEASURES (DEVELOPED IN COORDINATION WITH USFWS AND NMFS) WILL BE APPLIED TO ALL ACTIONS OF THIS PROJECT.

PROJECT DESIGN AND SITE PREPARATION.

1. STATE AND FEDERAL PERMITS.

A. ALL APPLICABLE REGULATORY PERMITS AND OFFICIAL PROJECT AUTHORIZATIONS WILL BE OBTAINED BEFORE PROJECT IMPLEMENTATION.

B. THESE PERMITS AND AUTHORIZATIONS INCLUDE, BUT ARE NOT LIMITED TO, NATIONAL ENVIRONMENTAL POLICY ACT, NATIONAL HISTORIC PRESERVATION ACT, THE APPROPRIATE STATE AGENCY REMOVAL AND FILL PERMIT, USACE CLEAN WATER ACT (CWA) 404 PERMITS, CWA SECTION 401 WATER QUALITY CERTIFICATIONS, AND FEMA NO-RISE ANALYSES.

2. TIMING OF IN-WATER WORK.

A. 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 (IWW) WILL BE FOLLOWED.

B. CHANGES TO ESTABLISHED WORK WINDOWS WILL BE APPROVED BY REGIONAL STATE BIOLOGISTS AND BPA'S EC LEAD.

C. BULL TROUT. FOR AREAS WITH DESIGNATED IN-WATER WORK WINDOWS FOR BULL TROUT OR AREAS KNOWN TO HAVE BULL TROUT, 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.

D. LAMPREY. WORKING IN STREAM OR RIVER CHANNELS THAT CONTAIN PACIFIC LAMPREY WILL BE AVOIDED FROM MARCH 1 TO JULY 1 FOR REACHES <5,000 FEET IN ELEVATION AND FROM MARCH 1 TO AUGUST 1 FOR REACHES >5,000 FEET. IF EITHER TIMEFRAME IS INCOMPATIBLE WITH OTHER OBJECTIVES, THE AREA WILL BE SURVEYED FOR NESTS AND LAMPREY PRESENCE, AND AVOIDED IF POSSIBLE. IF LAMPREYS ARE KNOWN TO EXIST, THE PROJECT SPONSOR WILL UTILIZE DEWATERING AND SALVAGE PROCEDURES (SEE FISH SALVAGE AND ELECTROFISHING SECTIONS) TO MINIMIZE ADVERSE EFFECTS.

E. THE IN-WATER WORK WINDOW WILL BE PROVIDED IN THE CONSTRUCTION PLANS.

3. CONTAMINANTS.

A. EXCAVATION OF MORE THAN 20 CUBIC YARDS WILL REQUIRE A SITE VISIT AND DOCUMENTED ASSESSMENT FOR POTENTIAL CONTAMINANT SOURCES. THE SITE ASSESSMENT WILL BE STORED WITH PROJECT FILES OR AS AN APPENDIX TO THE BASIS OF DESIGN REPORT.

B. THE SITE ASSESSMENT WILL SUMMARIZE:

1. THE SITE VISIT, CONDITION OF THE PROPERTY, AND IDENTIFICATION OF ANY AREAS USED FOR VARIOUS INDUSTRIAL PROCESSES;
2. AVAILABLE RECORDS, SUCH AS FORMER SITE USE, BUILDING PLANS, AND RECORDS OF ANY PRIOR CONTAMINATION EVENTS;
3. INTERVIEWS WITH KNOWLEDGEABLE PEOPLE, SUCH AS SITE OWNERS, OPERATORS, OCCUPANTS, NEIGHBORS, OR LOCAL GOVERNMENT OFFICIALS; AND
4. THE TYPE, QUANTITY, AND EXTENT OF ANY POTENTIAL CONTAMINATION SOURCES.

4. SITE LAYOUT AND FLAGGING.

A. CONSTRUCTION AREAS TO BE CLEARLY FLAGGED PRIOR TO CONSTRUCTION.

B. AREAS TO BE FLAGGED WILL INCLUDE:

1. SENSITIVE RESOURCE AREAS, SUCH AS AREAS BELOW ORDINARY HIGH WATER, SPAWNING AREAS, SPRINGS, AND WETLANDS;
2. EQUIPMENT ENTRY AND EXIT POINTS;
3. ROAD AND STREAM CROSSING ALIGNMENTS;
4. STAGING, STORAGE, AND STOCKPILE AREAS; AND
5. NO-SPRAY AREAS AND BUFFERS.

5. TEMPORARY ACCESS ROADS AND PATHS.

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.

B. VEHICLE USE AND HUMAN ACTIVITIES, INCLUDING WALKING, IN AREAS OCCUPIED BY TERRESTRIAL ESA-LISTED SPECIES WILL BE MINIMIZED.

C. 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.

D. 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).

E. 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.

F. HELICOPTER FLIGHT PATTERNS WILL BE ESTABLISHED IN ADVANCE AND LOCATED TO AVOID TERRESTRIAL ESA-LISTED SPECIES AND THEIR OCCUPIED HABITAT DURING SENSITIVE LIFE STAGES.

6. TEMPORARY STREAM CROSSINGS.

A. EXISTING STREAM CROSSINGS OR BEDROCK WILL BE PREFERENTIALLY USED WHENEVER REASONABLE, AND THE NUMBER OF TEMPORARY STREAM CROSSINGS WILL BE MINIMIZED.

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 DIRECTLY OVER WATER.

