



CONCEPTUAL RESTORATION PLAN, REACHES 6 TO 10 TUCANNON RIVER PHASE II

Prepared for

Columbia Conservation District
202 South 2nd Street, U.S. Post Office Building
Dayton, Washington 99328

Prepared by

Anchor QEA, LLC
1605 Cornwall Avenue
Bellingham, Washington 98225

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LIST OF ACRONYMS AND ABBREVIATIONS

BMP	Best management practices
CCD	Columbia Conservation District
CRB	Columbia River Basalt
CREP	Conservation Restoration Easement Program
EDT	Ecosystem Diagnosis and Treatment
ELJ	Engineered log jam
ESA	Endangered Species Act
ESU	Evolutionarily significant unit
LWD	Large woody debris
MSA	Major spawning area
MsA	Minor spawning area
NMFS	National Marine Fisheries Service
PA	Project area
RM	River mile
R/S	Return to smolt
SRSRB	Subbasin Plan and Snake River Salmon Recovery Plan
TSP	Tucannon Subbasin Plan
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VSP	Viable Salmonid Population
WDFW	Washington Department of Fish and Wildlife

1 INTRODUCTION

The Tucannon River is a tributary to the Snake River in southeast Washington (Figure 1). The river supports Endangered Species Act- (ESA-) listed summer steelhead, spring Chinook salmon, fall Chinook salmon, and bull trout, which have all been identified as aquatic focal species of concern in the *Tucannon Subbasin Plan* (TSP) (CCD 2004). These species collectively utilize the entire length of the river at some stage of their lifecycles; at least one species is present throughout the Tucannon River channel throughout the year.

Anchor QEA, LLC, was retained by the Columbia Conservation District (CCD) to develop a Tucannon River conceptual restoration plan for five reaches beginning at river mile (RM) 20 and continuing until RM 50. This plan builds on the findings from the *Tucannon River Geomorphic Assessment and Habitat Restoration Study* (Anchor QEA 2011). For this study, a basin-scale geomorphic study was used to delineate 10 discrete reaches throughout 50 miles of the river (Figure 2). The geomorphic assessment was prepared to strengthen the technical understanding of existing physical conditions and geomorphic processes in the basin in order to identify and prioritize habitat restoration opportunities. The assessment included: identification of the source, magnitude, and distribution of hydrologic and sediment inputs through the basin; analysis of floodplain connectivity; identification of passage barriers or infrastructure constraints; identification of stressors and features leading to habitat degradation; and a qualitative evaluation of restoration opportunities. Within each reach, potential restoration opportunities and concepts were identified and discussed. The results of that study were used to identify the study area for this project, RM 20 to 50 (Figure 3), for further refinement of conceptual projects.

Preliminary restoration opportunities identified in the geomorphic assessment were developed based on habitat-limiting factors identified in the *Subbasin Plan and Snake River Salmon Recovery Plan* (SRSRP) (SRSRB 2006), salmonid life history and distribution through the river system, and site-specific physical, hydrologic, and geomorphic conditions. The restoration framework was loosely categorized based on the actions described in Figure 2 from Roni et al. (2002). The initial restoration actions in the geomorphic assessment corresponding to the framework proposed by Roni include:

	Roni et al. (2002)	Tucannon Basin
1.	Protect and maintain natural processes	Promote natural hydrologic and sediment routing throughout the system; allow natural migration and wood recruitment
2.	Connect isolated habitats	Reconnect floodplains, groundwater channels, wetlands, and former mainstem and side channels
3.	Address roads, levees, and other human infrastructure impairing processes	Remove or modify levees, dredge spoils, rock embankments, and grade control structures.
4.	Restore riparian processes	Protect healthy riparian areas. Eradicate invasive species and plant native communities to rehabilitate degraded riparian forests.
5.	Improve instream habitat conditions	Install large individual trees and large woody debris structures in the channel

1.1 Purpose

The purpose of the current plan is to develop conceptual restoration plans for discrete project areas within Reaches 6 through 10 that can be implemented to substantially improve habitat conditions for key life stages of ESA-listed and other aquatic species. Twenty-eight conceptual project areas were delineated and evaluated for restoration potential. Project evaluation was based on findings in the 2011 *Geomorphic Assessment*, field reconnaissance during summer 2011 that characterized channel, floodplain, and riparian conditions; existing Chinook spawning and juvenile rearing data; and input from the Tucannon Coordinating Committee (a committee comprised of technical representatives from local, state, federal, and tribal government agencies) and the public.

Based on the results of our evaluation, project areas were organized into Tiers 1, 2, and 3, with Tier 1 projects being the highest priority for implementation. Following this plan, thirty percent designs will be developed for selected Tier 1 projects.

2 BASIN OVERVIEW

2.1 Basin Description

The Tucannon River basin is located in Columbia and Garfield counties in the southeast corner of Washington State (Figure 1). The main channel is approximately 58 miles long and drains approximately 503 square miles (mi²) from its headwaters in the Blue Mountains and Umatilla National Forest to the mouth at the Snake River approximately 3 miles upstream of the Lower Monumental Dam (CCD 2004). Several major tributaries drain into the main channel; the largest (by basin area) is Pataha Creek, which enters the main channel at RM 12.3. Pataha Creek is approximately 52 miles in length with a long, narrow watershed draining 185 mi². The second and third largest tributaries (by basin area) are Kellogg Creek (35 mi²) and Willow Creek (30 mi²).

A majority of the watershed downstream of Tualum Creek (RM 35.5) is cultivated, primarily with grain crops. The valley floor is occupied primarily by livestock pastures and some cultivated crops downstream of the National Forest boundary at RM 41, except for a vegetated riparian buffer along the margins of the channel. The watershed upstream of Tualum Creek is typically covered in evergreen forest, with scrub/shrub on the steeper, southwest-facing slopes. The valley floor is forested, with sparse undergrowth in the floodplain until upstream of Panjab Creek (RM 50.2), where tree and undergrowth density increases significantly. The riparian corridor typically contains interspersed evergreen and deciduous trees with dense undergrowth. Large forest fires in 2005 (School Fire), 2009 (Columbia Complex Fire), and 2010 (Hubbard Fire) impacted the upper basin, including the portions of the floodplain and riparian corridor.

2.2 Geomorphic Context

2.2.1 Regional Geology

The Tucannon watershed consists primarily of Miocene-aged Columbia River Basalt (CRB) flows of the Grande Ronde, Wanapum, and Frenchman Springs members with recent Quaternary river alluvium along the valley floor. Basalt is exposed at the surface upstream of Tualum Creek (RM 35.5) and along the valley walls and gullies down from Tualum Creek to RM 18. Downstream of RM 18, including within the Pataha and Willow Creek subbasins,

the basalt is overlain by loess deposits (fine sand and silt) of the Palouse Formation. In these areas, bedrock is typically exposed in gullies and along valley slopes. The valley walls in much of the lower basin downstream of RM 18 are composed of Quaternary flood outburst deposits consisting of stratified sand, gravel, and cobble. Alluvial fans line the valley floor at the mouths of tributaries throughout the study area; the fans tend to be large and wide in locations where tributaries drain loess-dominated subbasins, and small and narrow in basins where mainly bedrock is exposed. Significant ancient alluvial fan and hillslope deposits are present in many locations that constrict the overall valley and floodplain width.

2.2.2 Channel Patterns and Floodplain

Review of the historic aerial photographic record and traces of active channel positions through time revealed notable trends in channel form and behavior (Anchor QEA 2011). Channel types include single-thread sections; braided, gravel bar-dominated sections; multi-threaded anastomosing sections, and anabranching sections, which have two or more diverging channels separated by significant lengths of vegetated floodplain. The character of channel movement, or migration, was identified as both relatively steady channel migration of a riverbend through a gravel bar or floodplain, and channel avulsion where the river suddenly changes course, often through historic channels previously abandoned through a similar process.

2.2.3 Channel Confinement and Floodplain Connectivity

Confining features along the banks of the Tucannon River and within the floodplain influence hydraulic conditions during large floods, affecting local and reach-scale geomorphic processes, such as sediment mobility and channel migration. Confining features may be both natural and influenced by anthropogenic activities. However, the presence of anthropogenic features related to land use appears to be the primary factor related to adverse conditions created by channel confinement in the study area, particularly downstream of RM 47. Upstream of this point, natural features such as alluvial fans and overall valley width are more prominent and have a greater effect on channel confinement.

2.2.4 Large Woody Debris

Channel clearing and riparian timber harvesting in the Tucannon basin have removed large woody debris (LWD) from the system and greatly reduced recruitment of additional LWD, especially large-diameter mature trees that form the core of stable log jams. Previously logged and cleared riparian areas have been regenerating for approximately the last 20 to 50 years in publicly-owned and protected riparian forests. While these trees are fairly mature, many (particularly conifers in the upper watershed) may not be large enough to remain stable within the mainstem channel.

2.2.5 Future Channel Evolution

The Tucannon River is currently in the process of recovering from anthropogenic disturbance and re-establishing more natural conditions for the system. The river has been slowly recovering from clearing and straightening of the channel, although many simplified portions of the channel remain because of confinement by infrastructure. In unconfined areas, the channel is attempting to recover via channel migration, recruitment of LWD, and deposition of LWD and sediment. Through time, additional channel migration will further extend the length of the channel network, increase floodplain connectivity, and reduce in-channel velocities. Introduction of maturing riparian trees and LWD material will lead to the formation of log jams, which promote sediment deposition in the lee of the structures. Log jams also promote split flow and side channel development, leading to hydraulic conditions that often provide preferred habitat for juvenile salmonids, and distribute sediment load and organic debris across the floodplain. In addition, split flows and side channels reduce the hydraulic energy of the mainstem, increasing the ability for the channel to retain LWD and sediment.

In this manner, the recovery of the system is a feedback loop where channel migration leads to LWD deposition on bars and shallow areas, which leads to log jams and split flow conditions, which reduces hydraulic energy in the channel, leading to additional deposition of LWD and sediment, and the feedback loop continues. The result of the process is an overall widening of the active channel and better hydraulic connectivity between the river, side channels, and floodplain. The projects identified in this plan are developed to help achieve these desired conditions over time as natural processes are restored in selected areas.

2.3 Fish Timing and Distribution

The Tucannon River supports four ESA-listed Snake River Basin salmonid populations throughout all or a portion of their life stages. Summer steelhead, spring Chinook salmon, fall Chinook salmon, and bull trout were identified in the TSP as aquatic focal species (CCD 2004). Collectively, these species use the main channel from the mouth to the headwaters, as well as major tributaries, including Pataha Creek. The following information is summarized from the TSP (CCD 2004) and the SRSRP (2006), and revised to include new information from recent data being collected by the Washington Department of Fish and Wildlife (WDFW) and others in the basin (SRSRB 2011b, email communication; Gallinat and Ross 2010).

Table 2-1 shows the spatial distribution of steelhead and Chinook salmon in the mainstem of the Tucannon River, with darker shades of gray indicating higher densities of fish present during their respective life stages. Information on bull trout was not sufficient to provide detailed distribution data as reported for the other focal species.

2.3.1 Steelhead Trout

Steelhead trout in the Tucannon River are part of the Snake River Basin steelhead evolutionarily significant unit (ESU), which was listed as threatened in 1997. Summer steelhead trout enter the Tucannon River in September and begin spawning in late February to early March until mid-May. Spawning occurs in the mainstem from Kellogg Creek (RM 4.8) upstream to the Tucannon headwaters, as well as within Cummings Creek and in the lower portions Panjab and Sheep creeks; the greatest concentration of steelhead spawning is typically found in the mainstem between Tucannon Falls (RM 16.5) and Beaver Lake at approximately RM 42. Juveniles also rear throughout the mainstem but are typically found in the greatest numbers between approximately RM 18 and School Canyon (approximately RM 45).

Table 2-1
Distribution of Steelhead, Chinook Salmon, and Bull Trout in the Mainstem Tucannon River

Geographic Area	From (RM)	To (RM)	Summer Steelhead			Spring Chinook			Fall Chinook			Bull Trout		
			Spawning	Juvenile Rearing	Adult Holding	Spawning	Juvenile Rearing	Adult Holding	Spawning	Juvenile Rearing	Adult Holding	Spawning	Juvenile Rearing	Adult Holding
Mouth	0	0.7												
Lower Tucannon	0.7	4.8										Note: Migratory and resident fish. Distribution data are limited.		
	4.8	5.5												
	5.5	8.7												
	8.7	12.3												
Pataha-Marengo	12.3	16.5												
	16.5	18.6												
	18.6	22.8												
	22.8	26.6												
Marengo-Tumalum	26.6	35.6												
Tumalum-Hatchery	35.6	37.8												
	37.8	41.9												
Hatchery-Little Tucannon	41.9	44.6												
	44.6	45.6												
	45.6	48.1												
Mountain	48.1	50.2												

Notes:

1. Distribution data are summarized from CCD (2004) and updated based on recent data collected in the basin by WDFW, SRSRB, and others (SRSRB 2011b, email communication). Geographic areas and river mile sections correspond to Ecosystem Diagnosis and Treatment (EDT) analysis reaches used during subbasin planning.
2. Darker shades of gray indicate higher densities of fish present during their respective life stages.

2.3.2 Spring Chinook Salmon

Spring Chinook salmon in the Tucannon River are of the Snake River spring/summer Chinook salmon ESU that was listed as threatened by the ESA in 1992. Spring Chinook salmon enter the Tucannon River beginning as early as late April and as late as mid-September; spawning occurs from mid-August to the end of September. Spawning occurs almost exclusively in the main channel from approximately King Grade (RM 22.9) to the mouth of Sheep Creek near RM 55 (Gallinat and Ross 2010); the greatest densities are between Marengo and the Little Tucannon River (approximately RM 48.1). Juveniles rear from approximately Tucannon Falls (RM 16.5) to the headwaters, with the highest densities located between Marengo and School Canyon (approximately RM 45).

2.3.3 Fall Chinook Salmon

Fall Chinook salmon are part of the Snake River fall Chinook salmon ESU, also listed as threatened in 1992. Fall Chinook salmon enter the lower Tucannon River beginning in early October and have a brief holding period until spawning begins in mid-October. Fall Chinook salmon use the main channel of the river from the mouth to upstream of Pataha Creek (RM 12.3), with the highest concentration of spawning occurring from the mouth to around the Starbuck Dam near RM 5.5. Juvenile fall Chinook salmon do not overwinter in the Tucannon River and out-migrate shortly after emergence during the late winter to early summer.

2.3.4 Bull Trout

Bull trout in the Columbia Basin were listed as threatened by the ESA in 1998. The Tucannon River bull trout population is part of the Lower Snake River Critical Habitat Unit (USFWS 2010). Bull trout life histories present in the Tucannon River include resident, fluvial, and adfluvial forms. Migratory bull trout move upstream from the Snake River into the upper Tucannon River in the spring and early summer. Critical habitat in the Tucannon Critical Habitat Subunit, as designated by the U.S. Fish and Wildlife Service (USFWS), includes the mainstem Tucannon, Cummings Creek, Hixon Creek, the Little Tucannon River, Panjab Creek, Cold Creek, Sheep Creek, and Bear Creek (USFWS 2010). Juvenile rearing occurs upstream of Tumalum Creek to the headwaters. The lower Tucannon River is

an important migratory corridor to spawning and rearing areas upstream in the watershed, including headwaters and tributary streams.

Historically, the bull trout population in the Tucannon River has been considered healthy; however, recent data suggest some population declines (USFWS 2010). As cited by USFWS, WDFW surveys indicate that the number of redds in the upper Tucannon have dropped from more than 100 in 2002 and 2003 to less than 20 in 2007. This correlates with a decline in the number of adult migratory bull trout captured at the Tucannon Hatchery Trap as they were moving upstream.

3 HABITAT RESTORATION GOALS AND OBJECTIVES

The restoration objective for the Tucannon River is to improve habitat conditions for ESA-listed species for all life history stages within the river. Improving habitat conditions will lead to an increase in the abundance of listed species returning to the river. Increasing abundance will lead to delisting of the species, which is the overall recovery goal for the system.

3.1 Limiting Factors

An Ecosystem Diagnosis and Treatment (EDT) analysis was performed that assessed habitat conditions in the Tucannon River for aquatic focal species (CDD 2004, Appendix B of TSP). This analysis allowed watershed planners and stakeholders to identify the primary limiting factors to aquatic focal species in discrete reaches throughout the river. These results are summarized in the SRSRP for summer steelhead and spring Chinook salmon (Tables 3-1 and 3-2); the SRSRP also provides priority habitat objectives for the Upper Tucannon River major spawning area (MSA). The lower Tucannon River (downstream of Pataha Creek) was not a priority MSA and was not considered for active restoration in the 2006 SRSRP; however, the Lower Tucannon is now considered a priority minor spawning area (MsA) and thus the status was changed to a priority restoration reach beginning in 2010 (SRSRB 2011a).

Table 3-1
Factors Limiting the Viability of the Tucannon River Steelhead Population (SRSRB 2006)

Geographic area priority		Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
	Tucannon R, Pataha Cr to Marengo	○	○	●		●		●		●		●		●		●	●	
Tucannon R, Tumalum Cr to Panjab Cr	○	○	●		●		●		●	●			●		●	●		●
Pataha Cr, mouth to Pomeroy	○	○	●		●		●	●	●		●				●	●		●
Tucannon R, Marengo to Tumalum	○	○	●		●		●		●				●		●	●		●
Cummings Cr	○	○	●		●		●		●						●	●		●
Tucannon R, mouth to end of backwater	○	○	●		●		●		●				●	●	●	●		●
Panjab Cr	○	○	●		●		●		●						●	●		●
Pataha Cr, Pomeroy to headwaters	○	○	●		●		●		●		●				●	●		●
Tucannon R, Panjab Cr to headwaters	○	○	●		●		●		●						●	●		●
Tucannon R, end of backwater to Pataha Cr	○	○	●		●		●		●				●	●	●	●		●
Tumalum drainage		○	●		●		●		●					●	●	●		●
Bihmaier Gulch Cr			●						●		●				●	●		●
Dry Pataha Cr			●				●		●		●				●	●		●
Hixon Cr			●		●		●			●					●	●		●
Iron Springs Cr			●				●		●						●	●		●
Kellog Cr			●		●		●		●				●	●	●	●		●
Little Tucannon River drainage			●		●		●		●						●	●		●
Pataha above Dry Pataha			●				●		●	●					●	●		●
Smith Hollow Cr			●		●		●	●	●				●	●	●	●		●

Key to strategic priority (corresponding Benefit Category letter also shown)

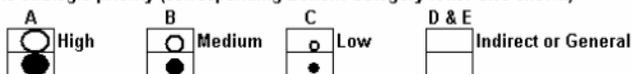


Table 3-2
Factors Limiting the Viability of Tucannon River Spring Chinook (SRSRB 2006)

Geographic area priority		Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
	Tucannon R, Pataha Cr to Marengo	○	○	●				●	●	●						●	●	
Tucannon R, mouth to Starbucks Dam		○	●				●	●	●	●			●	●	●	●		●
Pataha above Pomeroy		○	●				●	●	●	●	●				●	●		●
Pataha below Pomeroy		○	●				●	●	●	●	●				●	●		●
Tucannon R, Starbucks Dam to Pataha Cr		○	●				●	●	●	●	●				●	●		●
Tucannon R, Marengo to Tumalum	○	○	●		●		●	●	●	●			●		●	●		●
Tucannon R, Tumalum Cr to Panjab Cr	○	○	●				●	●	●	●					●	●		●
Pataha above Dry Pataha		○	●				●	●	●	●	●			●	●	●		●
Tucannon above Panjab		○	●				●	●	●	●					●	●		●
Panjab drainage			●		●		●	●	●	●					●	●		●

Key to strategic priority (corresponding Benefit Category letter also shown)

A	B	C	D & E
○	○	○	□
●	●	●	□
High	Medium	Low	Indirect or General

3.2 Viable Salmonid Population

To inform habitat restoration actions, spring Chinook in Reaches 6 through 10 were identified as a species to focus on with the expectation that restoration actions targeted at improving habitat conditions for spring Chinook life stages will also improve conditions for steelhead and other species important to the Tucannon. Another approach to evaluate the health of Tucannon spring Chinook is to consider how the population is performing compared to the National Marine Fisheries Service (NMFS) standard of a Viable Salmon Population (VSP), a population biology concept. According to the NMFS (McElhany et al. 2000), a viable salmonid population is an “independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year time frame.” McElhany et al. (2000) identified four key population characteristic or parameters for evaluating population viability status:

- Abundance
- Population growth rate or entire life-cycle productivity
- Population spatial structure
- Diversity

The following sections present a brief introduction to each of the VSP parameters and how these apply to the Tucannon River habitat conditions and future restoration planning.

It must be emphasized that any change in risk associated with these population parameters is affected by a myriad of factors (including in-basin factors, conditions in the Snake and Columbia rivers, and ocean conditions), and consequently is a long-term proposition. Many of these factors (e.g., ocean conditions and marine survival rates) are largely outside of human control. Moreover, changes expected from the types of actions considered in this report are most likely to occur on a generational scale; the likelihood is low that there would be detectable changes in the near future. Also, there is uncertainty associated with the Tucannon supplemental hatchery program that may affect the spring Chinook salmon population in ways that may not be well understood.

3.2.1 Abundance

Population size is perhaps the most straightforward measure of the VSP parameters and is an important consideration in estimating extinction risk. All other factors being equal, a population at low abundance is intrinsically at greater risk of extinction than is a larger one. The primary drivers of this increased risk are the many processes that regulate population dynamics, particularly those that operate differently on a relatively small population such as Tucannon spring Chinook. Examples include environmental variation and catastrophes, demographic stochasticity (intrinsic random variability in population size), selected genetic processes (e.g., inbreeding depression), and deterministic density effects. Although the negative interaction between abundance and productivity may protect some small populations, there is obviously a point below which a population is unlikely to persist (McElhany et al. 2000).

Tucannon spring Chinook populations spawn almost exclusively in the mainstem Tucannon River with spawning occurring from just above the mouth of Sheep Creek (RM 52) downstream to King Grade (RM 21). Average annual spawning for the past decade (2000 to 2010) is 200 redds, with 53 percent of these being natural spawners and 47 percent hatchery-origin fish (SRSRB 2011c, Appendix B).

Between 1986 and 2010, the annual returns of natural-origin spring Chinook to the Tucannon River ranged from 0 to 1,500 adults; the high of about 1,500 returning adults occurred in 2010 and the low of 0 returning natural-origin spawners occurred in 1995 and 1999 (Chart 1, Gallinat and Ross 2011). The 10-year geometric mean abundance has varied between approximately 100 and 400 returning adults. The Interior Columbia Technical Recovery Team (ICTRT) estimated that the minimum abundance threshold of returning adults is 750 and the current average is 371 (SRSRB 2011c).

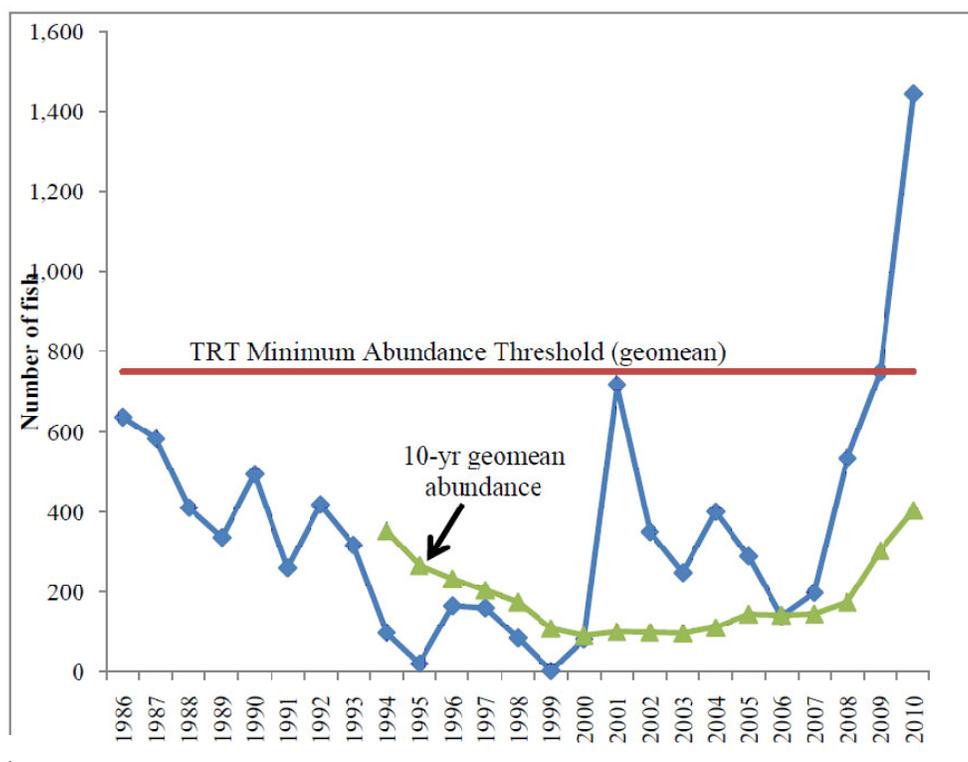


Chart 1

Estimated Abundance of Tucannon River Natural-Origin Spring/Summer Chinook Salmon Adults and 10-year Geomean between 1986 and 2010 (Gallinat and Ross 2011)

3.2.2 Life Cycle Productivity

Population growth rate (λ) or productivity over the entire life cycle is a key measure of population performance in a species' habitat. In simple terms, it describes the degree to which a population is replacing itself. A population growth rate of 1 ($\lambda = 1.0$) means that a population is exactly replacing itself (one spawner produces one spawner in the next generation), whereas a $\lambda = 0.71$, the λ value determined in the Tucannon for spring Chinook, means that the population is declining at a rate of 29 percent annually—a trend that is obviously not sustainable in the long term (Chart 2). This return to smolt (R/S) value does not account for the nearly 25 percent of returning adults that bypass the Tucannon River upon return, based on PIT-tag detections, and ascend the Snake River without returning back to the Tucannon River. Nevertheless, recruits per spawner are often less than 1 and documented R/S is nearly always less than 1 for spring Chinook (SRSRB 2011c). The Technical Review Team estimated that an R/S of 1.8 is needed for an extinction risk of less than 5 percent and an R/S of 2.1 is needed for an extinction risk of less than 1 percent (highly viable criteria) (SRSRB 2011c).

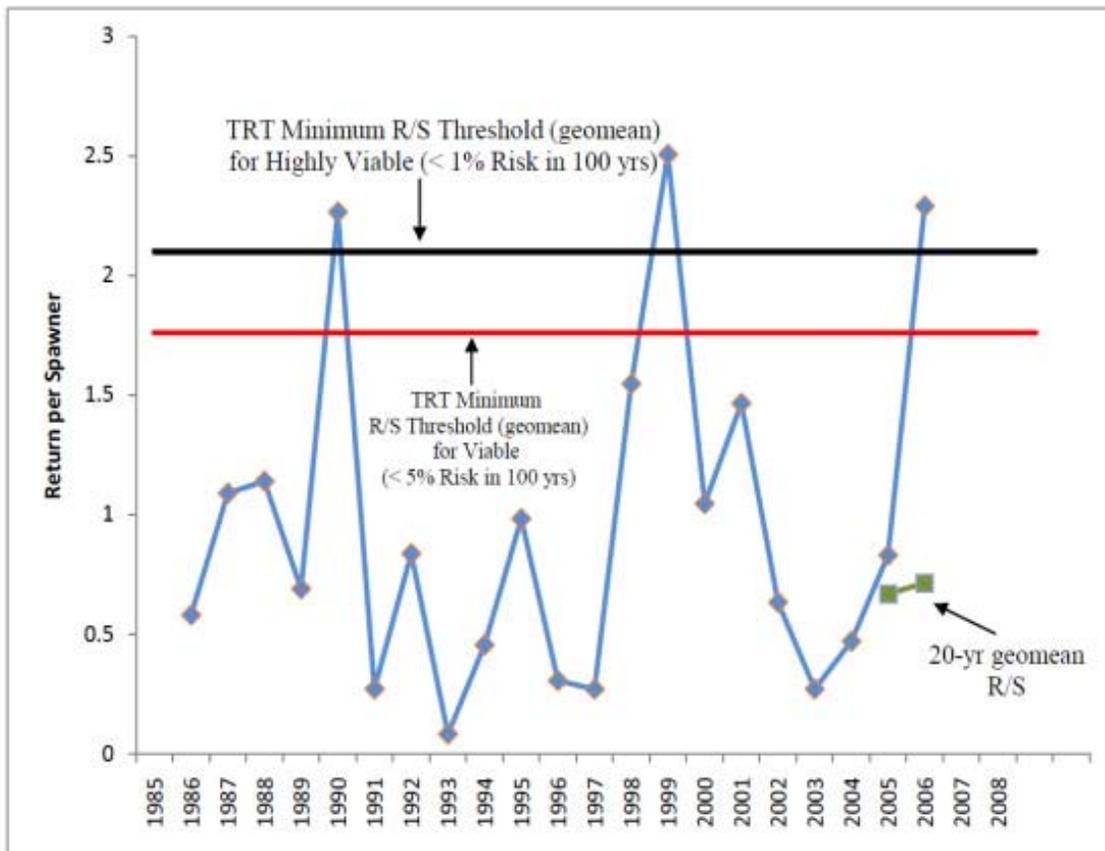


Chart 2
Estimated Productivity of Natural-Origin Spring/Summer Chinook Salmon Adults and 20-year Geomean from the Tucannon River

Note:
 1986 to 2003 data from NOAA salmon population summary SPS database:
<https://www.webapps.nwfsc.noaa.gov/apex/f?p=238:home:0>
 2003 to 2005 data from Gallinat and Ross (2010)

The causes for the low R/S are not precisely known and likely include multiple factors that are difficult to quantify, such as potential effects from habitat conditions and habitat capacity (Glen Mendel, WDFW, personal communication on 9/7/2011). Hatchery supplementation, the Columbia and Snake rivers, and ocean conditions are also factors of the R/S value.

3.2.3 *Spatial Structure*

Spatial structure, as the term suggests, refers to the geographic distribution of individuals in a population unit and the processes that generate that distribution. Distributed populations that interact genetically are often referred to as a metapopulation. Although the spatial distribution of a population, and thus its metapopulation structure, is influenced by many factors, none are perhaps as important as the quantity, quality, and distribution of habitat. One way to think about the importance or value of a broad geospatial distribution is to consider that in the presence of such a distribution, a population is less likely to go extinct from a localized catastrophic event or localized environmental perturbations (McElhany et al. 2000).

Spatial distribution (of spawning and summer rearing) of spring Chinook in the Tucannon River is primarily restricted to the area upstream of Marengo (RM 25) to the headwaters, yet historically it is presumed that spring Chinook spawned and reared at least down to Pataha Creek (RM 12.5) (Gallinat and Ross 2011). The spring Chinook salmon spawning and rearing distribution is reported in the 2006 Recovery Plan, which is currently being updated (SRSRB 2006). The information from the 2006 plan shown in Table 3-3 appears as Table B-3 in Appendix B of the draft 2011 SRSRP (SRSRB 2011c).

Table 3-3
Spring/Summer Chinook Redd Distribution in the Tucannon River

Section	River km (Rkm)	River mile (RM)	Percent of Total Redds	Average Redds	Redds per Rkm	Redds per RM
Mouth to Marengo (Lower)	0-20.1	0-13.6	0	0	0.0	0.0
Marengo	20.1-39.9	13.6-26.9	1.1	2	0.1	0.2
Hartsock	39.9-55.5	26.9-37.5	19.3	29	1.9	2.7
HMA	55.5-74.5	37.5-50.3	67.4	98	5.2	7.7
Wilderness	74.5-86.3	50.3-58.3	12.2	18	1.5	2.3
Upstream of Trap	> 59	> 39.9	60.7	87	-	-
Downstream of Trap	< 59	< 39.9	39.3	56	-	-

Note:

1985 to 2009 data from Gallinat and Ross (2009). Rkm and RM differ slightly; RM shown were developed for the current scope of work and have been compared to Rkm primarily based on landmarks (bridges, property boundaries) for consistency.

Per Table 3-3, it is noteworthy that approximately 88 percent of the spring Chinook spawning documented over the last 24 years occurs between RM 22.8 (King Grade) and RM 48.1 (near Cow Camp Bridge), recognizing that spawning near the headwaters may have occurred historically at a higher density than is currently occurring (Glen Mendel, personal communications, 9/7/2011).

The data provided in Table 3-3 have been further evaluated by delineating the spawning distribution into the geomorphic reaches identified in this report and in the *Geomorphic Assessment* (Anchor QEA 2011). This information was used in the project evaluation presented later in this report.

3.2.4 Life History Diversity

Biological diversity within and among populations of salmon is generally considered important for three reasons (McElhany et al. 2000):

- Diversity of life histories patterns is associated with a use of a wider array of habitats

- Diversity protects a species against short-term spatial and temporal changes in the environment
- Genetic diversity is the so-called raw material for adapting to long-term environmental change

The latter two reasons are often described as nature’s way of hedging its bets—a mechanism for dealing with the inevitable fluctuations in environmental conditions—in the long and short term. With respect to diversity, more is better to minimize the risk of extinction.

Current life-history diversity of Tucannon River spring Chinook is presumed to reflect historic life-history diversity, with the majority of juveniles emerging from the gravel in spring, rearing for one summer and one winter, and then out-migrating as 1-year-old smolts in the spring. Of interest is the apparent lack of winter rearing habitat and channel complexity (e.g., side channels, back water, and pools) that support juvenile fish. Existing data demonstrate that the largest mortality occurs between egg and smolt, with the majority of the mortality occurring between egg and parr; it is alarming that, from brood year 1983 to brood year 2003, on average less than 6 percent of spring Chinook survived from egg to smolt (Gallinat and Ross 2010).

3.3 Restoration Expectations Related to Viable Salmonid Population Goals

3.3.1 Abundance

Population abundance is a key parameter used to assess the status of a stock and evaluate trends in stock improvement or decline. Abundance is also useful in identifying critical population dynamics that can be used to identify success in restoring a stock or levels at which extinction risk is high and the level of attention given to restoration be increased. Collectively proposed restoration actions in the Tucannon River are intended to improve abundance holistically; hence, no restoration action proposed in this report is targeting abundance specifically.

3.3.2 Life Cycle Productivity

As presented and referenced in this document, previous studies have identified degraded habitat conditions and juvenile carrying capacity as primary causes for the low R/S ratio

currently observed in the Tucannon River. Therefore, proposed restoration actions are highly focused on addressing limitations to productivity. The largest mortality occurs between egg and smolt, with the majority of the mortality occurring between egg and parr (SRSRB 2006). In addition WDFW data indicate that smolt production generally increases with an increase in adult returns in the basin, although a carrying capacity issue may exist above approximately 200 female spawners (Gallinat and Ross 2010). Spawning and incubation for spring Chinook begins in August and continues through March, with fry developing to parr through June. This timeline represents a large range in hydrologic conditions and habitats used by Chinook; prioritizing specific time periods and associated habitats is necessary to target critical life-cycle periods affecting productivity (ISRP 2011a).

The life stage between egg and parr coincides with late summer low flow, winter storm flows, and the spring runoff period. Summer low flows are unpredictable, and other efforts in the basin are focused on improving water quality and quantity. Winter storm events are stochastic and vary greatly in the effect that they may have on growth and productivity. For example, several consecutive years of minor peak flows, where impacts to fish are also minor, may occur between larger, less frequent flood events that have the ability to scour redds, resulting in significant losses to the run. Spring runoff flows occur each year and are relatively predictable in their magnitude and their effect on the habitat types required by juvenile salmonids; these habitats are currently lacking in the system. Data from smolt trapping in the lower river indicates that parr are arriving in the lower basin throughout the spring runoff period, long before their genetic signal should be initiating movement downstream (Glen Mendel, personal communications, September 2011). It is speculated that this may be occurring either because they are being flushed downstream and are not able to find suitable refuge habitat, or because juvenile fish are actively seeking out habitats in the lower river because of the lack of refuge areas (carrying capacity) in the preferred rearing areas upstream.

Based on high egg-to-parr mortality and uncertainty related to much of the hydrologic cycle during the egg-to-parr timeline, improving habitat conditions for juveniles during the spring runoff period was determined to be of high priority and to provide the greatest certainty of success with respect to improving growth and productivity. Therefore, restoration actions that will provide hydraulic complexity; will improve or create side channels, alcoves, or

hydraulic refuge and cover; or will improve low-lying floodplain connectivity will be considered to have high biological benefit when developing conceptual projects.