C. FOR PROJECTS THAT REQUIRE EQUIPMENT AND VEHICLES TO CROSS IN THE WET:

1. THE LOCATION AND NUMBER OF ALL WET CROSSINGS SHALL BE APPROVED BY THE BPA EC LEAD AND DOCUMENTED IN THE CONSTRUCTION PLANS;
2. VEHICLES AND MACHINERY SHALL CROSS STREAMS AT RIGHT ANGLES TO THE MAIN CHANNEL WHENEVER POSSIBLE;
3. NO STREAM CROSSINGS WILL OCCUR 300 FEET UPSTREAM OR 100 FEET DOWNSTREAM OF AN EXISTING REDD OR SPAWNING FISH; AND
4. AFTER PROJECT COMPLETION, TEMPORARY STREAM CROSSINGS WILL BE OBLITERATED AND BANKS RESTORED.

7. STAGING, STORAGE, AND STOCKPILE AREAS.

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. STAGING AREAS CLOSER THAN 150 FEET WILL BE APPROVED BY THE EC LEAD.

B. NATURAL MATERIALS USED FOR IMPLEMENTATION OF AQUATIC RESTORATION, SUCH AS LARGE WOOD, GRAVEL, AND BOULDERS, MAY BE STAGED WITHIN 150 FEET IF CLEARLY INDICATED IN THE PLANS THAT AREA IS FOR NATURAL MATERIALS ONLY.

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.

D. ANY MATERIAL NOT USED IN RESTORATION, AND NOT NATIVE TO THE FLOODPLAIN, WILL BE DISPOSED OF OUTSIDE THE 100-YEAR FLOODPLAIN.

8. EQUIPMENT.

A. 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).

B. EQUIPMENT WILL BE STORED, FUELED, AND MAINTAINED IN AN CLEARLY IDENTIFIED STAGING AREA THAT MEETS STAGING AREA CONSERVATION MEASURES.

C. EQUIPMENT WILL BE REFUELED IN A VEHICLE STAGING AREA 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).

D. BIODEGRADABLE LUBRICANTS AND FLUIDS WILL BE USED ON EQUIPMENT OPERATING IN AND ADJACENT TO THE STREAM CHANNEL AND LIVE WATER.

E. EQUIPMENT WILL BE INSPECTED DAILY FOR FLUID LEAKS BEFORE LEAVING THE VEHICLE STAGING AREA FOR OPERATION WITHIN 150 FEET OF ANY NATURAL WATER BODY OR WETLAND.

F. EQUIPMENT WILL BE THOROUGHLY CLEANED BEFORE OPERATION BELOW ORDINARY HIGH WATER, AND AS OFTEN AS NECESSARY DURING OPERATION, TO REMAIN GREASE FREE.

9. EROSION CONTROL.

A. TEMPORARY EROSION CONTROL MEASURES INCLUDE:

1. TEMPORARY EROSION CONTROLS WILL BE IN PLACE BEFORE ANY SIGNIFICANT ALTERATION OF THE ACTION SITE AND APPROPRIATELY INSTALLED DOWNSLOPE OF PROJECT ACTIVITY WITHIN THE RIPARIAN BUFFER AREA UNTIL SITE REHABILITATION IS COMPLETE;
2. 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;
3. TEMPORARY EROSION CONTROL MEASURES MAY INCLUDE SEDGE MATS, FIBER WATTLES, SILT FENCES, JUTE MATTING, WOOD FIBER MULCH AND SOIL BINDER, OR GEOTEXTILES AND GEOSYNTHETIC FABRIC;
4. 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;
5. SEDIMENT WILL BE REMOVED FROM EROSION CONTROLS ONCE IT HAS REACHED 1/3 OF THE EXPOSED HEIGHT OF THE CONTROL; AND
6. ONCE THE SITE IS STABILIZED AFTER CONSTRUCTION, TEMPORARY EROSION CONTROL MEASURES WILL BE REMOVED.

B. EMERGENCY EROSION CONTROLS. THE FOLLOWING MATERIALS FOR EMERGENCY EROSION CONTROL WILL BE AVAILABLE AT THE WORK SITE:

1. A SUPPLY OF SEDIMENT CONTROL MATERIALS; AND
2. AN OIL-ABSORBING FLOATING BOOM WHENEVER SURFACE WATER IS PRESENT.

10. DUST ABATEMENT.

A. 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.

B. WORK WILL BE SEQUENCED AND SCHEDULED TO REDUCE EXPOSED BARE SOIL SUBJECT TO WIND EROSION.

C. 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 MIXED 50:50 WITH WATER.

D. 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).

E. SPILL CONTAINMENT EQUIPMENT WILL BE AVAILABLE DURING APPLICATION OF DUST ABATEMENT CHEMICALS.

F. PETROLEUM-BASED PRODUCTS WILL NOT BE USED FOR DUST ABATEMENT.

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PROJECT DESIGN AND SITE PREPARATION (CONTINUED).

11. SPILL PREVENTION, CONTROL, AND COUNTER MEASURES.

A. A DESCRIPTION OF HAZARDOUS MATERIALS THAT WILL BE USED, INCLUDING INVENTORY, STORAGE, AND HANDLING PROCEDURES WILL BE AVAILABLE ON-SITE.

B. WRITTEN PROCEDURES FOR NOTIFYING ENVIRONMENTAL RESPONSE AGENCIES WILL BE POSTED AT THE WORK SITE.

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.