Installing necessary instream structure to provide adequate cover and complexity, while designing within the basin and reach-scale geomorphic context, will be critical to achieving both an immediate biological benefit and long-term restoration success. Hydraulic complexity and off-channel habitat projects will provide hydraulic refuge and rearing habitat for juvenile salmonids during moderate to high flows and will also provide more desirable habitat during lower flow conditions. LWD placements will provide refuge and cover and will be used to initiate a geomorphic response in many locations where natural channel development and floodplain connectivity can be achieved. Levee and riprap removal will remove stressors in the system, allowing for more natural geomorphic processes and promoting habitat recovery. For more details on specific restoration actions proposed for the Tucannon, see Appendix A: Conceptual Restoration Actions.

Collectively, these improvements can re-establish natural “processes of material and energy transfer across the watershed that enables the formation and maintenance of productive habitat,” identified by the Independent Scientific Review Panel (ISRP) for the Tucannon (2011b). It is expected that these improvements will promote the re-establishment of natural processes, which will increase habitat diversity and total rearing area available for juveniles and will improve their survival and productivity. The habitat improvements should also increase spawning and emergence conditions over time through improved energy dissipation from increases in channel complexity, improved temperature conditions, and improved distribution of nutrients and fine sediment across the floodplain.

3.3.3 Spatial Structure

Improving the population spatial structure relates to improving habitat conditions throughout the river corridor such that habitat needs are met across the various life stages and hydrologic regimes, and the health of the population is not jeopardized by local environmental effects. While it is known that the majority of the spawning occurs upstream of Marengo and rearing densities decrease downstream of Cummings Creek, valuable existing and potential habitat exists throughout the basin. The restoration approach for the

Tucannon does not focus exclusively on one reach or segment of the study area, but values both areas of the river currently experiencing high fish use, as well as areas with high restoration potential should a “full build out” of restoration opportunity be realized. This approach is further described below and in Section 9 of this report.

In general terms, the restoration strategy for the Tucannon River is a holistic basin-scale approach that values both immediate and long-term biological benefits. Implementation of restoration projects will likely occur in high-use areas early to maximize growth and productivity in areas of current use. In addition, projects with high benefit and low cost will be highly recommended regardless of location to maximize the growth and productivity of the segment of the population currently using those areas. Projects implemented on the fringes of the current high-use areas will expand the linear extent of high-quality habitat throughout the river corridor, increasing the distribution and carrying capacity for fish using those areas. Projects removing stressors on habitat will allow for natural recovery of the system and better habitat continuity through the river in the long term.

This restoration strategy will improve the spatial distribution of the stock by improving existing high-use areas, implementing high-benefit/low cost projects in non high-use areas, expanding the size of high-use areas by implementing projects on the fringes of those areas, and removing stressors affecting natural processes for long-term improvement of quality habitat throughout the river corridor production; and improve the spatial distribution of the stock.

3.3.4 Life History Diversity

Because the majority of the population of spring Chinook are 1+ fish, and restoration actions will target improving habitat for juvenile fish, none of the proposed restoration actions will specifically target improving life history diversity within the target species.

4 REACH 10 CONCEPTUAL PROJECTS

Reach 10 is located from the mouth of Panjab Creek at RM 50.2 to the downstream end of Big Four Lake (RM 44.0; Figure 2). The reach is within the Umatilla National Forest and the Wenaha-Tucannon Wilderness area and includes both public (WDFW) and private holdings such as the Camp Wooten natural resources learning center. Reach 10 is an important reach for spring Chinook, steelhead, and bull trout. Spring Chinook spawn and rear in Reach 10, with a high density of juvenile rearing in the lower portion of Reach 10. Steelhead rearing and spawning also occurs in the reach. Reach 10 and the adjacent tributaries (especially Panjab Creek) are significant areas for bull trout spawning and rearing.

The valley is forested with conifers that increase in density upstream of Panjab Creek (RM 50.2). The reach contains several perennial tributaries that drain the headwater areas, as well as several spring sources; a majority of Reach 10 was identified as a gaining reach except for a small section between approximately RM 47.7 and 46 (HDR 2006). A majority of the subbasin areas between the Little Tucannon River (RM 48.0) and the downstream end of Reach 10 were affected by the 2005 School Fire; the most severely burned areas were the Hixon and Grub Canyon basins (USFS 2008).

Confinement in the reach is variable; confinement in the lower reach downstream of the Little Tucannon River is typically influenced by anthropogenic features and entrenchment, whereas confinement in the upper reach is associated with alluvial fans, debris flow deposits, and natural narrowing of the valley width. Channel pattern in Reach 10 transitions from a primarily single-thread channel near Panjab Creek into a more diverse channel network with some side channels and braided sections toward the lower end of the reach. Floodplain connectivity in Reach 10 is slightly impacted by infrastructure and strongly impacted by channel incision in many places.

Nine conceptual project areas were identified in Reach 10. The primary restoration strategy presented within Reach 10 focuses on addition of LWD, with a lesser number of projects that identify off-channel habitat opportunities. LWD addition is consistent with the limiting factors identified in the EDT analysis of key habitat quantity and increasing riparian function (Appendix J, CCD 2004). LWD will provide a greater quantity of holding areas by initiating

pools and will contribute to reversing the incised condition of much of the channel, which will eventually lead to better connectivity of riparian vegetation with water table and bank overtopping.

4.1 Project Area 1 (River Mile 50 to 48.9)

Project Area 1 (PA-1) is located from the Panjab Creek Bridge (RM 50) to just upstream of the campground near RM 48.9.

Table 4-1
Restoration Recommendations for Project Area 1

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes throughout the project area, particularly the ground water at RM 49.5.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	No significant infrastructure was identified that impairs natural processes.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 1.3 river miles; supplement existing rock structure (weirs) with LWD.

4.1.1 Site Description

4.1.1.1 Channel Characterization

The channel through PA-1 is characterized as a single-thread, plane-bed channel with local rapid sections (Photograph 4-1). This area is located in a relatively steep, narrow section of the valley. Five rock weirs are located within the project area and likely contribute to grade control of the channel profile. Multiple rock-rootwad restoration features were also observed throughout. Several minor side channels were observed during site reconnaissance, although many of these features are likely dry during the low-flow period. At approximately RM 49.05, a spring originates south of the campground and flows parallel to the river for approximately 0.1 miles.



Photograph 4-1
PA-1 near RM 49.6, looking downstream

The quality of instream habitat is limited by the lack of hydraulic and bedform complexity in the channel. Very few key logs were observed, so pools and instream cover were generally limited to the locations of man-made structures and small side channels. Overall, woody debris retention and temporary sediment storage was low.

4.1.1.2 *Floodplain Characterization*

Floodplain connectivity appears to be unaffected by infrastructure, although remnant alluvial fan and hillslope deposits create moderately high surfaces that restrict the area of the low floodplain throughout much of the project area. Small sections of remnant levees and sections of riprap are located in a few places; however, the influence of these features to natural processes appears to be minor.

The riparian zone is generally in a moderately healthy condition, with local areas that have been degraded by recreational use, development, and fire. Riparian trees are mixed deciduous and conifer, dominated by Ponderosa pine, willow, alder, and dogwood. Understory vegetation includes groundcover, shrubs, and small trees that provide overhanging vegetation. Species are moderately diverse but contain many invasive plants, including Robert geranium, reed canarygrass, oxeye daisy, and creeping buttercup that are dominant in local areas of the floodplain and the active channel.

4.1.2 Conceptual Project Actions

Restoration actions would involve placing large woody debris structures throughout the project area and supplementing existing rock structures with wood for added complexity (Figure B-1). LWD may include a range of treatments, from placing single logs in side channels and alcoves to engineered log jams (ELJs) in plane-bed sections of the main channel.

4.1.2.1 Geomorphic Implications

Addition of LWD will initiate a geomorphic response resulting in bank erosion, bed scour, and sorting of sediment, which form critical habitat features (e.g., pools, cover, and spawning gravels). Because the channel profile is controlled by man-made features, the larger ELJs are not expected to significantly affect the channel grade on a reach scale. However, the ELJs will influence the development of pool-riffle morphology through what is a mostly simplified, plane-bed channel. In addition, large wood structures will promote development of a more complex channel network by splitting flow, initiating island development, and promoting channel migration.

4.1.2.2 Biological Benefits

Adding complexity to the channel via LWD will provide hydraulic diversity and refuge in the mainstem significantly improving habitat conditions for juveniles. In the short term, the pools that form at the structures will increase the available area for holding in the project area. Increased hydraulic diversity will provide high-flow refuge and low-flow cover for juveniles. The structures will also increase sediment retention enhancing the size and quality of spawning areas. In the long term, ELJs will promote channel complexity by

splitting flow and encouraging natural processes driving the formation of habitat elements such as pools and side channels. Diversification of available habitats will increase the carrying capacity of juvenile salmonids and increase the number of pools for holding adults.

4.1.2.3 Potential Challenges

The project area covers more than 1 river mile and multiple access routes will be required to place LWD. Some trees and other existing vegetation may be disturbed in the process of gaining access to and placing the LWD structures.

4.2 Project Area 2 (River Mile 49.1 to 48.65)

Project Area 2 (PA-2) is located within the channel and floodplain on public land from an undeveloped campground at RM 49.1 to approximately RM 48.65.

Table 4-2
Restoration Recommendations for Project Area 2

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes primarily in the lower half of the mainstem and through the existing channel in the right floodplain.
2. Reconnect isolated habitats	Reconnect an approximately 1,410-linear foot channel with a 200 linear foot excavation, and supplement with groundwater.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	No significant infrastructure was identified that impairs natural processes.
4. Restore riparian processes	Install supplemental plantings as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 0.2 river miles as needed when associated with other restoration actions in the project area.

4.2.1 Site Description

4.2.1.1 Channel Characterization

The channel through PA-2 is characterized as a single-thread, plane-bed channel from RM 49.1 to 48.95. Downstream of RM 48.65 the channel contains a moderate amount of LWD that initiates an anastomosing channel with multiple pathways and a high amount of temporary sediment storage. Two rock weirs are located at the downstream end of the project area. Multiple side channels were observed during site reconnaissance. A large side channel diverts from the main channel near RM 48.85 and flows along the southwest valley wall. Instream habitat in the project area is generally good due to multiple off-channel areas that provide excellent juvenile rearing habitat and LWD that provides large holding pools, cover, and hydraulic refuge.

4.2.1.2 Floodplain Characterization

Floodplain connectivity appears to be unaffected by infrastructure in the project area. Remnant alluvial fan and hillslope deposits create a moderately high floodplain surface at the upstream end of the site. More recent alluvium composes the low floodplain downstream of approximately RM 49.0. A groundwater channel was identified in the floodplain, originating at approximately RM 49.05 at the toe of the high terrace. Because the water surface elevation in this channel was perched 1 to 2 feet above the water surface in the main channel, the source of the water was assumed to be a groundwater spring. The spring water flows parallel to the river along the base of the terrace and through the floodplain for approximately 550 feet until it meets the main channel near RM 48.95.

Two additional low-flow paths were identified in the floodplain. The first is a low depression just north of the spring channel near RM 48.95 that was dry at the time of observation. The second is located at the toe of the northern valley wall between approximately RM 48.95 and 48.7 and contained swampy flowing water with no clear source. The channel may be supplied by groundwater, hyporheic exchange, or more likely by water from narrow ephemeral drainages that outlet beneath Tucannon Road.

The riparian zone is generally in a moderately healthy condition, with local areas that have been degraded by development. Riparian trees are mixed deciduous and conifer, dominated

by Ponderosa pine and dogwood. Understory vegetation is generally thick and healthy, containing fern and saplings that provide overhanging shade in the spring channel (Photograph 4-2). Species are moderately diverse, but contain many invasive plants, including reed canarygrass, St. John's wart, teasel, and creeping buttercup.



Photograph 4-2

Vegetation on the floodplain at the existing spring channel near RM 49.0

The spring-fed wetland adjacent to the northeast valley wall is in moderately good health with ample shade and wood. The overstory is composed of a mixture of mature deciduous and conifer trees and several saplings. The understory is generally healthy and dominated by rushes, sedges, and ferns. Vegetation diversity is high and disturbance is low. At RM 48.8, there is another wetland with dense, healthy vegetation that provides shade and cover.

4.2.2 Conceptual Project Actions

Restoration actions in PA-2 involve routing the existing spring-fed channel north through the floodplain and into the roughly 1,400-foot channel along the northern edge of the valley (Figure B-2). The realigned channel may be supplemented with additional LWD or plantings at the time of construction. The two rock weirs at the downstream end of the project area would be supplemented with LWD.

4.2.2.1 Geomorphic Implications

The project is not expected to have significant geomorphic implications. Placing LWD in the main channel will promote local channel expansion and hydraulic complexity.

4.2.2.2 Biological Benefits

Increasing the quantity and duration of flow in the side channel will provide additional off-channel habitat area for rearing juveniles. The groundwater spring will supply cool, flowing, and clean water through the channel that is currently slow-moving and swampy. The thick vegetation growing along the channel will provide greater cover and complexity than the channel in its current configuration, which will likely reduce predation. Placing LWD in the main channel and supplementing the weirs with LWD will provide cover and complexity and may create better juvenile passage.

4.2.2.3 Potential Challenges

A short but relatively deep excavation would be required to connect the spring source to the tributary-fed channel, although the spoiled materials could be easily distributed atop the floodplain. Some trees and other existing vegetation may be disturbed in the process of excavation. Because the tributary channel is located near the toe of the road prism, the impacts of road runoff should be considered during the design process.

4.3 Project Area 3 (River Mile 48.65 to 46.8)

Project Area 3 (PA-3) is located within the active channel from one-quarter mile upstream of Cow Camp Bridge (RM 48.65) to the upstream end of the Camp Wooten Environmental Learning Center (RM 46.8).

Table 4-3
Restoration Recommendations for Project Area 3

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes throughout the project area.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 380 feet of riprap to re-establish floodplain connectivity of approximately 0.59 acres of low floodplain.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 1.3 river miles; supplement the existing rock structure (weir) with LWD.

4.3.1 Site Description

4.3.1.1 Channel Characterization

The channel through PA-3 is characterized as a single-thread channel containing both plane-bed, and forced pool-riffle sections. Local steep rapids are present; in these sections, the thalweg is typically deep with high velocities. One rock weir and multiple rock and rootwad restoration features were identified in the project area. Other than rock armor along the Cow Camp Bridge abutments and an approximately 350-foot riprap bank downstream of the bridge near RM 48.3, no other significant infrastructure was identified in the channel. Only a few side channels were observed that appeared to provide minimal habitat benefit.

The availability and quality of instream habitat is limited by lack of complexity and hydraulic conditions that prevent the retention of sufficient volumes of LWD and sediment. The spatial distribution of existing LWD is limited. Large jams and sediment deposits are present but sporadic (Photograph 4-3); the log jams that were observed were typically associated with local areas of high temporary sediment storage, split flow, and side channels. However, the majority of the project area is made up of long, straight, plane-bed stretches that lack any adequate cover or hydraulic complexity.



Photograph 4-3
A channel-spanning log jam near RM 47.5

4.3.1.2 Floodplain Characterization

Throughout a majority of the project area, the channel is moderately entrenched between the bedrock valley wall and remnant alluvial fan and hillslope deposits, resulting in a relatively high floodplain surface. Thus, much of the valley floor is not within the low floodplain.

The influence of the riprap at RM 48.3 to floodplain connectivity does not appear to be significant, although the armoring likely prevents channel migration and transfers energy downstream along the left bank. A relatively low former channel position is located in the western portion of the floodplain between RM 48.2 and RM 48.1. Flowing water was

observed through the channel, although it was unclear if it was supplied by hyporheic exchange or a groundwater spring. No fish use was observed within this feature.

The riparian zone is in a moderately healthy condition, with local areas that have been degraded by infrastructure, fire, and development. Riparian trees are mixed deciduous and conifer, dominated by Ponderosa pine, alder, and dogwood. The banks upstream of the Little Tucannon River (RM 48.1) are dominated by alder saplings, grasses and other emergent vegetation, buttercup, and other invasive species. Downstream of RM 48.1, understory vegetation is thick and healthy and contains fern and saplings that provide overhanging shade in the channel. Species are moderately diverse but contain many invasive plants, including reed canarygrass, St. John's wart, teasel, and creeping buttercup.

4.3.2 Conceptual Project Actions

Restoration actions would involve placing LWD throughout the project area and supplementing the existing rock weir with wood (Figure B-3). Large woody debris may include a range of treatments, from placing single logs in side channels and alcoves to ELJs in plane-bed sections of the main channel. Additionally, the riprap bank between RM 48.3 and 48.2 would be removed to allow channel migration to occur through this area of the floodplain. Long-term planning should consider reconfiguration or replacement of the Cow Camp Bridge with a longer spanning bridge that would allow for better connectivity and ability to migrate across the low floodplain. The bridge is currently in disrepair.

4.3.2.1 Geomorphic Implications

Addition of LWD will initiate a geomorphic response resulting in bank erosion, bed scour, and sorting of sediment, which form critical habitat features (e.g., pools, cover, and spawning gravels). Over time, the large ELJs will promote retention of bedload sediment throughout the project area, reversing some of the effects of channel entrenchment. Log jams will also promote development of a more complex channel network by splitting flow, initiating island development, and promoting channel migration. Removal of the riprap bank will additionally allow natural channel processes such as migration to occur.

4.3.2.2 Biological Benefits

Adding complexity to the reach via LWD will provide hydraulic diversity and refuge in the mainstem, significantly improving habitat conditions for juveniles. In the short term, the pools that form at the structures will increase the available area for holding in the project area. Increased hydraulic diversity will provide high-flow refuge and low-flow cover for juveniles. The structures will also increase sediment retention, enhancing the size and quality of spawning areas. In the long term, ELJs will promote channel complexity by splitting flow and encouraging natural processes that drive the formation of habitat elements such as pools and side channels. Diversification of available habitats will increase the carrying capacity of juvenile salmonids and increase the number of pools for holding adults. Riprap removal will decrease velocities along the face of the bank and promote natural channel processes.

4.3.2.3 Potential Challenges

The project area is approximately 2 river miles long and multiple access routes will be required to place the LWD. Some trees and other existing vegetation may be disturbed in the process of gaining access to the riprap removal and LWD placement sites, particularly within the more heavily wooded area upstream of the Little Tucannon River. Downstream of this location, the lack of understory will make for easier access, although some existing vegetation will likely be disturbed. Any wood that must be removed for access may be incorporated into the LWD placements or used to decommission access routes.

4.4 Project Area 4 (River Mile 46.8 to 46.4)

Project Area 4 (PA-4) is located within the active channel and in the floodplain adjacent to the Camp Wooten Environmental Learning Center between RM 46.8 and 46.4.