D. WORKERS WILL BE TRAINED IN SPILL CONTAINMENT PROCEDURES AND WILL BE INFORMED OF THE LOCATION OF SPILL CONTAINMENT KITS.

E. ANY WASTE LIQUIDS GENERATED AT THE STAGING AREAS WILL BE TEMPORARILY STORED UNDER AN IMPERVIOUS COVER, SUCH AS A TARPAULIN, UNTIL THEY CAN BE PROPERLY TRANSPORTED TO AND DISPOSED OF AT A FACILITY THAT IS APPROVED FOR RECEIPT OF HAZARDOUS MATERIALS.

F. PUMPS USED ADJACENT TO WATER SHALL USE SPILL CONTAINMENT SYSTEMS.

12. INVASIVE SPECIES CONTROL.

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.

B. WATERCRAFT, WADERS, BOOTS, AND ANY OTHER GEAR TO BE USED IN OR NEAR WATER WILL BE INSPECTED FOR AQUATIC INVASIVE SPECIES.

C. WADING BOOTS WITH FELT SOLES ARE NOT TO BE USED DUE TO THEIR PROPENSITY FOR AIDING IN THE TRANSFER OF INVASIVE SPECIES UNLESS DECONTAMINATION PROCEDURES HAVE BEEN APPROVED BY THE EC LEAD.

WORK AREA ISOLATION AND FISH SALVAGE.

1. WORK AREA ISOLATION.

A. ANY WORK AREA WITHIN THE WETTED CHANNEL WILL BE ISOLATED FROM THE ACTIVE STREAM WHENEVER ESA-LISTED FISH ARE REASONABLY CERTAIN TO BE PRESENT, OR IF THE WORK AREA IS LESS THAN 300-FEET UPSTREAM FROM KNOWN SPAWNING HABITATS.

B. WORK AREA ISOLATION AND FISH SALVAGE ACTIVITIES WILL COMPLY WITH THE IN-WATER WORK WINDOW.

C. DESIGN PLANS WILL INCLUDE ALL ISOLATION ELEMENTS AND AREAS (COFFER DAMS, PUMPS, DISCHARGE AREAS, FISH SCREENS, FISH RELEASE AREAS, ETC.).

D. 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.

2. FISH SALVAGE.

A. MONITORING AND RECORDING WILL TAKE PLACE FOR DURATION OF SALVAGE. THE SALVAGE REPORT WILL BE COMMUNICATED TO AGENCIES VIA THE PROJECT COMPLETION FORM (PCF).

B. SALVAGE ACTIVITIES SHOULD TAKE PLACE DURING CONDITIONS TO MINIMIZE STRESS TO FISH SPECIES, TYPICALLY PERIODS OF THE COOLEST AIR AND WATER TEMPERATURES WHICH OCCUR IN THE MORNING VERSUS LATE IN THE DAY.

C. SALVAGE OPERATIONS WILL FOLLOW THE ORDERING, METHODS, AND CONSERVATION MEASURES SPECIFIED BELOW:

1. SLOWLY REDUCE WATER FROM THE WORK AREA TO ALLOW SOME FISH TO LEAVE VOLITIONALLY.
2. BLOCK NETS WILL BE INSTALLED AT UPSTREAM AND DOWNSTREAM LOCATIONS AND MAINTAINED IN A SECURED POSITION TO EXCLUDE FISH FROM ENTERING THE PROJECT AREA.
3. 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 AS LONG AS PASSAGE REQUIREMENTS ARE MET.
4. NETS WILL BE MONITORED HOURLY DURING IN-STREAM DISTURBANCE.
5. IF BLOCK NETS REMAIN IN PLACE MORE THAN ONE DAY, THE NETS WILL BE MONITORED AT LEAST DAILY TO ENSURE THEY ARE SECURED AND FREE OF ORGANIC ACCUMULATION. IF BULL TROUT ARE PRESENT, NETS ARE TO BE CHECKED EVERY 4 HOURS FOR FISH IMPINGEMENT.
6. CAPTURE FISH THROUGH SEINING AND RELOCATE TO STREAMS.
7. WHILE DEWATERING, ANY REMAINING FISH WILL BE COLLECTED BY HAND OR DIP NETS.
8. SEINES WITH A MESH SIZE TO ENSURE CAPTURE OF THE RESIDING ESA-LISTED FISH WILL BE USED.
9. MINNOW TRAPS WILL BE LEFT IN PLACE OVERNIGHT AND USED IN CONJUNCTION WITH SEINING.
10. ELECTROFISH TO CAPTURE AND RELOCATED FISH NOT CAUGHT DURING SEINING PER ELECTROFISH CONSERVATION MEASURES.
11. CONTINUE TO SLOWLY DEWATER STREAM REACH.
12. COLLECT ANY REMAINING FISH IN COLD-WATER BUCKETS AND RELOCATED TO THE STREAM.
13. LIMIT THE TIME FISH ARE IN A TRANSPORT BUCKET.
14. MINIMIZE PREDATION BY TRANSPORTING COMPARABLE SIZES IN BUCKETS.
15. BUCKET WATER TO BE CHANGED EVERY 15 MINUTES OR AERATED.
16. BUCKETS WILL BE KEPT IN SHADED AREAS OR COVERED.
17. DEAD FISH WILL NOT BE STORED IN TRANSPORT BUCKETS, BUT WILL BE LEFT ON THE STREAM BANK TO AVOID MORTALITY COUNTING ERRORS.