Table 4-4
Restoration Recommendations for Project Area 4

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel processes occurring upstream of RM 46.6 and the tributary/floodplain channel habitat on the south side of the floodplain.
2. Reconnect isolated habitats	Excavate approximately 260 linear feet to reconnect 820 linear feet of additional side channel; enhance 1,970 feet of existing channel by increasing flow in the side channel for a greater time period.
3. Address roads, levees, other anthropogenic infrastructure impairing processes	Set back approximately 670 feet of the levee (includes the gravel road) to reconnect approximately 1.6 acres of low floodplain.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 0.45 river miles in the project area.

4.4.1 Site Description

4.4.1.1 Channel Characterization

In the upper portion of the project area from RM 46.8 to 46.65, the river contains multiple rapid/run channels separated by forested islands. Downstream of RM 46.65, the river and floodplain are highly confined between a levee and the road grade, which has resulted in a single-thread, high-velocity channel with large armor substrate and angular riprap banks (Photograph 4-4). The levee on the right bank currently serves as an access road to the upstream side of the Camp Wooten facilities, including Donnie Lake. The lake outfall channel flows along the toe of the road, meeting the main channel at approximately RM 46.55. Several juvenile fish were observed in the outfall channel. It is not clear if the pond itself is spring-fed or receives water via diversion from the river.



Photograph 4-4

PA-4 near RM 46.5, looking downstream from the right bank levee

The quality of instream habitat in this project area is limited by the lack of hydraulic and bedform complexity in the channel. In the upper multiple-thread channel, some mobile debris has accumulated at the apex of islands and along the channel margins. The different flow paths create variable hydraulic conditions that are likely to be active year-round. Although a few trees were observed in the lower portion of the channel, the high-velocity conditions likely prevent any retention of mobile debris or sediment deposition, and these trees likely will be transported downstream during the next high-flow event.

4.4.1.2 *Floodplain Characterization*

Floodplain connectivity is greatly limited by the right bank road levee, which confines the channel to the left side of the valley and cuts off a majority of the floodplain to the right. A

large amount of low floodplain area and low-lying channel paths exist within the cutoff portion of the floodplain. One of these channels originates on the downstream side of the levee near RM 46.6 and flows through the camp on the southeast side of the valley. During field observation, the channel was dry at the upstream end and became wetted where a tributary meets the main valley at approximately RM 46.5; this tributary may be spring-fed, as indicated on U.S. Geological Survey (USGS) topographic maps (cite), although it was unclear if the flow is perennial due to the unusually wet conditions at the time of observation. The floodplain channel continues through the floodplain and does not flow into the main channel until approximately 0.9 RM downstream of the project area, gaining additional tributary flow along the way.

The riparian zone is generally in a moderately healthy condition, where it has not been cleared or disturbed for development of the Camp Wooten site and for other recreational use. The most notable area of disturbance is associated with the levee near RM 46.5. Riparian trees are predominantly immature deciduous trees, with very few mature or coniferous trees in the area. Understory vegetation upstream of the levee contains shrubs such as flowering dogwood that provide overhanging shade and leaf drop. Downstream of the levee where the channel is more confined, the riparian zone narrows to approximately 5- to 10-foot wide and vegetation limited with little overhang. In the overall project area, species are moderately diverse. The levee zone contains a high number of invasive species, including St. John's wart, common teasel, Himalayan blackberry, and Robert's geranium, Mullein and reed canarygrass grow atop much of the open area in the active channel.

4.4.2 Conceptual Project Actions

Upon discussion with several stakeholders, including the entities that operate and maintain Camp Wooten, it is understood that removal or significant modification of the facilities are not desired at this time. Restoration actions in PA-4 involve re-establishing a side channel through the disconnected floodplain, setting back a portion of the levee between RM 46.6 and 46.4 to ease channel confinement, and placing LWD (Figure B-4). Flow to the floodplain channel would be achieved by re-routing outfall of the pond. A culvert would be placed through the levee to connect the upstream and downstream ends of the side channel. The northwest corner of the road and levee around the camp would be set back to the edge of the

floodplain terrace. This action would require four portable cabins and a few small outbuildings to be relocated elsewhere on the site.

4.4.2.1 Geomorphic Implications

Widening the floodplain corridor via levee setback would significantly increase the width of the floodplain corridor and remove confining features that affect instream hydraulics and geomorphic processes. During high flows, dispersion of floodwaters over this area would significantly decrease velocities in the main channel and allow for dispersion of overbank sediments and mobile debris. Over time, the channel will have a greater capacity to establish a more natural channel configuration and ability to retain wood and store sediment. Establishing the side channel through the floodplain is not expected to have significant geomorphic implications.

4.4.2.2 Biological Benefits

Biological benefits include decreased instream velocities and increased complexity. Increased flow in the approximately 2,000-linear-foot side channel will increase the juvenile carrying capacity. In the long term, re-establishing and enhancing floodplain processes via levee setback will promote wood and sediment retention and increase the presence of side channels and diverse instream complexity.

4.4.2.3 Potential Challenges

Implementing this project will require some modifications to Camp Wooten and will cause disturbance during construction activities. The project would require a significant amount of earthwork, though much of the excavated material would be re-used to build the setback levee or dispersed on site. Trees and other vegetation on the portion of the levee that is setback would be removed, but the material may be incorporated into other habitat features. Because the current levee was built and is maintained by the U.S. Army Corp of Engineers (USACE), the setback levee will likely require USACE consultation and adherence to their standards. Some trees and other existing vegetation in the floodplain may be disturbed in the process of gaining access to the channel to place LWD at the upstream end of the site.

4.5 Project Area 5 (River Mile 46.4 to 45.95)

Project Area 5 (PA-5) is located within the active channel from the downstream end of the Camp Wooten Environmental Learning Center (46.4) to the Tucannon Campground Bridge at RM 45.95.

Table 4-5
Restoration Recommendations for Project Area 5

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes through naturally functioning areas. Protect the existing side channel along the SE valley wall.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, other anthropogenic infrastructure impairing processes	Remove approximately 2,330 feet of roadway that separates the main channel from approximately 9.27 acres of low floodplain and establish alternate bridge access to Camp Wooten. Remove approximately 990 feet of levees and riprap banks between RM 46.4 and 46.2 to reconnect approximately 1.5 acres of low floodplain; approximately 95 feet of levee will be set back along the Camp Wooten loop.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 0.5 river miles.

4.5.1 Site Description

4.5.1.1 Channel Characterization

Throughout the project area, the river is characterized by multiple channels separated by unvegetated gravel bars or forested islands. This portion of the channel is located downstream of a tightly confined section (PA-4). The active channel area is relatively wide and wood and sediment is more likely to deposit resulting in a relatively dynamic reach with a greater volume of LWD, temporary sediment storage, and channel migration than has been observed in upstream reaches (Photograph 4-5). Steady migration of meander bends was observed in many of the outside meander bends, most notably at RM 46 along the left bank. Side channels ranging from perennial to high-flow were observed with variable depths and

presence of LWD. Many side channels, however, were relatively wide, shallow, and lacking complexity.



Photograph 4-5

A secondary flow path within PA-5 near RM 46.1, looking downstream

The variety of hydraulic conditions created by channel processes, wood, and sediment in this project area create relatively good instream habitat conditions. Overall, however, the project area is lacking in sufficient volume and size of LWD. The log jams observed did not appear substantial enough to persist and retain additional LWD over time.

4.5.1.2 Floodplain Characterization

Floodplain connectivity in this project area is highly affected by the presence of infrastructure. Approximately half of the low floodplain area, including a major former

channel position along the southeast valley wall, is cut off from the river by the road connecting the Tucannon Campground to Camp Wooten. The side channel was flowing at the time of field observation, which was likely from tributary inputs (Hixon and Grub canyons).

A hyporheic- or groundwater-fed channel was identified in the right floodplain near RM 46.4. At the time of observation, the channel flowed downstream to a dry side channel at approximately RM 46.3, where it became subsurface. The flow from this channel may be supplementing some standing water pools within the dry side channel, where several isolated juvenile salmonids were observed.

The riparian zone is generally in a moderately healthy condition, with local areas that have been disturbed by recreational use and development, such as the Tucannon Campground. There are very few mature or coniferous trees adjacent to the main channel. Understory vegetation includes groundcover, shrubs, and small trees that provide overhanging vegetation along the banks. Species are moderately diverse and contain only a moderate amount of invasive plants. Mullein and reed canarygrass grow atop a majority of the open areas in the active channel.

The vegetation surrounding the tributary-fed channel along the southeast valley wall downstream of Camp Wooten is generally in good health. Riparian trees are a mixture of deciduous and conifer species, including Ponderosa pine and cottonwood. Understory vegetation includes groundcover, shrubs, and small trees that provide ample overhanging vegetation. Species are diverse and contain few invasive plants. Several juvenile salmonids were observed in the channel.

4.5.2 Conceptual Project Actions

Restoration actions in PA-5 involve reconnecting the low floodplain via road removal and enhancing instream habitat by LWD placement (Figure B-5). These actions are independent from each other and may be implemented in phases. Road removal would occur from the intersection of the Camp Wooten loop (RM 46.4) to the intersection of the Tucannon Campground loop (RM 46.0). A new bridge crossing to Camp Wooten will be required

upstream. The location of the bridge may be affected by project actions associated with PA-4 (see Section 4.4).

4.5.2.1 Geomorphic Implications

Widening the floodplain corridor by removing the roadway would approximately double the accessible floodplain through the project area and allow natural floodplain and channel processes to occur. During high flows, dispersion of floodwaters over this area would decrease velocities in the main channel and allow for distribution of overbank sediments and mobile debris. Over time, the functionality of channel, floodplain, and riparian processes will be increased, in turn leading to ecosystem benefits. Addition of LWD will initiate pool scour, provide cover, retain sediment, maintain existing side channels, and increase hydraulic complexity. In the long term, large wood structures will form a complex channel network by maintaining and creating additional islands and promoting channel migration.

4.5.2.2 Biological Benefits

Biologic benefits include decreased channel velocities, better connectivity with the floodplain, and increased complexity and refuge related to LWD placement. Over time, greater floodplain connectivity will lead to a healthier riparian zone and in turn drive floodplain ecosystem processes. The LWD will promote channel complexity by splitting flow and initiating a geomorphic response that will create habitat elements such as pools and side channels. The diversification of available habitats will increase the carrying capacity of juvenile salmonids in the project area and increase the holding area for adults.

4.5.2.3 Potential Challenges

Road removal will require a significant amount of material be hauled off site. Implementing this project as shown requires the construction of a new bridge, which is expected to be a high-cost effort.

4.6 Project Area 6 (River Mile 45.95 to 45.3)

Project Area 6 (PA-6) is located within the active channel from the weir upstream of the Tucannon Campground Bridge (RM 49.95) to the former U.S. Forest Service (USFS) Road 140 crossing at RM 45.3.

Table 4-6
Restoration Recommendations for Project Area 6

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Protect natural channel and floodplain processes between RM 45.7 and 45.3, and within the tributary-fed channel along the southeast valley wall.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove the access road and bridge to the campground. Retire the campground and remove any infrastructure (including approximately 145 feet of levee) that may impact habitat conditions or impede natural processes.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD within approximately 0.2 RM; supplement existing rock structures (weirs) with LWD.

4.6.1.1 Channel Characterization

In the upper portion of the project area from RM 45.95 to 45.7, the channel is a single-thread, plane-bed channel with little complexity (Photograph 4-6a). Two vortex weirs between RM 46.0 and 45.8 hold the channel grade and form deep pools on the downstream end. This portion of the channel contains very little LWD or other hydraulic complexity, other than the pools at the weirs. Very little suitable habitat for juvenile fish was observed except near the channel margins. Habitat conditions may also be affected in the summer months by recreational use as this portion of the river is adjacent to the campground.



Photograph 4-6a

The plane-bed section of the channel during low flow near RM 45.8, looking upstream

Between RM 45.7 and 45.3, the channel is a more complex, multi-channel configuration with forced pools and riffles at LWD and along the bedrock valley wall (Photograph 4-6b). Instream habitat conditions in the main channel are generally good, due to the presence of large LWD that retains additional mobile wood and forces deep pools. Two large side channels that meet the main river at approximately RM 45.5 and RM 45.3 provide good off-channel rearing habitat with ample cover, depth, and low velocities.



Photograph 4-6b

A side channel with moderate woody debris near RM 45.4, looking downstream

4.6.1.2 Floodplain Characterization

Floodplain connectivity in this project area is adversely affected by the presence of the bridge and campground, which cut off approximately half of the low floodplain area. A major former channel position along the southeast valley wall is separated from the river by the campground area. Floodplain connectivity is less impacted from RM 45.8 through the downstream end of the project area, where no infrastructure is present. The portion of the floodplain between RM 45.5 and 45.3 is somewhat naturally confined by remnant alluvial fan and hillslope deposits from the northwest side of the valley.

The riparian zone is generally in moderate to poor health, with many dead or dying plants in the upstream end of the project area. Riparian trees are generally immature and sparse; some

larger deciduous shrubs are present, including flowering dogwood and vine maple. The understory is in moderate health but provides little overhanging vegetation. The dry exposed areas contain many invasive plants, including St. John's wart, reed canarygrass, and common teasel.

Towards the downstream end of the project area, the riparian zone is in moderately healthy condition. Riparian trees are mixed coniferous and deciduous, including Ponderosa Pine, alder, and dogwood. Understory vegetation includes groundcover, shrubs, and small trees that provide overhanging vegetation along the banks. Species are moderately diverse and contain a moderate amount of invasive plants such as reed canarygrass.

4.6.2 Conceptual Project Actions

Between RM 45.95 and 45.7, proposed restoration actions include retiring the campground, supplementing the existing weirs with LWD, and adding instream habitat and complexity with LWD placements (Figure B-6). Implementing this project in conjunction with PA-5 should be considered for optimum habitat and physical benefits; implementing both projects would allow the bridge to the campground to be removed. No active restoration is proposed within the project area between RM 45.7 and 45.3; this area should be protected as natural processes continue to create and maintain relatively good habitat conditions.

4.6.2.1 Geomorphic Implications

Retiring the campground is not expected to have significant geomorphic implications related to floodplain connectivity, unless the campground is removed as a part of road removal described in PA-5 (see Section 5.5). Implementing the two projects together would allow floodplain connectivity without risk to infrastructure. If the campground and bridge are removed, in addition to road removal, the benefits of the project to natural processes would be considerable. The channel would no longer be constricted at the bridge crossing and the channel would be able to freely migrate through the campground area, decreasing velocities and leading to more natural distribution of wood and sediment. Addition of LWD will develop instream complexity in the wide, shallow portions of the project area by initiating bed scour and sediment deposition and developing pools and velocity shadows. In the long

term, large wood structures will initiate formation of a more complex channel network by creating islands and promoting channel migration.

4.6.2.2 *Biological Benefits*

Immediate biological benefits of the project include decreased channel velocities during high flows from better connectivity with the floodplain, additional instream complexity, and pool development via LWD placement. Over time, greater floodplain connectivity will lead to a healthier riparian zone and, in turn, drive many ecosystem processes. The LWD will promote channel complexity by splitting flow and encouraging processes such as pool scour to create hydraulic complexity where it is lacking in the plane-bed portion of the channel. Over time, the LWD will promote channel migration and other processes that drive the formation of habitat elements (e.g., pools and side channels), leading to a more complex channel network. The availability of more and diverse habitats will increase the carrying capacity for juvenile salmonids.

4.6.2.3 *Potential Challenges*

The Tucannon Campground is highly popular and generates a significant amount of revenue for the USFS; retiring the campground may not be desired. However, an alternate action would be to convert the campground to a primitive walk-in site with access from Camp Wooten or from another location downstream. This would allow removal of infrastructure (including removal of the bridge if combined with PA-5), while maintaining revenue and promoting diverse use of USFS properties. Retiring or conversion of the campground may require relocation of the facility or other means of assurance that lost revenue can be recovered.

4.7 Project Area 7 (River Mile 45.3 to 44.85)

Project Area 7 (PA-7) is located within the active channel and floodplain from the former USFS Road 140 crossing at RM 45.3 to the Curl Lake intake structure at RM 44.85.

Table 4-7
Restoration Recommendations for Project Area 7

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural processes are impaired in this project area.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 2,700 feet of Tucannon Road and relocate approximately 2,470 feet of the road between RM 45.3 and 44.85; remove approximately 340 linear feet of riprap and other infrastructure.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout approximately 0.5 river miles.

4.7.1 Site Description

4.7.1.1 Channel Characterization

Within this project area, the channel is a single-thread, plane-bed channel with local rapid sections. Between RM 45.2 and 45, the channel is entrenched and incised between alluvial fan deposits and Tucannon Road, which appears to be built mostly on remnant fan deposits. An approximately 10-foot high bank between RM 44.9 and the Curl Lake intake also indicates an incised condition (Photograph 4-7). The section of the channel between RM 45.3 and RM 44.9 contains multiple rock and rootwad restoration features that force pools along the margin of the channel. Immobile boulders in the channel bed also provide a minor amount of pool formation and hydraulic complexity. Some riprap is present along the channel banks between RM 45.1 and 45.05, although it likely has no effect on channel migration in its currently entrenched state. At the Curl Lake intake, the channel is roughened with boulders and cobbles.



Photograph 4-7

An incised section of the main channel near RM 44.9, looking upstream

Between RM 45.3 and 44.9, the channel contains a moderate amount of LWD that provides some cover and hydraulic complexity to the channel in addition to the restoration structures. However, the confined condition of the channel through the project area results in a lack of side channels and likely concentrates velocities during high flows. Juvenile rearing habitat is severely limited by the lack of hydraulic refuge (e.g., off-channel areas and secondary flow paths). In addition, the hydraulic conditions likely prevent suitable spawning gravels from accumulating in the project area.

4.7.1.2 Floodplain Characterization

The limited floodplain connectivity in this project area is a product of the incision and high floodplain surfaces in this portion of the valley. However, Tucannon Road and the riprap present in the project area may limit the ability of the channel to migrate and develop low-lying floodplain areas, exacerbating the confined conditions. One potential side channel is present on the far southeast side of the valley that appears to have little connectivity to the channel; it is likely a drainage pathway for tributaries. A former mill pond located in the left floodplain between the channel and Tucannon Road at RM 45.3 contains wetland vegetation and standing water. Small trees are growing within the pond bottom and around the margins.