D. SALVAGE GUIDELINES FOR BULL TROUT, LAMPREY, MUSSELS, AND NATIVE FISH.

1. CONDUCT SITE SURVEY TO ESTIMATE SALVAGE NUMBERS.
2. PRE-SELECT SITE(S) FOR RELEASE AND/OR MUSSEL BED RELOCATION.
3. SALVAGE OF BULL TROUT WILL NOT TAKE PLACE WHEN WATER TEMPERATURES EXCEED 15 DEGREES CELSIUS.
4. IF DRAWDOWN LESS THAN 48 HOURS, SALVAGE OF LAMPREY AND MUSSELS MAY NOT BE NECESSARY IF TEMPERATURES SUPPORT SURVIVAL IN SEDIMENTS.
5. SALVAGE MUSSELS BY HAND, LOCATING BY SNORKELING OR WADING.
6. SALVAGE LAMPREY BY ELECTROFISHING (SEE ELECTROFISHING FOR LARVAL LAMPREY SETTINGS AND LARVAL LAMPREY DRY SHOCKING SETTINGS).
7. SALVAGE BONY FISH AFTER LAMPREY WITH NETS OR ELECTROFISHING (SEE ELECTROFISHING FOR APPROPRIATE SETTINGS).
8. REGULARLY INSPECT DEWATERED SITE SINCE LAMPREY LIKELY TO EMERGE AFTER DEWATERING AND MUSSELS MAY BECOME VISIBLE.
9. MUSSELS MAY BE TRANSFERRED IN COOLERS.
10. MUSSELS WILL BE PLACED INDIVIDUALLY TO ENSURE ABILITY TO BURROW INTO NEW HABITAT.

3. ELECTROFISHING.

A. INITIAL SITE SURVEY AND INITIAL SETTINGS.

1. IDENTIFY SPAWNING ADULTS AND ACTIVE REDDS TO AVOID.
2. RECORD WATER TEMPERATURE. ELECTROFISHING WILL NOT OCCUR WHEN WATER TEMPERATURES ARE ABOVE 18 DEGREES CELSIUS.
3. IF POSSIBLE, A BLOCK NET WILL BE PLACED DOWNSTREAM AND CHECKED REGULARLY TO CAPTURE STUNNED FISH THAT DRIFT DOWNSTREAM.
4. INITIAL SETTINGS WILL BE 100 VOLTS, PULSE WIDTH OF 500 MICRO SECONDS, AND PULSE RATE OF 30 HERTZ.
5. RECORDS FOR CONDUCTIVITY, WATER TEMPERATURE, AIR TEMPERATURE, ELECTROFISHING SETTINGS, ELECTROFISHER MODEL, ELECTROFISHER CALIBRATION, FISH CONDITIONS, FISH MORTALITIES, AND TOTAL CAPTURE RATES WILL BE INCLUDED IN THE SALVAGE LOG BOOK.

B. ELECTROFISHING TECHNIQUE.

1. SAMPLING SHOULD BEGIN USING STRAIGHT DC. POWER WILL REMAIN ON UNTIL THE FISH IS NETTED WHEN USING STRAIGHT DC. GRADUALLY INCREASE VOLTAGE WHILE REMAINING BELOW MAXIMUM LEVELS.
2. MAXIMUM VOLTAGE WILL BE 1100 VOLTS WHEN CONDUCTIVITY IS <100 MILLISECONDS, 800 VOLTS WHEN CONDUCTIVITY IS BETWEEN 100 AND 300 MILLISECONDS, AND 400 VOLTS WHEN CONDUCTIVITY IS >300 MILLISECONDS.
3. IF FISH CAPTURE IS NOT SUCCESSFUL USING STRAIGHT DC, THE ELECTROFISHER WILL BE SET TO INITIAL VOLTAGE FOR PDC. VOLTAGE, PULSE WIDTH, AND PULSE FREQUENCY WILL BE GRADUALLY INCREASED WITHIN MAXIMUM VALUES UNTIL CAPTURE IS SUCCESSFUL.
4. MAXIMUM PULSE WIDTH IS 5 MILLISECONDS. MAXIMUM PULSE RATE IS 70 HERTZ
5. ELECTROFISHING WILL NOT OCCUR IN ONE AREA FOR AN EXTENDED PERIOD.
6. THE ANODE WILL NOT INTENTIONALLY COME INTO CONTACT WITH FISH. THE ZONE FOR POTENTIAL INJURY OF 0.5 M FROM THE ANODE WILL BE AVOIDED.
7. SETTINGS WILL BE LOWERED IN SHALLOWER WATER SINCE VOLTAGE GRADIENTS LIKELY TO INCREASE.
8. ELECTROFISHING WILL NOT OCCUR IN TURBID WATER WHERE VISIBILITY IS POOR (I.E. UNABLE TO SEE THE BED OF THE STREAM).
9. OPERATIONS WILL IMMEDIATELY STOP IF MORTALITY OR OBVIOUS FISH INJURY IS OBSERVED. ELECTROFISHING SETTINGS WILL BE REEVALUATED.

C. SAMPLE PROCESSING.

1. FISH SHALL BE SORTED BY SIZE TO AVOID PREDATION DURING CONTAINMENT.
2. SAMPLERS WILL REGULARLY CHECK CONDITIONS OF FISH HOLDING CONTAINERS, AIR PUMPS, WATER TRANSFERS, ETC.
3. FISH WILL BE OBSERVED FOR GENERAL CONDITIONS AND INJURIES
4. EACH FISH WILL BE COMPLETELY REVIVED BEFORE RELEASE. ESA-LISTED SPECIES WILL BE PRIORITIZED FOR SUCCESSFUL RELEASE.

D. BULL TROUT ELECTROFISHING.

1. ELECTROFISHING FOR BULL TROUT WILL ONLY OCCUR FROM MAY 1 TO JULY 31. NO ELECTROFISHING WILL OCCUR IN ANY BULL TROUT OCCUPIED HABITAT AFTER AUGUST 15. IN FMO HABITATS ELECTROFISHING MAY OCCUR ANY TIME.
2. ELECTROFISHING OF BULL TROUT WILL NOT OCCUR WHEN WATER TEMPERATURES EXCEED 15 DEGREES CELSIUS.

E. LARVAL LAMPREY ELECTROFISHING.

1. PERMISSION FROM EC LEAD WILL BE OBTAINED IF LARVAL LAMPREY ELECTROFISHER IS NOT ONE OF FOLLOWING PRE-APPROVED MODELS: ABP-2 "WISCONSIN", SMITH-ROOT LR-24, OR SMITH-ROOT APEX BACKPACK.
2. LARVAL LAMPREY SAMPLING WILL INCORPORATE 2-STAGE METHOD: "TICKLE" AND "STUN".
3. FIRST STAGE: USE 125 VOLT DC WITH A 25 PERCENT DUTY CYCLE APPLIED AT A SLOW RATE OF 3 PULSES PER SECOND. IF TEMPERATURES ARE BELOW 10 DEGREES CELSIUS, VOLTAGE MAY BE INCREASED GRADUALLY (NOT TO EXCEED 200 VOLTS). BURSTED PULSES (THREE SLOW AND ONE SKIPPED) RECOMMENDED TO INCREASE EMERGENCE.
4. SECOND STAGE (OPTIONAL FOR EXPERIENCED NETTERS): IMMEDIATELY AFTER LAMPREY EMERGE, USE A FAST PULSE SETTING OF 30 PULSES PER SECOND.
5. USE DIP NETS FOR VISIBLE LAMPREY. SIENES AND FINE MESH NET SWEEPS MAY BE USED IN POOR VISIBILITY.
6. SAMPLING WILL OCCUR SLOWLY (>60 SECONDS PER METER) STARTING AT UPSTREAM AND WORKING DOWNSTREAM.
7. MULTIPLE SWEEPS TO OCCUR WITH 15 MINUTES BETWEEN SWEEPS.
8. POST-DRAWDOWN "DRY-SHOCKING" WILL BE APPLIED IF LARVAL LAMPREY CONTINUE TO EMERGE. ANODES TO BE PLACED ONE METER APART TO SAMPLE ONE SQUARE METER AT A TIME FOR AT LEAST 60 SECONDS. FOR TEMPERATURES LESS THAN 10 DEGREES CELSIUS, MAXIMUM VOLTAGE MAY BE GRADUALLY INCREASED TO 400 VOLTS (DRY-SHOCKING ONLY).

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WORK AREA ISOLATION AND FISH SALVAGE (CONTINUED).

4. DEWATERING.

A. DEWATERING WILL OCCUR AT A RATE SLOW ENOUGH TO ALLOW SPECIES TO NATURALLY MIGRATE OUT OF THE WORK AREA.

B. WHERE A GRAVITY FEED DIVERSION IS NOT POSSIBLE, A PUMP MAY BE USED. PUMPS WILL BE INSTALLED TO AVOID REPETIVE DEWATERING AND REWATERING.

C. WHEN FISH ARE PRESENT, PUMPS WILL BE SCREENED IN ACCORDANCE WITH NMFS FISH SCREEN CRITERIA. NMFS ENGINEERING REVIEW AND APPROVAL WILL BE OBTAINED FOR PUMPS EXCEEDING 3 CUBIC FEET PER SECOND.

D. DISSIPATION OF FLOW ENERGY AT THE BYPASS OUTFLOW WILL BE PROVIDED TO PREVENT DAMAGE TO THE STREAM CHANNEL AND RIPARIAN VEGETATION.

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

CONSTRUCTION AND POST CONSTRUCTION CONSERVATION MEASURES.

1. FISH PASSAGE.

A. FISH PASSAGE WILL BE PROVIDED FOR ADULT AND JUVENILE FISH LIKELY TO BE PRESENT DURING CONSTRUCTION UNLESS PASSAGE DID NOT EXIST BEFORE CONSTRUCTION, THE STREAM IS NATURALLY IMPASSABLE, OR PASSAGE WILL NEGATIVELY IMPACT ESA-LISTED SPECIES OR THEIR HABITAT.

B. FISH PASSAGE ALTERNATIVES WILL BE APPROVED BY THE BPA EC LEAD UNDER ADVISEMENT BY THE NMFS HABITAT BIOLOGIST.

2. CONSTRUCTION AND DISCHARGE WATER.

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

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

C. CONSTRUCTION DISCHARGE WATER WILL BE COLLECTED AND TREATED TO REMOVE DEBRIS, NUTRIENTS, SEDIMENT, PETROLEUM HYDROCARBONS, METALS, AND OTHER POLLUTANTS.

3. TIME AND EXTENT OF DISTURBANCE.

A. EARTHWORK REQUIRING IN-STREAM MECHANIZED EQUIPMENT (INCLUDING DRILLING, EXCAVATION, DREDGING, FILLING, AND COMPACTING) WILL BE COMPLETED AS QUICKLY AS POSSIBLE.