The riparian zone is generally in a moderately healthy condition. Riparian trees are a mixture of coniferous and deciduous species, predominantly young to mature Ponderosa pines, and alder and other hardwoods. The understory is in moderate health, dominated by immature trees and woody shrubs that provide some amount of overhang. A few local exposed areas contain many invasive plants, primarily reed canarygrass and other weedy species.

4.7.2 Conceptual Project Actions

Restoration actions would involve relocating Tucannon Road to the west side of the Tucannon Guard Station between approximately RM 45.3 and 44.85 and removing any riprap or other infrastructure in the project area (Figure B-7). A former road grade is located up the hillslope that may be an ideal location to relocate the road alignment. LWD would be placed throughout the channel and would likely need to be placed in large, stable complexes to withstand hydraulic forces and initiate a geomorphic response.

4.7.2.1 Geomorphic Implications

While road removal will not reconnect low-lying floodplain, the channel will have the ability to migrate into the floodplain material and adjust its planform to a more natural configuration. Installing LWD complexes will initiate a geomorphic response by scouring pools, promoting channel migration, and expanding the width of the active channel. As additional LWD material is retained in the project area, the active channel will be widened

and the bed elevation will increase, promoting improved connectivity with the floodplain through time.

4.7.2.2 *Biological Benefits*

Immediate biological benefits of the project include high-flow refuge, low-flow cover, and pool development from LWD placement. Over time, the LWD will promote the formation of habitat elements (e.g., pools and side channels), leading to the development and maintenance of diverse habitats that will support salmonids throughout various life stages. Reversing the incised condition of the channel will lead to better floodplain connectivity, in turn creating a healthier riparian zone and distribution of water and sediment across the floodplain that drives many ecosystem processes.

4.7.2.3 *Potential Challenges*

Road realignment will likely be an involved process with several stakeholders and regulatory agencies. Road and building relocation associated with the Guard Station may be not be desired by forest and recreational managers. Implementation may be a long process and should be initiated early. This portion of Tucannon Road has been considered by the USFS for relocation in the past; the cost-benefit analysis was determined to be inadequate to complete the project.

4.8 Project Area 8 (River Mile 44.85 to 44.4)

Project Area 8 (PA-8) is located within the active channel and floodplain from Curl Lake intake structure at RM 44.85 to downstream of Curl Lake at RM 44.4.

Table 4-8
Restoration Recommendations for Project Area 8

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural processes are impaired in this project area.
2. Reconnect isolated habitats	Establish a better connection between the spring, the wetland, and the river with a shallow excavation to create a total of approximately 990 linear feet of spring-fed side channel; reposition the outfall through the floodplain channel to provide 546 feet of additional off-channel habitat.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 680 feet, and setback approximately 330 feet, of rock and levee material to re-establish floodplain connectivity of approximately 1.01 acres of low floodplain.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout approximately 0.3 river miles of the mainstem.

4.8.1 Site Description

4.8.1.1 Channel Characterization

Throughout the project area, the single-thread channel is typically wide, shallow, and plane-bed. A few local high-velocity areas occur along the toe of the bedrock valley wall (Photograph 4-8). Levees are present along much of the left bank, confining the active channel and low floodplain to the far side of the valley. No side channels or secondary flow paths were identified. A large ELJ is present on the right bank at RM 44.8 and provides some cover and pool habitat. The channel contains little other LWD except small, transient material. Although juvenile fish may use the shallow margins of the channel, the lack of cover, complexity, and pools results in generally poor habitat conditions throughout this section of the river.



Photograph 4-8
The mainstem channel near RM 44.7, looking downstream

4.8.1.2 Floodplain Characterization

Floodplain connectivity in this project area is poor due to the incised condition of the channel and the presence of infrastructure that confines and disconnects the channel from a majority of the low-lying floodplain. A narrow corridor of low floodplain is present from approximately RM 44.8 to the Curl Lake outfall at RM 44.55, but it is cut off from the channel by levees. A groundwater spring located near RM 44.85 appears to originate west of Tucannon Road, where several wetland plants were observed but no flowing water. East of the road, the spring becomes a surface water channel, eventually flowing into a wetland near RM 44.75. The channel is lined with ferns, sedges, and rushes that provide good shading and cover. The spring flows into a portion of the disconnected low floodplain, consisting of a

muddy to ponded wetland area vegetated with rushes, sedges, ferns, and cattails. Several dead or dying trees are present in this area. The spring channel has a poor downstream connection with the river and no fish were observed in the channel.

Adjacent to Curl Lake, another disconnected floodplain area is present that is fed by seepage through the lake berm. The water accumulates into a small side channel and meets the river near RM 44.6, providing a minor amount of off-channel habitat. Downstream of Curl Lake, a ponded wetland dominated by cattails and grasses makes up a majority of the floodplain. Trees and other cover or shading is sparse.

In general, the riparian zone is in a moderately healthy condition, but conditions adjacent to the main channel provide little cover or shading. Few mature riparian trees are present along the channel margins. Riparian trees in the project area consist of young to moderately mature Ponderosa pines, dogwood, and alder. The understory is moderately dense and dominated by emergent vegetation that provides little overhang. Understory species are moderately diverse but contain several invasive plants, including St. John's wart, common teasel, Himalayan blackberry, sulfur cinquefoil, and reed canarygrass.

4.8.2 Conceptual Project Actions

Restoration actions in the project area involve creating a better connection between the spring flow, wetlands, and river to optimize the quantity of available off-channel habitat (Figure B-8). Levees and bank armoring will be removed to reconnect the low-lying floodplain and materials will be placed along the Curl Lake berm. LWD placement in the main channel is recommended. In addition, the outfall may be re-positioned so that the flow is routed out through the floodplain downstream of the lake, creating additional off-channel area. Because of the lack of cover in this area, LWD (single logs or similarly small placements) should be placed to provide cover, and willows or other shrubs should be planted to shade the channel.

4.8.2.1 Geomorphic Implications

LWD in the main channel will diversify the thalweg and initiate development of bedforms such as pools and gravel bars in the plane-bed channel. When the levees are removed, the

LWD will initiate split flows and development of a more complex channel network as the channel is able to migrate and overtop its banks into the low-lying floodplain. Creating a better surface water connection between the groundwater spring and the main channel is not expected to have significant geomorphic implications.

4.8.2.2 Biological Benefits

Relocation of rock and levee material to the toe of the existing lake berm will open up low wetland areas that are currently disconnected from the main channel. These areas will provide excellent off-channel habitat for juvenile fish. The channel will have a greater floodplain connectivity and ability to migrate, creating additional habitat areas over time via natural disturbance that creates habitat complexity. LWD in the main channel will provide adult holding, high-flow refuge, and cover for juveniles.

Connecting the channel to the groundwater spring will supply cool, flowing, and clean water through the channel and reconnected wetland area, providing temperature refuge and off-channel habitat that is preferred by juvenile fish. The wood debris and thick vegetation currently growing along the groundwater channel will provide good cover and complexity, as well as nutrients and protection from predators. Positioning the lake outfall through the floodplain will create additional off-channel habitat that will likely be highly utilized by juveniles if adequate cover and shading are provided along the channel.

4.8.2.3 Potential Challenges

Careful consideration must be given to the placement of materials along the Curl Lake berm to maximize the protection they may provide if the mainstem channel moves into this location in the future. Some trees and other existing vegetation (including wetland areas) will likely be disturbed in the process of proposed restoration actions, particularly levee removal and repositioning the lake outflow through the wetland/floodplain. Excavation required to connect the spring source to the main channel is expected to be minimal but will disturb some existing wetland area.

4.9 Project Area 9 (River Mile 44.4 to 44)

Project Area 9 (PA-9) is located within the active channel from just downstream of Curl Lake at RM 44.4 to RM 44.0.

Table 4-9
Restoration Recommendations for Project Area 9

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes throughout the project area.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove Big Four Lake and associated intake structure (approximately 2,560 linear feet) to re-establish floodplain connectivity downstream of the lake.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout approximately 0.6 river miles in the project area.

4.9.1 Site Description

4.9.1.1 Channel Characterization

Throughout PA-9, the river is characterized by multiple-channel pathways containing a variety of hydraulic conditions forced by the presence of LWD, including several pools and secondary flow paths (Photograph 4-9). Local channel expansion is occurring in the project area from just upstream of RM 44.4 to RM 44.25, as evidenced by bank erosion and multiple-flow path development, recently recruited trees in the channel and side channels, and high amounts of temporary sediment storage. A levee is located along the right bank from approximately RM 44.4 to RM 44.3 at the diversion structure to Big Four Lake. The structure is composed rock armoring and some rootwads along the toe. The channel adjacent to the levee is wide, shallow, and relatively well-armored due to locally high velocities. A straight, plane-bed stretch of channel adjacent to Big Four Lake near RM 44.1 had a well-armored bed lined with large cobbles. In general, the project area has good side channel

connectivity and contains a variety of side channel types from perennial to high-flow pathways.



Photograph 4-9

Deep pools and complex hydraulic conditions caused by LWD, near RM 44.4

The complex sections of channel within this project area provide a variety of hydraulic conditions, including a relatively high amount of off-channel habitat, that provide preferred habitat throughout different life stages over the water year. Instream habitat conditions in the main channel are generally good in these complex sections due to the presence of large LWD that retains additional mobile wood, forces deep pools, forms side channels, and provides cover and hydraulic refuge. These areas have several well-connected side channels and a wide active channel and floodplain, which allow the channel to migrate. However, the plane-bed sections of the project area lack a sufficient volume and size of LWD necessary for

instream complexity, which has led to wide, shallow conditions during low flows and high velocities during seasonal high flows. The LWD observed in these reaches did not appear substantial enough to persist and retain additional LWD over time.

4.9.1.2 Floodplain Characterization

This project area is characterized by a large active channel area but little floodplain connectivity. The floodplain surface is relatively high above the channel bed with a small amount of low floodplain area throughout the valley. The right bank levee at RM 44.35 likely prevents channel migration, but it does not cut the channel off from any significant low areas of the floodplain (within the 5-year water surface elevation). Big Four Lake is approximately two-thirds of the width of the valley, confining the potential width of the floodplain corridor. A large amount of low floodplain exists on the downstream side of the lake, which contained flowing water at the time of field observation that was likely sourced from lake seepage or tributary flow. The current position of the lake prevents an upstream surface water connection to this area.

The riparian zone is generally in moderate health, with some local areas that have been highly disturbed by fire. Riparian trees are predominantly mature Ponderosa pines and young dogwoods and alders. The understory is in moderate health dominated by emergent vegetation that provides little overhang. There are few mature trees and intermediate-sized plants and poor vegetation diversity in several areas. The upstream end of the severe burn zone from the 2005 School Fire begins at the downstream end of the project area (approximately RM 44.0). Many invasive plants were identified that were prominent in local areas, including reed canarygrass, evergreen blackberry, common teasel, Robert's geranium, sulfur cinquefoil, horsetail, and creeping buttercup.

4.9.2 Conceptual Project Actions

Restoration actions in PA-9 include removal of Big Four Lake and associated infrastructure, including the armored levee and intake structure at RM 44.35, and decommissioning the parking area near RM 44.2 (Figure B-9). Upon removal of the lake infrastructure, the plane-bed sections of the channel would be supplemented with LWD to provide instream complexity in these areas and to promote maintenance of the complex channel network that

is developing through the project area. LWD may include a range of treatments, from placing single logs in side channels and alcoves to larger ELJs.

4.9.2.1 Geomorphic Implications

In the short term, the addition of LWD to the main channel will force deep pools, sort sediment, and diversify the thalweg to create hydraulic diversity in plane-bed sections of the channel. Over time, the added LWD and the wood that is currently accumulating in the more complex sections of the project area will retain and distribute wood and sediment throughout the active channel, leading to increased channel complexity and floodplain connectivity. Removal of Big Four Lake will widen the low floodplain area and will allow better access for floodwaters to the floodplain on the downstream side of the lake.

4.9.2.2 Biological Benefits

Adding hydraulic complexity via LWD will form scour pools, increasing the available area for adult holding in the project area. The hydraulic diversity created by the structures will provide high-flow refuge and low-flow cover for juveniles where it is lacking in plane-bed sections. The structures also sort bedload sediment, promoting the development of spawning areas, and promote channel complexity. In the long term, these features will help maintain complex habitat in the project area to support the survival of juvenile salmonids and the productivity of adults.

4.9.2.3 Potential Challenges

Removing Big Four Lake may be undesirable for recreational managers as it will reduce public fishing options. However, Big Four Lake is currently threatened by potential flooding damage and is being considered for modification or removal (WDFW 2010). Removing the lake and regrading the area will require careful consideration of water source areas to the lake to maximize the future benefits from the lake area. In addition, the area should be carefully sloped so that floodwaters can recede without stranding juveniles.

5 REACH 9 CONCEPTUAL PROJECTS

Reach 9 is located from RM 44.0 near Big Four Lake to the hatchery dam at RM 40.0 (Figure 2). The reach spans the National Forest boundary at approximately RM 41.4. The reach is important for steelhead and spring Chinook, particularly for steelhead rearing and spring Chinook spawning and rearing.

The portion of the main channel riparian zone from approximately RM 40.4 to 42.8 was moderately to severely burned in the 2005 School Fire and all of the subbasins draining into Reach 9 were moderately to severely burned, including the Waterman Gulch and Big Four Canyon areas (USFS 2008). The portion of the valley that was not burned is primarily conifer forest with sparse undergrowth. No major hydrologic inputs are located in Reach 9 and a vast majority of the reach was identified as a losing reach (HDR 2006).

Approximately half of the length of the reach is unconfined by infrastructure and the other half is moderately confined. Although some portions of the reach are relatively dynamic in terms of channel planform and migration, many areas are incised and lack channel complexity and good floodplain connectivity. Channel confinement is also related to the road, to the berms around Watson and Beaver lakes, and to narrow portions of the valley created by alluvial fans and bedrock outcrops (e.g., RM 42.8).

Three conceptual project areas were identified in Reach 9. The primary restoration strategies focus on adding LWD, restoring riparian areas, and removing confining infrastructure. These actions are consistent with the limiting factors identified in the EDT analysis of key habitat quantity and increasing riparian function (Appendix J, CCD 2004). LWD will provide a greater quantity of holding areas by initiating pools and will contribute to reversing the incised condition of much of the channel that will eventually lead to better connectivity of riparian vegetation with water table and bank overtopping. Removal of confining infrastructure will reconnect low-lying areas of the floodplain, initiating recovery of riparian vegetation. Over time, these actions will allow the development of channel complexity and long-term creation and maintenance of habitat features such as pools and off-channel areas.

5.1 Project Area 10 (River Mile 44 to 42.4)

Project Area 10 (PA-10) is located within the active channel from just upstream of the North South Campground at RM 44 to one quarter-mile upstream of the Beaver/Watson lakes intake structure at RM 42.4.

Table 5-1
Restoration Recommendations for Project Area 10

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes in the recovering area between RM 43.85 and 43.65.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, other anthropogenic infrastructure impairing processes	Remove approximately 1,300 feet of levee infrastructure affecting channel and floodplain processes to re-establish floodplain connectivity to approximately 5.83 acres of low floodplain.
4. Restore riparian processes	Restore and re-vegetate riparian areas throughout the burn zone in the project area (approximately 40 acres).
5. Improve instream habitat conditions	Place LWD throughout 1.5 river miles.

5.1.1 Site Description

5.1.1.1 Channel Characterization

The channel through PA-10 is typically a single-thread, plane-bed channel. The channel contains very little hydraulic complexity and is highly incised throughout a majority of the project area. One section of the project area between approximately RM 43.85 and 43.65 is a highly dynamic, aggrading channel containing many flow paths forced by LWD that has been placed by the WDFW in previous years. The downstream sections of the project area are more characteristic of a single-thread channel with forced pools and riffles (Photograph 5-1). In addition to the placed LWD, rock/rootwad placements and other rock structures such as barbs were observed in a few locations. Multiple armored rock and “sugar dike”-style levees were observed throughout the project area from approximately RM 43.1 to 42.85. The left bank levee at RM 42.9 confines the channel against the valley wall at Waterman Creek, resulting in a deep, narrow, rapid section with high velocities. The upstream end of the

project area to approximately RM 43.1 contains a moderate amount of well-connected side channels, including a long, perched channel that appears to convey water from the downstream end of Big Four Lake and likely drains several tributaries. Downstream of RM 43.1, the project area contains few off-channel areas and little hydraulic complexity.



Photograph 5-1
A section of the main channel in PA-10 near RM 42.6

With the exception of the section of the channel between RM 43.85 and 43.6, the availability and quality of instream habitat in the project area is limited by lack of channel and hydraulic complexity, particularly downstream of RM 43.1 where the channel contains very little LWD. Although a few large downed logs were observed that provide some cover and holding habitat, these logs typically did not retain adequate wood or sediment to provide quality instream habitat. In addition, there are very few off-channel areas or secondary flow

paths available for juvenile fish to rear and seek refuge in the downstream end of the project area. The incised condition of the channel has resulted in limited floodplain connectivity. With little side channel habitat availability or floodplain connectivity, there is a lack of hydraulic refuge. The project area also lacks adequate shading along the river banks due to the severe burn of the riparian zone that occurred during the 2005 School Fire. In the long term, the lack of LWD recruitment from having no mature riparian trees limits the quality of habitat in this project area.

5.1.1.2 Floodplain Characterization

Floodplain connectivity is generally poor due to the incised condition of the channel. Although the project area contains a large amount of low-lying floodplain, bank overtopping is likely infrequent. The outlet of Waterman Creek, a tributary near RM 42.9, was perched 1 to 2 feet above the water surface elevation in the main channel at the time of field observation. The influence of most of the levee features around RM 43.1 to 42.85 to floodplain connectivity appeared relatively insignificant, although these features may impede channel migration and exacerbate the incised condition of the channel. The left bank levee at approximately RM 42.9 does appear to confine the channel against the valley wall and disconnect it from the low-lying area in the left floodplain.

One large, low-lying area is located along the base of the southeast valley slope between RM 42.75 and 42.4. Slow-moving water was observed in the channel that was assumed to be draining small tributaries from the valley slope. The channel had a good downstream surface water connection to the main river but appeared quite disconnected from the main channel at the upstream end, even during high seasonal and frequent flood events (e.g., 2-year recurrence interval).