B. MECHANIZED EQUIPMENT WILL WORK FROM TOP OF BANK UNLESS WORK FROM ANOTHER LOCATION WILL RESULT IN LESS HABITAT DISTURBANCE (TURBIDITY, VEGETATION DISTURBANCE, ETC.).

4. CESSATION OF WORK.

A. PROJECT OPERATIONS WILL CEASE WHEN HIGH FLOW CONDITIONS MAY RESULT IN INUNDATION OF THE PROJECT AREA (FLOOD EFFORTS TO DECREASE DAMAGES TO NATURAL RESOURCES PERMITTED).

B. WATER QUALITY LEVELS EXCEEDED. SEE CWA SECTION 401 WATER QUALITY CERTIFICATION AND TURBIDITY MEASURES.

5. SITE RESTORATION.

A. DISTURBED AREAS, STREAM BANKS, SOILS, AND VEGETATION WILL BE CLEANED UP AND RESTORED TO IMPROVED OR PRE-PROJECT CONDITIONS.

B. PROJECT-RELATED WASTE WILL BE REMOVED.

C. TEMPORARY ACCESS ROADS AND STAGING WILL BE DECOMPACTED AND RESTORED. SOILS WILL BE LOOSENED IF NEEDED FOR REVEGETATION OR WATER INFILTRATION.

D. THE PROJECT SPONSOR WILL RETAIN THE RIGHT OF REASONABLE ACCESS TO THE SITE TO MONITOR AND MAINTAIN THE SITE OVER THE LIFE OF THE PROJECT.

6. REVEGETATION.

A. PLANTING AND SEEDING WILL OCCUR PRIOR TO OR AT THE BEGINNING OF THE FIRST GROWING SEASON AFTER CONSTRUCTION.

B. A MIX OF NATIVE SPECIES (INVASIVE SPECIES NOT ALLOWED) APPROPRIATE TO THE SITE WILL BE USED TO REESTABLISH VEGETATION, PROVIDE SHADE, AND REDUCE EROSION. REESTABLISHED VEGETATION SHOULD BE AT LEAST 70% OF PRE-PROJECT CONDITIONS WITHIN THREE YEARS.

C. VEGETATION SUCH AS WILLOWS, SEDGES, OR RUSH MATS WILL BE SALVAGED FROM DISTURBED OR ABANDONED AREAS TO BE REPLANTED.

D. SHORT-TERM STABILIZATION MEASURE MAY INCLUDE THE USE OF NON-NATIVE STERILE SEED MIX (WHEN NATIVE NOT AVAILABLE), WEED-FREE CERTIFIED STRAW, OR OTHER SIMILAR TECHNIQUES.

E. SURFACE FERTILIZER WILL NOT BE APPLIED WITHIN 50 FEET OF ANY STREAM, WATE BODY, OR WETLAND.

F. FENCING WILL BE INSTALLED AS NECESSARY TO PREVENT ACCESS TO REVEGETATED SITES BY LIVESTOCK OR UNAUTHORIZED PERSONS.

G. INVASIVE PLANTS WILL BE REMOVED OR CONTROLLED UNTIL NATIVE PLANT SPECIES ARE WELL ESTABLISHED (TYPICALLY THREE YEARS POST-CONSTRUCTION).

7. SITE ACCESS AND IMPLEMENTATION MONITORING.

A. THE PROJECT SPONSOR WILL PROVIDE CONSTRUCTION MONITORING DURING IMPLEMENTATION TO ENSURE ALL CONSERVATION MEASURES ARE ADEQUATELY FOLLOWED, EFFECTS TO LISTED SPECIES ARE NOT GREATER THAN PREDICTED, AND INCIDENTAL TAKE LIMITATIONS ARE NOT EXCEEDED.

B. THE PROJECT SPONSOR OR DESIGNATED REPRESENTATIVE WILL SUBMIT THE PROJECT COMPLETION FORM (PCF) WITHIN 30 DAYS OF PROJECT COMPLETION.

8. CWA SECTION 401 WATER QUALITY CERTIFICATION.

A. THE PROJECT SPONSOR OR DESIGNATED REPRESENTATIVE WILL COMPLETE AND RECORD WATER QUALITY OBSERVATIONS (SEE TURBIDITY MONITORING) TO ENSURE IN-WATER WORK IS NOT DEGRADING WATER QUALITY.

B. DURING CONSTRUCTION, WATER QUALITY PROVISIONS PROVIDED BY THE OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY, WASHINGTON DEPARTMENT OF ECOLOGY, IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY WILL BE FOLLOWED.

STAGED REWATERING PLAN.

A. WHEN REINTRODUCING WATER TO DEWATERED AREAS AND NEWLY CONSTRUCTED CHANNELS, A STAGED REWATERING PLAN WILL BE APPLIED.

B. THE FOLLOWING WILL BE APPLIED TO ALL REWATERING EFFORTS. COMPLEX REWATERING EFFORTS MAY REQUIRE ADDITIONAL NOTES OR A DEDICATED SHEET IN THE CONSTRUCTION DETAILS.

1. TURBIDITY MONITORING PROTOCOL WILL BE APPLIED TO REWATERING EFFORTS.
2. PRE-WASH THE AREA BEFORE REWATERING. TURBID WASH WATER WILL BE DETAINED AND PUMPED TO THE FLOODPLAIN OR SEDIMENT CAPTURE AREAS RATHER THAN DISCHARGING TO FISH-BEARING STREAMS.
3. INSTALL SEINE NETS AT UPSTREAM END TO PREVENT FISH FROM MOVING DOWNSTREAM UNTIL 2/3 OF TOTAL FLOW IS RESTORED TO THE CHANNEL.
4. STARTING IN EARLY MORNING INTRODUCE 1/3 OF NEW CHANNEL FLOW OVER PERIOD OF 1-2 HOURS.
5. INTRODUCE SECOND THIRD OF FLOW OVER NEXT 1 TO 2 HOURS AND BEGIN FISH SALVAGE OF BYPASS CHANNEL IF FISH ARE PRESENT.
6. REMOVE UPSTREAM SEINE NETS ONCE 2/3 FLOW IN REWATERED CHANNEL AND DOWNSTREAM TURBIDITY IS WITHIN ACCEPTABLE RANGE (LESS THAN 40 NTU OR LESS THAN 10% BACKGROUND).
7. INTRODUCE FINAL THIRD OF FLOW ONCE FISH SALVAGE EFFORTS ARE COMPLETE AND DOWNSTREAM TURBIDITY VERIFIED TO BE WITHIN ACCEPTABLE RANGE.
8. INSTALL PLUG TO BLOCK FLOW INTO OLD CHANNEL OR BYPASS. REMOVE ANY REMAINING SEINE NETS.
9. IN LAMPREY SYSTEMS, LAMPREY SALVAGE AND DRY SHOCKING MAY BE NECESSARY.

TURBIDITY MONITORING.

A. RECORD THE READING, LOCATION, AND TIME FOR THE BACKGROUND READING APPROXIMATELY 100 FEET UPSTREAM OF THE PROJECT AREA USING A RECENTLY CALIBRATED TURBIDIMETER OR VIA VISUAL OBSERVATION (SEE THE HIP HANDBOOK TURBIDITY MONITORING SECTION FOR A VISUAL OBSERVATION KEY).

B. RECORD THE TURBIDITY READING, LOCATION, AND TIME AT THE MEASUREMENT COMPLIANCE LOCATION POINT.

1. 50 FEET DOWNSTREAM FOR STREAMS LESS THAN 30 FEET WIDE.
2. 100 FEET DOWNSTREAM FOR STREAMS BETWEEN 30 AND 100 FEET WIDE.
3. 200 FEET DOWNSTREAM FOR STREAMS GREATER THAN 100 FEET WIDE.
4. 300 FEET FROM THE DISCHARGE POINT OR NONPOINT SOURCE FOR LOCATIONS SUBJECT TO TIDAL OR COASTAL SCOUR.

C. TURBIDITY SHALL BE MEASURED (BACKGROUND LOCATION AND COMPLIANCE POINTS) EVERY 4 HOURS WHILE WORK IS BEING IMPLEMENTED.

D. IF THERE IS A VISIBLE DIFFERENCE BETWEEN A COMPLIANCE POINT AND THE BACKGROUND, THE EXCEEDANCE WILL BE NOTED IN THE PROJECT COMPLETION FORM (PCF). ADJUSTMENTS OR CORRECTIVE MEASURES WILL BE TAKEN IN ORDER TO REDUCE TURBIDITY.

E. IF EXCEEDANCES OCCUR FOR MORE THAN TWO CONSECUTIVE MONITORING INTERVALS (AFTER 8 HOURS), THE ACTIVITY WILL STOP UNTIL THE TURBIDITY LEVEL RETURNS TO BACKGROUND. THE BPA EC LEAD WILL BE NOTIFIED OF ALL EXCEEDANCES AND CORRECTIVE ACTIONS AT PROJECT COMPLETION.

F. IF TURBIDITY CONTROLS (COFFER DAMS, WADDLES, FENCING, ETC.) ARE DETERMINED INEFFECTIVE, CREWS WILL BE MOBILIZED TO MODIFY AS NECESSARY. OCCURRENCES WILL BE DOCUMENTED IN THE PROJECT COMPLETION FORM (PCF).

G. FINAL TURBIDITY READINGS, EXCEEDANCES, AND CONTROL FAILURES WILL BE SUBMITTED TO THE BPA EC LEAD USING THE PROJECT COMPLETION FORM (PCF).

Designed___ Drawn___ Checked___ Approved___ Title___

HIP GENERAL CONSERVATION MEASURES

BONNEVILLE POWER ADMINISTRATION: ENVIRONMENT, FISH AND WILDLIFE DIVISION

File Name *2021 HIP GCA*

Drawing No.

Sheet 3 of 3

APPENDIX I - 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.

APPENDIX J - NORTHERN SPOTTED OWL CONSERVATION MEASURES

1) To reduce adverse effects to NSO, projects will not occur during the critical breeding period, typically March 1 through July 15, but may vary by location. Timing can be locally revised based on current information available from the appropriate USFWS field office. Projects should be delayed until after the critical breeding season (unless action involves Type I helicopters, which extends the critical nesting window to September 30), or it is determined that young are not present.

2) The USFWS wildlife biologist may extend the restricted season based on site-specific information (e.g., a late or recycled nesting attempt).

3) Table 9 shows disruption distances applicable to the equipment. These distances can be locally altered based on current information and concurred with by appropriate USFWS official.

Table 9. Disturbance, disruption (harass) and/or physical injury (harm) distance thresholds for NSO. Distances are to a known occupied NSO nest tree or suitable nest trees in unsurveyed habitat.