The riparian zone is generally in poor health as it has been highly disturbed by fire and incision has limited the availability of hyporheic groundwater exchange with riparian vegetation. Riparian trees are predominantly mature Ponderosa pines that have been severely burnt; a majority of the trees have fallen over, lost most limbs and needles, or are standing dead or dying. Young dogwoods and alders have begun to populate the area since the fire occurred. The understory is in poor to moderate health dominated by emergent

vegetation and grasses that provide little overhang. There are few intermediate-sized plants and generally poor vegetation diversity. The project area contains invasive plants including St. John's wart, reed canarygrass, common teasel, and mullein. Most of the off-channel areas containing flowing water are heavily vegetated with reed canarygrass.

5.1.2 Conceptual Project Actions

Restoration actions involve placing LWD structures and removing infrastructure as access conditions allow (Figure B-10). LWD may include a range of treatments; however, larger structures such as ELJs are recommended in this project area to achieve a desired geomorphic and biologic response. Those levees affecting channel and floodplain processes should be removed. Intensive riparian treatment is also recommended in this project area to address the severe fire damage to the riparian zone during the 2005 School Fire.

5.1.2.1 Geomorphic Implications

Intensive LWD placement throughout this project area will force pools and hydraulic variability in this dominantly plane-bed, simplified channel in the short term. Over the long term, large LWD placements such as ELJs will promote side channel development, retention of additional LWD, and bedload, building up the bed elevation to reverse its incised condition and increase floodplain connectivity. Developing a healthy riparian zone additionally benefits natural processes in the long term. The vegetation creates roughness along the banks and floodplain that slow velocities during high flows and trap LWD and sediment. Mature riparian trees provide a sustainable source of LWD to the channel.

5.1.2.2 Biological Benefits

Immediate biological benefits of the project include high-flow refuge, low-flow cover, and pool development from LWD placement. Over time, the LWD will promote the formation of habitat elements (e.g., pools and side channels), leading to the development and maintenance of diverse habitats that will support salmonids throughout various life stages. ELJs will promote channel complexity by splitting flow and retaining wood and sediment. In the long term, reversing the incised condition of the channel will lead to better floodplain connectivity, in turn creating a healthier riparian zone and distribution of water and sediment across the floodplain that drives many ecosystem processes.

Riparian planting in this project area will have beneficial long-term effects on channel and floodplain habitat quality. A well-vegetated riparian zone will provide nutrients in the form of leaf-litter and terrestrial insect drop to the system and will support both fish and other animals that interact within the ecosystem. Riparian trees and diverse overhanging vegetation provide shade along the channel banks that greatly contributes to reduction of in-stream temperatures during adult migration and juvenile rearing. Healthy riparian trees provide LWD to the channel, providing a natural source and sustainable driver for habitat complexity.

5.1.2.3 *Potential Challenges*

The project area is approximately 1.5 river miles in length and multiple access point will be required to distribute LWD throughout. Some trees and other existing vegetation may be disturbed in the process of gaining access to and placing the LWD structures. Riparian revegetation will require several years of maintenance and monitoring. Establishing vegetation may be difficult where the incised condition of the river limits hyporheic exchange to the riparian zone.

5.2 Project Area 11 (River Mile 42.3 to 40.7)

Project Area 11 (PA-11) is located within the active channel and floodplain from one quarter-mile upstream of the Beaver/Watson lakes intake structure (RM 42.3) to RM 40.7.

Table 5-2
Restoration Recommendations for Project Area 11

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes where applicable in the project area.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove/modify approximately 1,100 linear feet of infrastructure associated with Beaver and Watson lakes, the access bridge, and parking area to re-establish floodplain connectivity to approximately 1.43 acres of low-lying floodplain. The reconfiguration of Watson Lake will require the removal of approximately 1,540 feet of road, and 650 feet of road realignment to maintain access for stocking fish to both lakes.
4. Restore riparian processes	Restore and revegetate riparian areas throughout the burn zone in the project area (approximately 40 acres).
5. Improve instream habitat conditions	Place LWD throughout 1.8 river miles.

5.2.1 Site Description

5.2.1.1 Channel Characterization

The channel through PA-11 between approximately RM 42.3 and RM 41.4 is characterized as a single-thread, plane-bed channel with few LWD-forced pools (Photograph 5-2). The channel is relatively straight and somewhat incised and was likely channelized historically. Downstream of RM 41.4, a large log jam has initiated an anabranching channel pattern and that extends to the downstream end of the project area. This portion of the channel contains more diverse channel types, although it is also somewhat incised and lacking instream complexity. Three weirs are located adjacent to Watson and Beaver lakes, along with some rock and LWD placements along the banks at the lake access footbridge. An armored levee associated with the bridge and parking lot is located along the left bank from approximately RM 42.1 to 42. The intake for Deer Lake, which includes an armored levee, is located at the downstream end of the eastern split flow channel near RM 40.9. Few side channels were observed upstream of RM 41.4. Several flow pathways are present between approximately RM 41.4 and 41.1.



Photograph 5-2

The main channel in PA-11 near RM 41.75, looking downstream

The availability and quality of instream habitat is limited by lack of channel and hydraulic complexity. Little LWD is present in the project area; deep pools with cover were typically observed only at LWD and rock restoration features near the access footbridge. Within the upstream end of the project area, there are very few off-channel areas or secondary flow paths available for juvenile fish to rear and seek refuge. The incised condition of the channel provides little opportunity to disperse velocities during high flows. Without side channels or sufficient LWD, there is very little hydraulic refuge in the project area. Shading along the river banks is highly limited due to the severe burn of the riparian zone that occurred during the 2005 School Fire. The channel is open and exposed, with little cover provided by instream LWD.

5.2.1.2 Floodplain Characterization

Floodplain connectivity is limited by the incised condition of the channel, although the amount of low-lying floodplain in the project area is relatively high. Few levees or other confining features are present, except the infrastructure associated with Watson and Beaver lakes and the parking area, which confine the channel and accessible floodplain to a narrow corridor. The rock levee located from approximately RM 42.1 to 42.0 disconnects low areas of the left floodplain, which were occupied by wet, swampy areas at the time of field reconnaissance. Low-lying elevations located on the opposite (west) side of Tucannon Road from approximately RM 41.8 to 41.4 were observed to be dry with no indication of river connectivity or groundwater availability.

Tributary flow was observed in several locations that drained small tributaries along the east side of the valley; much of the water flows through small culverts and drains to the high terrace flanking the right side of the channel from Beaver Lake to approximately RM 41.3. Downstream of Watson and Beaver lakes, at approximately RM 41.9, a large cattail pond is located in the floodplain that is perched above the water surface elevation in the river channel.

The riparian zone is generally in poor health, as it has been highly disturbed by fire, and incision has limited the availability of hyporheic groundwater exchange with riparian vegetation. Riparian trees are predominantly mature Ponderosa pines that have been severely burnt; a majority of the trees have fallen over, lost most limbs and needles, or are standing dead or dying. Young dogwoods and alders have begun to populate the area since the fire occurred. The understory is in poor to moderate health, dominated by emergent vegetation that provides little overhang. There are few intermediate-sized plants and generally poor vegetation diversity. The project area contains invasive plants, including St. John's wart, reed canary grass, common teasel, and mullein.

5.2.2 Conceptual Project Actions

Restoration actions would involve placing LWD structures throughout the project area, supplementing existing rock structures with wood for added complexity, and modifying the Watson Lake footprint to provide a wider floodplain corridor (Figure B-11). LWD may

include a range of treatments, from placing single logs in side channels to ELJs in plane-bed sections of the main channel to initiate split flow through the low-lying floodplain. Modifying Watson Lake and re-aligning a portion of the fish-stocking road to both Watson and Beaver lakes is recommended to aid in the recovery of this project area and provide a wider corridor for flooding and future channel migration. This will allow the fish-stocking road between RM 42.2 and 41.9 to be decommissioned. Removal of the parking lot and associated levees on the west side of the river will also add to a wider corridor and ease confinement. The lakes may be converted to a wade-in fly fishing use to minimize impacts to the channel, and the parking area could be moved to the upland campground (Beaver Watson Campground). At the downstream end of project area, reconfiguration of the Deer Lake intake structure is also recommended to allow long-term evolution of the river through the large floodplain area downstream of the intake. Intensive riparian treatment is recommended in this reach to address the severe fire damage done to the riparian zone during the 2005 School Fire.

5.2.2.1 Geomorphic Implications

Because the lakes are located on a high terrace that appears to be relatively resistant, widening the floodplain corridor by modifying Watson Lake will likely not have immediate geomorphic implications. However, this action in conjunction with removal of the parking area and levees will allow greater floodplain connectivity and hydraulic diversity, and allow a wider corridor for future channel migration with less risk to infrastructure. LWD placement in this and other areas of the project area will force pools and hydraulic variability in this dominantly plane-bed, simplified channel in the short term. In addition, placing ELJs in strategic locations to promote side channel development will develop complex channel patterns over time. Over the long term, large LWD placements will promote retention of additional LWD and bedload, building up the bed elevation to reverse its incised condition and to increase floodplain connectivity. Developing a healthy riparian zone additionally benefits natural processes in the long term. Vegetation creates roughness along the banks and floodplain that slow velocities during high flows. Mature riparian trees provide a sustainable source of LWD to the channel.

5.2.2.2 *Biological Benefits*

Immediate biological benefits of the project include high-flow refuge, low-flow cover, and pool development from LWD placement. Over time, the LWD will promote the formation of habitat elements (e.g., pools and side channels), leading to the development and maintenance of diverse habitats that will support the salmonids throughout various life stages. ELJs will promote channel complexity by splitting flow and allowing the project area to retain wood and sediment. In the long term, reversing the incised condition of the channel will lead to better floodplain connectivity, in turn creating a healthier riparian zone and distribution of water and sediment across the floodplain that drives many ecosystem processes. Removing the levees at the lake access parking lot will allow greater floodplain connectivity, decreasing velocities in the main channel.

Riparian planting in this project area will have beneficial long-term effects on channel and floodplain habitat quality. A well-vegetated riparian zone will provide nutrients in the form of leaf-litter and terrestrial insect drop to the system and will support both fish and other animals that interact within the ecosystem. Riparian trees and diverse overhanging vegetation provide shade along the channel banks that greatly contributes to reduction of instream temperatures during adult migration and juvenile rearing. Healthy riparian trees provide LWD to the channel, providing a natural source and sustainable driver for habitat complexity.

5.2.2.3 *Potential Challenges*

Modifying Watson Lake may be undesirable for recreational managers as it will reduce the size of the lake. Removing the parking lot and bridge would likely require the lakes to be converted to a different use because of the change in access conditions (e.g., fly-fishing). Riparian revegetation will require several years of maintenance and monitoring. Establishing vegetation may be difficult where the incised condition of the river limits hyporheic exchange to the riparian zone.

5.3 **Project Area 12 (River Mile 40.7 to 40)**

Project Area 12 (PA-12) is located within the active channel and floodplain from RM 40.7 to the hatchery dam (RM 40).

Table 5-3
Restoration Recommendations for Project Area 12

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Protect natural channel and floodplain processes throughout the main channel.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	No significant infrastructure was identified that impairs natural processes.
4. Restore riparian processes	Restore and revegetate riparian areas throughout the burn zone in the project area (approximately 18 acres).
5. Improve instream habitat conditions	Place LWD within the side channel along the left valley floor through approximately 0.4 RM.

5.3.1 Site Description

5.3.1.1 Channel Characterization

The channel through PA-12 is relatively complex with many flow pathways through a relatively wide corridor; natural processes are occurring that are aiding in recovery through this area. No major infrastructure was observed within the channel, although the Hatchery Dam at the downstream end of the project area is a significant grade control. Several side channels were observed, a majority of which are initiated by LWD. An anabranching channel pattern is located between RM 40.5 and 40.1, where a significant side channel has cut through the floodplain along the left valley floor (Photograph 5-3). This channel runs below a power line adjacent to the road through a grassy area. Another major side channel observed between approximately RM 40.2 and 40.0 conveyed at least a third of the total discharge at the time of observation.



Photograph 5-3

The side channel in the west floodplain near RM 40.4, looking upstream

Instream habitat in PA-12 is currently limited but recovering. The project area contains a moderate amount of LWD that provides some amount of cover and initiates channel and hydraulic complexity. The most significant limitation is the lack of adequate shading, nutrients, and other elements provided by a healthy riparian zone, due to the severe burn that occurred during the 2005 School Fire.

5.3.1.2 Floodplain Characterization

Floodplain connectivity in PA-12 is moderate and appears to be relatively unaffected by infrastructure. Deer Lake occupies a portion of the right floodplain around RM 40.4, but the floodplain is not significantly constricted by the presence of the lake or associated infrastructure. A perched wetland pond is present on the downstream side of the lake berm.

Additional remnant levees or spoil piles are located in a few places; however, the influence of these features to natural processes appears to be insignificant.

The riparian zone is generally in poor health due to fire disturbance. Riparian trees are predominantly mature Ponderosa pines that have been severely burnt; a majority of the trees have fallen over, lost most limbs and needles, or are standing dead or dying. Young dogwoods and alders have begun to populate the area since the fire occurred. The understory is in poor to moderate health, dominated by emergent vegetation that provides little overhang. There are few intermediate-sized plants and generally poor vegetation diversity. The project area contains invasive plants, including St. John's wart, reed canarygrass, common teasel, and mullein. The downstream end of the project area between RM 40.2 and 40 has healthier riparian zone along the outside margin of the severely burned area of the School Fire.

5.3.2 Conceptual Project Actions

LWD will be placed within the side channel along the left valley floor (Figure B-12). The mainstem channel should be protected as natural processes continue to recover and generate improved habitat conditions. Intensive riparian treatment is recommended in this reach to address the severe fire damage and address temperature concerns.

5.3.2.1 Geomorphic Implications

No immediate geomorphic implications are expected as a result of this project, although placement of LWD within the large side channel will provide roughness, likely retain mobile wood, and reduce the likelihood that the side channel will develop into the mainstem channel. Over time, continued LWD and sediment retention will continue to promote instream and channel complexity. Developing a healthy riparian zone is a long-term benefit to natural processes. The vegetation creates roughness along the banks and floodplain that slow velocities during high flows. Mature riparian trees provide a sustainable source of LWD to the channel.

5.3.2.2 Biological Benefits

LWD in the side channel will provide cover and complexity that is currently lacking. Riparian planting in the burn zones will have beneficial long-term effects on channel habitat quality. A well-vegetated riparian zone will provide shade and nutrients in the form of leaf-litter and terrestrial insect drop to the system and will support both fish and other animals that interact within the ecosystem. Shading will reduce instream temperatures during the summer months. A long-term source of wood to the channel will create pools and cover and distribute wood to downstream reaches.

5.3.2.3 Potential Challenges

Riparian revegetation will require several years of maintenance and monitoring. Establishing vegetation may be difficult where the incised condition of the river limits hyporheic exchange to the riparian zone.

6 REACH 8 CONCEPTUAL PROJECTS

Reach 8 is located from the hatchery dam just upstream of Rainbow Lake (RM 40.0) to RM 32.1 (Figure 2). The upstream end of the reach is at the boundary of the area that was severely burned by the School Fire; it also marks a significant change in general channel patterns and confinement. Reach 8 is used by steelhead and spring Chinook for spawning and rearing habitat. There is a high density of steelhead rearing and spring Chinook spawning and rearing in the reach, and the lower portion of the reach is particularly important for juvenile rearing of both species, as well as for steelhead spawning. The reach is likely only used by bull trout during migration periods.

The valley in Reach 8 is occupied with wooded wetland and forested floodplain, while some farmsteads and fields are present up to the mouth of Cummings Creek at (RM 37.8) where the W.T. Wooten Wildlife Area begins. The Tumulum Creek and Cummings Creek drainages were affected by the 2005 School Fire, with the greatest impacts in the Cummings Creek basin (USFS 2008). Tumulum and Cummings creeks are both major hydrologic inputs within Reach 8. The reach is primarily a losing reach except for the section of the valley between the two tributaries that was identified as gaining (HDR 2006).

Reach 8 is primarily a single-thread channel with moderate confinement due to the presence of infrastructure, which includes levees and bank armoring. Floodplain connectivity is typically highly impacted in areas of confinement. Some locations are locally incised, further limiting connectivity. The downstream end of the reach between RM 33.1 and 32.1 is relatively unconfined with good floodplain connectivity and dynamic conditions.

Six conceptual project areas were identified in Reach 8. The primary restoration strategies focus on establishing floodplain connectivity and promoting channel complexity via infrastructure removal and LWD placement. Two areas of protection are also recommended where the channel is naturally recovering. Allowing channel migration and floodplain connectivity where possible and adding LWD in areas lacking instream complexity will address the habitat-limiting factor of key habitat quantity identified in the EDT assessment (Appendix J, CCD 2004). Over time, a more complex channel network will allow the

development of channel complexity and long-term creation and maintenance of habitat features such as pools and off-channel areas.

6.1 Project Area 13 (River Mile 40 to 39.2)

Project Area 13 (PA-13) is located within the active channel and floodplain from the Hatchery Dam at RM 40.0 to the hatchery access road bridge at RM 39.2.

Table 6-1
Restoration Recommendations for Project Area 13

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural processes are impaired in this project area.
2. Reconnect isolated habitats	Levee removal will reconnect approximately 3.91 acres of wetland habitat near RM 39.3.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 3,190 linear feet of levees to re-establish floodplain connectivity of 3.91 acres of low-lying floodplain. Set back approximately 760 feet of levees to allow better floodplain connectivity.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout approximately 0.7 river miles in plane-bed reaches.

6.1.1 Site Description

6.1.1.1 Channel Characterization

The channel through PA-13 is characterized as a single-thread, plane-bed channel with forced pool-riffle and local rapid sections (Photograph 6-1). The channel is typically straight, wide, and contains little complexity in much of the project area. Large levees confine the channel along the right bank from approximately RM 39.95 to 39.8, at RM 39.6, and from RM 39.5 to 39.2. The levees are typically heavily armored with large angular boulders. The hatchery dam at the upstream end of the project area controls the channel grade. At the time of field observation, the dam had an approximately 3-foot drop in water surface elevation with a deep plunge pool on the downstream side. No significant side channels or off-channel areas were observed in the project area at the time of field reconnaissance.



Photograph 6-1

The main channel near RM 39.6 just upstream of the large levee on the right bank, looking downstream

The quality and availability of instream habitat is restricted by the lack of channel and hydraulic complexity. The straight and confined channel results in hydraulic conditions that create high velocities and high transport capacity. These conditions do not support the retention of LWD and bedload, and, therefore, lack hydraulic complexity. A few downed logs and one log jam provide pools and cover in the actively eroding area near RM 39.7, but overall very few adequate pools for adult holding are available. The lack of side channels (except some apparent high-flow channels) limits the quantity of habitat for rearing juveniles.

6.1.1.2 Floodplain Characterization

Floodplain connectivity in this project area is affected by the presence of infrastructure, and little low-lying floodplain is present, except the area near RM 39.8 and 39.3, which is disconnected by infrastructure. Although there is not a high quantity of disconnected floodplain, likely because of local channel incision, the levees prevent channel migration and the development of gravel bars and low-lying emergent floodplain, which exacerbates the limited floodplain connectivity. Rainbow Lake, the public camping areas, and the access road to these areas are located atop a terrace and not within the low-lying floodplain.

The riparian zone is generally in moderately good health, except for along the levees, which are typically populated with invasive understory species. The left side of the channel and forested areas in the right (east) floodplain contain riparian trees that are mostly deciduous, dominated by young to mature alders and cottonwood with some Ponderosa pine and older conifers. Understory vegetation is moderately diverse and includes groundcover, shrubs, and small trees that provide a moderate amount of overhanging vegetation. The levees are typically sparsely vegetated with shrubs and covered in thistle and other weedy plants that provide little overhang. The disconnected low-lying area in the east floodplain near RM 39.3 is a grassy field with some patches of sparse trees and shrubs.

6.1.2 Conceptual Project Actions

Restoration actions involve removing or setting back levees that restrict natural floodplain connectivity and channel migration, yet appear to be unnecessary to maintaining operations at the hatchery. Although some LWD is present, little is being recruited within the project area or being transported from upstream; therefore, LWD would be placed throughout the channel (Figure B-13).

6.1.2.1 Geomorphic Implications

Levee removal will allow the channel to adjust via bank erosion and channel migration, establishing a more natural configuration that allows for retention of LWD and sediment. These conditions will decrease channel velocities during high flows and allow pools and spawning gravels to develop. Reconnecting low-lying floodplain will allow dispersion of floodwaters, decreasing velocities in the main channel and allowing for dispersion of

overbank sediments and mobile debris. LWD placement in the project area will force pools and hydraulic variability in this dominantly plane-bed, simplified channel in the short term. Placing ELJs in strategic locations can promote side channel development through the low-lying areas in the left floodplain, increasing channel complexity.

6.1.2.2 Biological Benefits

Immediate biological benefits of the project include decreased instream velocities during high flows and additional instream complexity and pool development via LWD placement. In the long term, opening up the floodplain will increase complexity through the project area, providing diverse habitats for various life stages such as holding areas, side channels for rearing, and high-flow refuge.

6.1.2.3 Potential Challenges

Site access and project actions will likely involve disturbance and removal of existing vegetation. Any trees growing on levees to be removed could be incorporated into ELJs or other elements of the design. Levee removal will require a large amount of earthwork; the armor and other angular materials that compose the levee can be incorporated into ballast or set back to infrastructure in the floodplain, such as Rainbow Lake. An infiltration gallery used for hatchery operations is located in the low-lying floodplain upstream of the access bridge; potential impacts to this feature from the project actions would need to be assessed further.

6.2 Project Area 14 (River Mile 39.2 to 37.15)

Project Area 14 (PA-14) is located within the active channel and floodplain from the hatchery access road bridge (RM 39.2) to the downstream extent of public (WDFW) land at RM 37.15.

Table 6-2
Restoration Recommendations for Project Area 14

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural channel and floodplain processes are impaired in this project area.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 160 feet of spoils near RM 39.1 to increase floodplain connectivity and promote channel migration within the approximately 17.77-acres of low-lying floodplain west of the river.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 1.95 river miles.

6.2.1 Site Description

6.2.1.1 Channel Characterization

The channel through PA-14 is primarily a single-thread, plane-bed channel with local forced pool-riffle and boulder rapids (Photograph 6-2a). Adjacent to the hatchery, the channel is relatively straight and simplified. Existing WDFW hatchery infrastructure, including the hatchery bridge and the levee adjacent to the hatchery ponds, confines the channel from approximately RM 39.2 to 39.0. From RM 39.0 to RM 38.5, the active channel widens slightly and a few side channels and split-flow paths are present.



Photograph 6-2a

The main channel and floodplain near RM 38.3, looking upstream

Between RM 38.2 and the mouth of Cummings Creek (RM 37.8), the channel is confined and somewhat entrenched into alluvial fan and hillslope deposits through a narrow section of the valley. The channel contains several large immobile boulders and rapids. Between RM 37.8 and 37.15, adjacent to the WFDW headquarters, the channel is single-thread and often plane-bed, but transitioning into a recovering state. Channel migration, LWD recruitment, and development of instream and channel complexity were all observed though this area (Photograph 6-2b). There was a higher amount of temporary sediment deposition and wider active channel in this portion of the project area. Only a few significant side channels were observed near RM 38.75, 38.6 and 37.3. The Spring Lake and Blue Lake outfalls both had downstream connections to the main channel.



Photograph 6-2b

Wood recruitment in the channel near RM 37.5

Upstream of Cummings Creek, instream habitat conditions in PA-14 are limited by a lack of hydraulic complexity. Very little substantial LWD was observed and the channel has little sediment sorting or pool development. The rapid sections contain high velocities throughout the year. The lack of side channels means there is little off-channel rearing area or high-flow refuge for juveniles. The remainder of the project area has a moderate amount of pools and cover, typically associated with migrating bends with overhanging banks and local wood recruitment. This section does not contain an adequate quantity of preferred juvenile rearing habitat; however, variable hydraulic conditions due to the presence of bedforms, LWD, and slow-moving margin area may provide useful rearing habitat.

6.2.1.2 Floodplain Characterization

Floodplain connectivity varies considerably throughout the project area. Between the hatchery bridge and RM 38.6, the low-lying floodplain is wide and comprises most of the valley bottom. A long, wide, and relatively low pathway is located through the floodplain between RM 39.1 and 38.6 that had no hyporheic connection with the river upon field observation. A short length of flowing water was observed at the downstream end of the channel that may have been from seepage out of Blue Lake. The floodplain from RM 38.6 to Cummings Creek has a poor connection to the channel. Remnant alluvial fan deposits create high cutbanks that are several feet higher than the channel in some places. Downstream of Cummings Creek, floodplain connectivity is moderate but still contains some locally incised areas with poor connectivity.

The riparian zone is generally in moderately good health, with some locally poor areas disturbed by fire or with poor connectivity to hyporheic exchange from the river. Riparian trees are mixed deciduous and conifers, dominated by alder, cottonwood, locust, and Ponderosa pine. Some areas contain several snags, dying trees, or burnt mature trees. The area between RM 37.7 and 37.3 is populated by several very large mature cottonwoods, some of which are being actively recruited to the channel. The understory is relatively dense with moderately diverse species in most areas. Some areas are dominated by invasive grasses or other weedy plants.

A large wetland area in the west floodplain near RM 38.8 is in good health, dominated by ferns, sedges, and dogwoods, but also contains some invasive species such as reed canarygrass and horsetail. There are many mature conifers in the floodplain, providing shade and a source of woody debris to the wetland.

6.2.2 Conceptual Project Actions

Restoration of this project area is focused on adding ELJs and other LWD to initiate side channel development through the low floodplain areas (Figure B-14). Removing or regrading the spoil piles in the left floodplain near RM 39.1 would allow future channel migration and better connectivity to the low floodplain. Long-term planning should consider replacement of the hatchery road access bridge at the upstream end of the project

area with a longer-spanning bridge that would allow for better connectivity and ability to migrate across the low floodplain. This may involve road relocation atop the hatchery levee or elsewhere. In addition, removing the footbridge near RM 37.75 will also improve hydraulic and geomorphic conditions, as it is markedly narrower than the highway bridge just upstream.

6.2.2.1 *Geomorphic Implications*

LWD placement throughout the project area upstream of RM 38.2 will force pools and hydraulic variability in this dominantly plane-bed, simplified channel in the short term. In addition, placing ELJs in strategic locations to promote side channel development will develop channel complexity. Downstream of RM 38.2, the ELJs may not have a significant effect on channel migration due to the relatively resistant materials that compose the banks; however, the ELJs will force pools to create more hydraulic variability. Throughout the LWD placement areas, the structures will promote retention of additional LWD and bedload. Between RM 38.2 and 37.8, and in the locally incised areas in the lower end of the project area, this effect may contribute to building up the bed elevation over time and increasing floodplain connectivity. Removing the spoil piles near RM 39.1 would likely result in better distribution of floodwaters across the floodplain as it exits the confined reach upstream of the bridge and drops in energy. In the future, the channel would have better ability to migrate and develop side channels through the floodplain.

6.2.2.2 *Biological Benefits*

Immediate biological benefits of the project include high-flow refuge, low-flow cover, and pool development from LWD placement. Over time, the LWD will promote the formation of habitat elements (e.g., pools and side channels), leading to the development and maintenance of diverse habitats that will increase the carrying capacity for juvenile salmonids. ELJs will promote channel complexity by splitting flow and promoting retention of wood and sediment, creating additional spawning areas, pools with cover, and refuge. In the long term, reversing the incised condition of the channel between RM 38.2 and Cummings Creek will lead to better floodplain connectivity, in turn creating a healthier riparian zone and distribution of water and sediment across the floodplain that drives many ecosystem processes. Removing the spoils near RM 39.1 will allow better access to the low

floodplain, decreasing velocities in the main channel and promoting channel migration and complexity that will lead to the generation of additional habitats.

6.2.2.3 *Potential Challenges*

Several access routes will be necessary to access all of the LWD placement sites. Some trees and other existing vegetation may be disturbed in the process of gaining access to and placing the LWD structures. Future channel migration and flooding in the low floodplain west of the hatchery must be considered in the design effort.

6.3 **Project Area 15 (River Mile 37.15 to 36.35)**

Project Area 15 (PA-15) is located within the active channel and floodplain from the downstream extent of public (WDFW) land at RM 37.15 to approximately RM 36.35.

Table 6-3
Restoration Recommendations for Project Area 15

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Protect the existing spring channel through the right floodplain.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 860 feet of levees to promote increased floodplain connectivity over time.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 0.8 river miles. Modify log and rock structures so that they provide greater habitat benefits while allowing for natural processes, including channel migration and floodplain connectivity.

6.3.1 Site Description

6.3.1.1 Channel Characterization

The channel through PA-15 is characterized as a single-thread channel with forced pools and local rapid sections. Many of the bends in the channel are held by placed rock and wood structures (e.g., rock barb and LWD-rock revetments), which likely also influences the overall channel grade in the project area. Locally incised areas of the channel were consistent with the placement of many of the larger revetment structures, as evidenced by the high elevation of the rootwads relative to the channel bottom. In some cases, the rootwads were perched above or at the water surface (Photograph 6-3). The thalweg adjacent to the structures was deep, fast-moving, and turbulent. A few minor side channels were observed, one of which cut behind the head of the rock revetment at RM 37.7. A spring channel originating from the east floodplain at approximately RM 37.0 produces a significant quantity of flow that flows parallel to the main channel for approximately one-half mile and joins the main channel near RM 36.55. Many juvenile fish were observed in the channel throughout its length.



Photograph 6-3

Local incision and rapid velocities along the face of a rootwad and rock revetment

Instream habitat conditions in the main channel are affected by local high velocities, lack of complexity in plane-bed sections, and limited off-channel areas. Although a large quantity of LWD was observed between approximately RM 37.0 and 36.8, the remainder of the project area contained little LWD except for man-made structures, and the pools forced by these structures were typically fast-moving and turbulent. The spring channel provides excellent off-channel habitat but few other accessible side channels were observed.

6.3.1.2 Floodplain Characterization

Floodplain connectivity is primarily limited by the incised condition of the channel and also somewhat by levee and spoil features in the floodplain. A levee between RM 36.45 and 36.35 confines the channel to the toe of a tributary fan and cuts it off from the floodplain.

Several flood pathways are present through the floodplain that were accessed during the 1996 flood; these areas are lined with cobble and support little vegetation but do not appear to be inundated at more frequent flooding events.

The riparian zone adjacent to the channel is generally in a moderately healthy condition, with some local areas that have been degraded by development, historic flooding, or poor hyporheic connection with the channel. Riparian trees are predominantly cottonwoods and other deciduous species, with some Ponderosa pines. Understory vegetation is moderately diverse groundcover, shrubs, and small trees that provide overhanging vegetation adjacent to the channel. The areas of the floodplain inundated by the 1996 flood typically have little understory except for sparse grasses and weedy plants. Reed canarygrass is prominent along the banks and in the floodplain.

Wetlands observed in the floodplain near RM 36.9 and 36.8 contained juvenile salmonids but had a poor downstream surface water connection with the main channel. These areas contained sedges, rushes, and grasses that provide shade and terrestrial insect drop for the fish. Several stagnant and dried-up pools were observed in the floodplain.

6.3.2 Conceptual Project Actions

Protect the existing spring channel in the right floodplain. Install ELJs and other LWD to initiate side channel development through the left floodplain, which was recently converted to public land (Figure B-15). Remove levees and spoils and modify existing wood and rock structures to improve their habitat benefits and reduce impediments to natural processes.

6.3.2.1 Geomorphic Implications

LWD placement throughout the will force pools and hydraulic variability in the plane-bed channel sections, decrease instream velocities, and provide additional hydraulic complexity in the deep, incised sections. Placing ELJs in strategic locations along the left bank will promote side channel development through the former Russell property, developing a more complex channel network. Throughout the LWD placement areas, the structures will promote retention of additional LWD and bedload that will promote building up the bed elevation over time and increasing floodplain connectivity. Removing the levee at RM 36.4

will ease channel confinement and allow for better floodplain connectivity during high flows.

6.3.2.2 *Biological Benefits*

Adding complexity to the project area via LWD will address habitat limiting factors in the mainstem by diversifying the channel and initiating side channel development. In the short term, the pools that form at the structures will increase the available area for holding in the project area. The hydraulic diversity created by the structures will provide high-flow refuge and low-flow cover for juveniles. The structures also sort bedload sediment, leading to the formation of spawning areas. In the long term, ELJs will promote channel complexity by splitting flow and encouraging the natural processes that drive the formation of habitat elements such as pools and side channels. The availability of diverse habitats will increase the carrying capacity for juvenile salmonids and increase the number of pools for holding adults. Levee removal and modifying the existing revetment structures will increase floodplain connectivity and the ability for the channel to migrate throughout the valley. In the long term, increased floodplain connectivity will lead to better riparian conditions that drive many ecosystem processes that are beneficial to both aquatic and non-aquatic species.

6.3.2.3 *Potential Challenges*

Some trees and other existing vegetation may be disturbed in the process of gaining access to and placing the LWD structures and removing the levee. Project actions in the upstream end of the project area from RM 37.15 to 36.85 will involve cooperation of adjacent landowners. Because this project area is located just upstream of a residential area, LWD will likely require stabilization under extreme high-flow conditions to prevent it from mobilizing.

6.4 Project Area 16 (River Mile 36.35 to 34.9)

Project Area 16 (PA-16) is located within the active channel and floodplain from RM 36.35 to the intersection of McGovern Road and Tucannon Road (RM 34.9).

Table 6-4
Restoration Recommendations for Project Area 16

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural processes are impaired within this project area.
2. Reconnect isolated habitats	No significant isolated habitats will be reconnected by this project.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 520 feet of levee to reconnect approximately 4.59 acres of low-lying floodplain.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD in approximately 0.3 river miles within low-risk sections and in select locations to encourage side channel development away from infrastructure. Excavate floodplain areas to create side channels that will convey seasonal flows, approximately 1,120 feet.

6.4.1 Site Description

6.4.1.1 Channel Characterization

The channel through PA-16 is characterized as a single-thread, plane-bed channel with occasional pools forced by engineered structures and resistant banks. The channel is located through a highly developed residential area and is significantly affected by several levees, armored banks, and rock and LWD structures. These structures provide limited habitat benefits and prevent channel migration and floodplain connectivity. In addition, portions of the left bank are confined against resistant alluvial fan deposits. Some banks within the project area were actively eroding and migrating (Photograph 6-4). Remnant levee or spoil piles were observed on the right bank at approximately RM 35.9 and from about RM 35.7 to the mouth of Tumulal Creek. Large right bank levees with LWD and rock structures at the toe were observed from RM 35.45 to just downstream of RM 35.2. Large left bank levees were observed from approximately RM 35.2 to 35.1. Both banks from RM 35.1 to 34.9 were sporadically armored with large angular rock and riprap. Larger J-hook structures at the upstream end of the project area to approximately RM 36.2 likely have an influence on the channel grade. Very few off-channel areas were observed except the mouth of Tumulal

Creek and a short side channel at approximately RM 35.25 that appeared to be maintained for water diversion.



Photograph 6-4

Bank erosion adjacent to private infrastructure near RM 35.1, looking across at right bank

Instream habitat is limited by a lack of complexity and hydraulic conditions due to confinement. The confined condition of the channel likely results in high velocities during seasonal high flows and flooding that prevents the retention of sufficient volumes of LWD for cover and refuge, or sediment for spawning areas. Few pools were observed except at man-made structures, many of which were fast-moving along outer banks. Preferred juvenile rearing areas were very limited due to the absence of side channels. Much of the channel had little overhanging vegetation.

6.4.1.2 Floodplain Characterization

Floodplain connectivity in this project area is low. Levees, spoils, bank armoring, and other infrastructure observed throughout the project area disconnect several low-lying areas of the floodplain. Several low-lying cobble-bed channels were observed in the floodplain; all of them were dry. Many of these channels are disconnected from the main channel by infrastructure, and others are disconnected because the channel is low relative to the floodplain, such as in the left bank near RM 35.0. A wetted floodplain channel was observed in the right floodplain at approximately RM 35.9; however, no downstream connection to the main channel was observed. The mouth of Tumulum Creek is confined by levees along both banks that perch the water surface elevation of the creek above the low-lying floodplain areas that parallel the river (RM 35.65).

The riparian zone is generally in a moderately healthy condition where it has not been cleared or degraded by development, or is lacking a poor groundwater connection with the channel. Riparian trees are predominantly deciduous cottonwoods and locust trees; willows line the banks where bank armoring and restoration projects are present. Some Ponderosa pines have been planted along the right bank in a few areas. There are very few mature trees, except in the left floodplain at the upper end of the project area. Understory vegetation includes groundcover, shrubs, and small trees that provide minor amount of overhanging vegetation in most of the project area. There are several areas along the banks that are devoid of vegetation other than grasses and weeds; many of these areas are consistent with the presence of levees or irrigated fields. Many of the disconnected floodplain areas also have little vegetation other than weedy species such as chicory and cheat grass growing among cobble.