Project Activity	No Effect (Mar 1 – Sep 30)	NLAA **"may affect" disturbance distance** (Mar 1 – Sep 30)	LAA – Harass **early nesting season disruption distance** (Mar 1–Jul 15[11])	LAA – Harass **late nesting season disruption distance** (Jul 16[11]–Sep 30)	LAA – Harm **direct injury and/or mortality** (Mar 1 – Sep 30)
Light maintenance (e.g., road brushing and grading) and heavily-used roads	>0.25 mile	≤ 0.25 mile	NA[1]	NA	NA
Log hauling on heavily-used roads (FS maintenance levels 3, 4, and 5)	>0.25 mile	≤ 0.25 mile	NA[1]	NA	NA
Chainsaws (includes felling hazard/danger trees)	>0.25 mile -	66 yards to 0.25 mile -	≤ 65 yards[2]	NA	NA
Heavy equipment for road construction, road repairs, bridge construction, culvert replacements, piling removal, etc.	>0.25 mile	66 yards to 0.25 mile	≤ 65 yards[2]	NA	NA
Helicopter: Chinook 47d	>0.5 mile	266 yards to 0.5 mile	≤ 265 yards[3]	≤ 100 yards[4] (hovering only)	NA
Helicopter: Boeing Vertol 107, Sikorsky S-64 (SkyCrane)	>0.25 mile	151 yards to 0.25 mile	≤ 150 yards[5]	≤ 50 yards[4] (hovering only)	NA
Helicopters: K-MAX, Bell 206 L4, Hughes 500	>0.25 mile	111 yards to 0.25 mile	≤ 110 yards[6]	≤ 50 yards[4] (hovering only)	NA

1. NA = not applicable. Based on information presented in Temple and Guttiérez (2003, p. 700), Delaney et al. (1999, p. 69), and Kerns and Allwardt (1992, p. 9), we anticipate that spotted owls that select nest sites in close proximity to open roads either are undisturbed by or habituate to the normal range of sounds and activities associated with these roads.

2. Based on Delaney et al. (1999, p. 67) which indicates that spotted owl flush responses to above-ambient equipment sound levels and associated activities are most likely to occur at a distance of 65 yards (60 m) or less.
3. Based on an estimated 92 dBA sound-contour (approximately 265 yards) from sound data for the Chinook 47d presented in Newman et al. (1984, Table D.1).
4. Rotor-wash from large helicopters is expected to be disruptive at any time during the nesting season due the potential for flying debris and shaking of trees located directly under a hovering helicopter. The hovering rotor-wash distance for the Chinook 47d is based on a 300-ft radius rotor-wash zone for large helicopters hovering at < 500 above ground level (from WCB 2005, p. 2 – logging safety guidelines). We reduced the hovering helicopter rotor-wash zone to a 50-yard radius for all other helicopters based on the smaller rotor-span for all other ships.
5. Based on an estimated 92 dBA sound contour from sound data for the Boeing Vertol 107 the presented in the San Dimas Helicopter Logging Noise Report (USFS 2008, chapters 5, 6).
6. The estimated 92 dBA sound contours for these helicopters is less than 110 yards (e.g., K-MAX (100 feet) (USFS 2008, chapters 5, 6), and Bell 206 (85-89 dbA at 100 m)(Grubb et al. 2010, p. 1277).

4) No hovering or lifting within 500 feet of the ground within occupied spotted owl habitat during the critical breeding season by ICS Type I or II helicopters would occur as part of any proposed action addressed by the programmatic consultation.

5) Tree Removal for Large Wood Projects. The following Conservation Measures apply to tree removal within the range of NSO.

a. Forested stands less than 80 years old that are not functioning as foraging habitat within a NSO home range

   i. This section does not apply to tree selection in older stands or hardwood-dominated stands unless stated otherwise.

   ii. A wildlife biologist must be fully involved in all tree-removal planning efforts and be involved in making decisions on whether individual trees are suitable for nesting or have other important documented bird habitat values.

   iii. Outside of one site-potential tree height from streams , trees can be removed to a level not less than a relative density (RD) of approximately 35 (stand scale), which is considered as fully occupying a site. This equates to approximately 60 trees per acre in the overstory and a tree spacing averaging 26 feet. Additionally, 40% canopy cover would be maintained when in NSO critical habitat, or when dispersal habitat for NSO is limited in the area.

   iv. Tree species removed should be relatively common in the stand (i.e., not "minor" tree species).

   v. Snags and trees with broad deep crowns ("wolf" trees), damaged tops or other abnormalities that may provide a valuable wildlife habitat component shall not be removed.

   vi. No gaps (openings) greater than 0.5 acre will be created in northern spotted owl critical habitat. No gaps greater than ¼ acre will be created in marbled murrelet critical habitat.

b. Forested stands greater than 80 years old, or stands that are functioning as foraging habitat within NSO home range

   i. Individual trees or small groups of trees should come from the periphery of permanent openings (e.g., roads) or from the periphery of non-permanent openings (e.g., plantations, along recent clear-cuts, etc.).

   ii. A minimum distance of one site-potential tree height should be maintained between individual or group removals.

   iii. No known NSO nest trees or alternate nest trees are to be removed, including historical nest sites. Potential NSO nest trees may only be removed in limited instances when it is confirmed with the USFWS wildlife biologist that nest trees will not be limited in the stand after removal.

iv. When within either NSO critical habitat, stands greater than 80 years old providing suitable habitat, or within stands providing foraging habitat to NSO home ranges , gaps will be restricted to 1/2 acre openings or less.