6.4.2 Conceptual Project Actions

Because this project area includes more private infrastructure than any of the other areas, restoration actions focus on achieving biological and geomorphic benefit while considering the highly restricted physical limitations. Proposed restoration actions include adding LWD in low-risk portions of the channel to initiate side channels through uninhabited portions of the low floodplain, such as river left near RM 35.55 (Figure B-16). Removal of the levee near RM 35.55 will reconnect the area of low-lying floodplain on the west side of the channel.

Off-channel habitat may be created by excavating one or more channels through the left floodplain between approximately RM 35.15 and 34.95 that would be active during seasonal high flows (i.e., spring runoff). The spoils from the excavation could be placed at the toe of McGovern Road.

6.4.2.1 Geomorphic Implications

The most significant geomorphic effect of this project will be decreased instream velocities. Placing LWD in the channel and promoting better side channel and floodplain connectivity where it is possible will collectively decrease overall velocities. The LWD placements will promote pools and deposition of sediment in the local areas around each structure.

6.4.2.2 Biological Benefits

In the short term, the pools that form at the LWD structures will increase the available area for holding, and the hydraulic diversity created by the structures will provide high-flow refuge and low-flow cover for juveniles. Establishing a channel through the floodplain at the downstream end of the project area will increase the available rearing area for juveniles and further diversify available habitat during seasonal high flows. In the long term, ELJs and removal of confining features will promote additional side channel development and floodplain access for high-flow refuge, and potentially for juvenile rearing year round. The availability of diverse habitats will increase the carrying capacity for juvenile salmonids and increase the number of pools for holding adults.

6.4.2.3 Potential Challenges

This project area contains the highest density of different landowners than any of the other areas within this study. Landowner coordination and involvement will be a high priority in order to implement projects. A detailed risk assessment will likely be necessary to implement some project elements.

6.5 Project Area 17 (River Mile 35.15 to 34.3)

Project Area 17 (PA-17) is located within the active channel and floodplain from one quarter-mile upstream of the intersection of McGovern Road and Tucannon Road (RM 35.15) to the upstream end of the WDFW property at RM 34.3.

Table 6-5
Restoration Recommendations for Project Area 17

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural processes are impaired in this project area.
2. Reconnect isolated habitats	No significant isolated habitats will be reconnected by this project.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 710 feet of levee to establish increased connectivity and allow channel migration within 2.25 acres of low-lying floodplain. Relocate approximately 720 feet of McGovern Road to increase the width of the floodplain corridor.
4. Restore riparian processes	Restore and revegetate riparian areas throughout approximately 17 acres of the project area.
5. Improve instream habitat conditions	Place LWD throughout approximately 0.6 river miles. Excavate an approximately 1,610 linear foot side channel that will be available during seasonal flows.

6.5.1 Site Description

6.5.1.1 Channel Characterization

The channel through PA-17 is characterized as a single-thread, plane-bed channel with local deep, rapid sections that contain little hydraulic complexity (Photograph 6-5). Resistant fine-grained material is located along much of the left bank. Bank armoring was observed in the upstream portion of the project area between RM 34.85 and 34.75 on both the left and right banks. From this section to approximately RM 34.7, the channel is incised and disconnected from the floodplain; riparian planting projects undertaken here have been largely unsuccessful, likely due to poor hyporheic exchange with the channel. Downstream of RM 34.7, the channel is wide and plane-bed with some deeper areas adjacent to the

resistant bank between RM 34.5 and 33.35. A few minor side channels were observed at approximately RM 34.5 and 34.35 that were wetted at the time of field observation.



Photograph 6-5

A plane-bed section of the channel that flows along the base of a high terrace (right bank) near RM 34.4

Instream habitat is limited by lack of complexity and high-velocity conditions through the incised portion of the project area. Very little LWD was observed. The straight, confined, and incised conditions found throughout much of the project area likely result in high velocities during seasonal high flows and floods, which prevent the retention of sufficient volumes of LWD that would provide cover, refuge, or sediment deposition for spawning areas. Few side channels are available to provide preferred rearing habitat for juveniles.

6.5.1.2 Floodplain Characterization

Floodplain connectivity in this project area is poor to moderate. There is little low-lying floodplain on river left due to natural alluvial fan deposits. Much of the right floodplain is composed of remnant alluvial fan and hillslope deposits that have been reworked during the 1996/1997 flooding. These surfaces are covered in cobble and support little vegetation. Some remnant spoils and armor material were observed on the floodplain, which limit the channel from naturally migrating and expanding into the low areas of the floodplain. Terraces are also present that appear to provide some level of erosion resistance—for example, in the left floodplain adjacent to RM 34.7. Dry channels were observed around RM 34.9, 34.8, and 34.55 that likely convey floodwaters during high-flow events. Channels observed in the floodplain were largely dry; some standing water was observed at approximately RM 34.55 in the right floodplain.

The riparian zone adjacent to the channel is generally in a moderately healthy condition, with some local areas that have been degraded by development, historic flooding, or poor hyporheic connection with the channel.

The riparian zone is generally in poor health and contains few mature trees, sparse vegetation coverage, and an overall narrow riparian corridor. The upstream end of the site between RM 34.9 and 34.5 contains the poorest conditions; the floodplain vegetation appears to have a poor hyporheic connection with the channel and little to no soil development. Riparian trees are mostly immature deciduous species, dominated by cottonwoods, willows, and locusts. Understory vegetation includes groundcover and small shrubs that provide little overhanging vegetation. Plant species are moderately diverse but contain large amounts of invasive species, including a large patch of knapweed near the bridge at the upstream end of the project area.

6.5.2 Conceptual Project Actions

Restoration actions proposed in this project area involve addition of LWD throughout the channel, removal and reconfiguration of infrastructure to allow floodplain connectivity, and development of off-channel areas (Figure B-17). Relocating McGovern Road, beginning at approximately RM 35.05 through the far left side of the floodplain, will greatly increase the

available floodplain width. Removing the levee on the downstream side of the bridge is also recommended. Side channel habitat will be created by excavating channels through the poorly connected areas of the floodplain. These channels will likely be active during seasonal high flows (i.e., spring runoff). Remnant spoils will be removed and placed along with excavated material across the floodplain or at the toe of the far left terrace. Riparian planting is recommended throughout the project area.

6.5.2.1 *Geomorphic Implications*

Relocating the road and removing the levee on the downstream side of the road will allow the channel to evolve over time and promote floodplain connectivity. LWD placement will force pools, provide hydraulic variability and complexity in the plane-bed channel sections, and decrease instream velocities in the deeply incised sections. Placing ELJs at the heads of excavated side channels will promote good surface water connectivity with the channel. Other ELJs may be placed to promote activation of other channels through the low floodplain. Placing LWD will promote retention of additional LWD and bedload that will help build up the bed elevation over time and increase connectivity through the sparsely vegetated and poorly connected floodplain. Removing spoils that confine the channel will allow migration so that the channel can develop a more natural and complex pattern over time. Developing a healthy riparian zone additionally benefits natural processes long term. The vegetation creates roughness along the banks and floodplain that slows velocities during high flows. Mature riparian trees provide a sustainable source of LWD to the channel.

6.5.2.2 *Biological Benefits*

Hydraulic diversity created by the structures will provide high-flow refuge and low-flow cover for juveniles, and pools that form at the structures will increase the available area for adult holding. Establishing side channels through the floodplain will increase and diversify the available rearing area for juveniles during seasonal flows. In the long term, ELJs and removal of confining features (spoils and levees) will promote additional side channel development and floodplain access for high-flow refuge and potentially juvenile rearing year-round over time. The availability of diverse habitats will increase the carrying capacity for juvenile salmonids and increase the number of pools for holding adults. Riparian planting will have beneficial long-term effects on channel and floodplain habitat quality. A

well-vegetated riparian zone will provide nutrients in the form of leaf litter and terrestrial insect drop to the system and will support both fish and other animals that interact within the ecosystem. Riparian trees and diverse overhanging vegetation provide shade along the channel banks that greatly contributes to reducing instream temperatures during adult migration and juvenile rearing. Healthy riparian trees provide LWD wood to the channel, providing a natural source and sustainable driver for habitat complexity.

6.5.2.3 *Potential Challenges*

Road realignment will likely be an involved process with several stakeholders, landowners, and regulatory agencies; implementation may be a long process and should be initiated early. However, road relocation may not be desired by surrounding landowners and those that use the road for property access. Removal of the levee on the downstream side of the bridge may not be desired by the landowner on the left bank; however, this property has been for sale in the past and acquisition may be possible. Side channel excavation may require a significant amount of earthwork, but the excavated materials could be easily distributed atop the floodplain or along the base of the far left terrace where houses and fields are located. Some trees and other existing vegetation may be disturbed in the process of gaining access to and placing the LWD structures; others will need to be removed in order to excavate side channels. Riparian revegetation will require several years of maintenance and monitoring. Establishing vegetation may be difficult where the incised condition of the river limits hyporheic exchange to the riparian zone, but this condition may be improved by excavating the side channels.

6.6 Project Area 18 (River Mile 34.3 to 32.1)

Project Area 18 (PA-18) is located within the active channel and floodplain from the upstream end of the WDFW property (RM 34.3) to RM 32.1.

Table 6-6
Restoration Recommendations for Project Area 18

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Protect natural channel and floodplain processes between RM 34.3 and 33.65, and RM 33.1 and 32.1. Protect the spring channel through the left floodplain. Prevent LWD clearing from the channel.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	No significant infrastructure was identified that impairs natural processes.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout approximately 0.7 river miles.

6.6.1 Site Description

6.6.1.1 Channel Characterization

The channel in PA-18 is primarily a dynamic channel with multiple flow paths, active channel migration, and a relatively high amount of LWD. ELJs and rock/rootwad placements are present in the WDFW portion of the reach between RM 34.2 and 33.7, along with some historic spoils and other features in the floodplain including the Quonset Hut. A levee is located along the left bank upstream of the RM 33.1 bridge that disconnects a low-lying area of the floodplain. No significant infrastructure was observed downstream of the bridge. Aggradation and channel expansion was observed throughout much of the project area, as evidenced by bank erosion, high volumes of sediment deposition, and multiple flow path development. These areas generally have a relatively high amount of LWD recruitment and retention. The channel is recruiting large, mature trees, many of which appear too large for the river to transport easily (Photograph 6-6). Many of these large trees retained smaller material transported from upstream to create more substantial log jams, including several channel-spanning jams. Several side channels were observed that originated at these log jams. A short section near the mouth of Hartsock Creek (approximately RM 33.7 to 33.35) is a single-thread, plane-bed channel with local high-velocity rapid sections.



Photograph 6-6
Several large downed trees near RM 32.6

The complex instream hydraulic conditions created by the presence of large wood, the ability of the river to migrate, and the high volume and supply of bed load sediments creates relatively good instream habitat conditions in a majority of the project area. Deep pools at recruited trees provide ample holding areas for adults, and cover and refuge for juvenile fish. There are several side channels, particularly downstream of RM 33.1, that provide excellent off-channel rearing habitat. Between RM 33.65 and 33.1, the channel is fairly simplified and lacks complexity. Few pools or substantial LWD were observed through the area and no significant side channels.

6.6.1.2 *Floodplain Characterization*

The floodplain in this project area is relatively well-connected and contains a large quantity of low-lying floodplain. Some low-lying areas such as the floodplain around the abandoned property near RM 33.0 are dominated by dry, weedy plants and do not appear to have good floodplain or groundwater connectivity. Small sections of remnant levees and spoils are located in a few places; however, the influence of these features to natural processes appears to be insignificant.

Flowing water was observed in several areas of the floodplain throughout the project area. A spring water channel is located in the left floodplain that originates upstream of the WDFW building near RM 34.2. This channel flows for more than a half-mile through the floodplain, providing flow to several wetland ponds, eventually joining the main channel near RM 33.5. Hartsock Creek contained surface water at the time of field observation. The water from the creek is captured by sedimentation ponds on the east side of Tucannon Road.

Upstream of RM 33.1, the riparian zone is generally in a moderately healthy condition, with some local areas that have been disturbed by development and infrastructure. Downstream of RM 33.1, the riparian zone is wider and contains a greater number of mature trees, better species diversity, and greater plant density. Riparian trees in the project area are primarily deciduous, dominated by cottonwoods, dogwoods, and alders, with few conifers. Understory vegetation includes groundcover, shrubs, and small trees (mostly willows and vine maple) that provide good overhanging vegetation in much of the project area. Species are moderately diverse but contain some invasive plants, including mullein, common teasel, and reed canarygrass.

The area around the RM 33.1 bridge contains very little overhanging vegetation and a high amount of invasive plants. Willows populate the area around the bridge. There are several wetland patches surrounding the bridge that are dominated by cattails and sedges. The wetland on the downstream side of the bridge is ponded and perched above the river water surface elevation; the source of the water was unclear. The wetland on the right bank upstream of the bridge span is disconnected from the channel by a levee and did not appear to contain surface water.

The floodplain adjacent to the pond and the abandoned house near RM 33.0 contains several noxious weeds and invasive plants throughout the property. The pond berms and floodplain contain large patches of thistle, knapweed, teasel, and poison hemlock. A muddy wetland populated by sedges, horsetails, and other wetland plants is located at the toe of berms between the ponds and the river.

6.6.2 Conceptual Project Actions

Restoration actions in this project area are minimal and focus on protection to maintain natural processes that are already occurring. Addition of LWD is proposed in the section between RM 33.65 and RM 33.1 to promote side channel development in the low-lying portions of the left floodplain (Figure B-18). Protection of existing processes in the WDFW property from 34.3 to 33.6, and in the channel and riparian zone within the private property between RM 33.1 and 32.1 is recommended. Long-term planning should consider levee removal and replacement of the bridge at RM 33.1 with a longer-spanning bridge that would allow for better conveyance of floodwaters, sediment, and LWD, as well as the allow the channel to migrate across the low floodplain.

6.6.2.1 Geomorphic Implications

The small area of active restoration is not expected to have significant geomorphic implications; however, the placement of LWD will promote local wood and sediment retention and, based upon the dynamic conditions directly upstream, ample supply of each is likely in the future. The LWD placements will force pools and hydraulic variability through the plane-bed channel. Placing ELJs in strategic locations will promote side channel development through the low-lying areas of the left floodplain. In the protection areas, natural processes such as channel migration and wood recruitment are expected to continue creating and maintaining hydraulic diversity and habitat features.

6.6.2.2 Biological Benefits

Hydraulic diversity created by the structures will provide high-flow refuge and low-flow cover for juveniles, and the pools that form at the structures will increase the available area for adult holding in the project area. In the long term, ELJs will promote additional side channel development and floodplain access for high-flow refuge, and potentially juvenile

rearing year-round over time. The availability of diverse habitats will increase the carrying capacity for juvenile salmonids and increase the number of pools for holding adults.

6.6.2.3 Potential Challenges

Some trees and other existing vegetation may be disturbed in the process of gaining access to and placing the LWD structures.

7 REACH 7 CONCEPTUAL PROJECTS

Reach 7 is located from just upstream of the Tucannon Road crossing at RM 32.1 to RM 27.5 at Marengo (Figure 2). Reach 7 is significant for juvenile rearing of both steelhead and spring Chinook, as well as steelhead spawning. The reach is also used by spring Chinook for spawning and adult holding. Migratory bull trout likely only pass through this reach during migration.

Land use in the valley is almost entirely pastures and hay fields up to the boundary of the riparian buffer. No major hydrologic inputs drain into Reach 7. The reach was identified as losing throughout (HDR 2006).

Reach 7 has a high amount of confinement and is positioned along the toe of the valley slope throughout a majority of the reach. The channel is typically a straight, single-thread, plane-bed channel with local rapid sections. Anthropogenic features such as levees, spoil piles, and bank armoring confine the reach throughout much of its length. Several grade controls (primarily rock weirs) hold the bed elevation; in several locations, the presence of spoil piles indicates the grade may have been artificially lowered. The amount of low-lying floodplain is relatively low and floodplain connectivity is typically poor due to infrastructure that disconnects these areas, as well as the low river bed elevation relative to the floodplain surface.

Reach 7 includes six conceptual project areas. Restoration strategies focus primarily on setting back levees and LWD placement to add instream complexity and promote recovery of channel and floodplain processes over time. Allowing channel migration and floodplain connectivity where possible within known physical limitations (e.g., agricultural fields) and adding LWD in areas that are lacking instream complexity will address the habitat-limiting factor of key habitat quantity identified in the EDT assessment (Appendix J, CCD 2004). Over time, a more complex channel network will allow the development of channel complexity and long-term creation and maintenance of habitat features such as pools and off-channel areas.

7.1 Project Area 19 (River Mile 32.1 to 31.8)

Project Area 19 (PA-19) is located within the active channel and floodplain from RM 32.1 to the bridge at RM 31.8.

Table 7-1
Restoration Recommendations for Project Area 19

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes throughout the project area.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 200 feet of levee to promote better floodplain connectivity and channel migration within the low floodplain; replace bridge span to widen the active channel.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD as needed when associated with other restoration actions in the project area (approximately 0.3 RM). Evaluate 435 feet of armor and replace with bioengineered structures if appropriate to create better instream habitat conditions.

7.1.1 Site Description

7.1.1.1 Channel Characterization

The river through PA-19 is characterized as a single-thread, plane-bed channel. The channel is wide and shallow with little complexity. A rock-armored levee is located along the right bank near RM 31.95, and other large boulders and riprap were observed along the left bank upstream of the bridge. The bridge abutments are lined with corrugated steel sheeting. The bridge span and low chord elevation create a narrow opening beneath the bridge (Photograph 7-1). This likely constricts the river during high flows and creates high velocities through the bridge opening and on the downstream side. The bridge appeared to be old and in disrepair. No available off-channel areas other than a minor flow split near RM 32.0 were observed in this project area.



Photograph 7-1
The bridge at RM 31.8, looking downstream

Instream habitat is characterized by a wide, shallow channel with a lack of pools, off-channel areas, cover, and hydraulic refuge. Only small LWD and some undercut root masses were observed that provided cover in the channel. During high flows, the bridge crossing and the area downstream likely contain very high velocities that may be detrimental to fish, particularly juveniles.

7.1.1.2 *Floodplain Characterization*

Floodplain connectivity in this project area is poor. A majority of the left side of the channel is lined by the bedrock valley wall and an alluvial fan deposit and contains very little low-lying floodplain. Much of the right side of the channel is lined with armoring and separated from the adjacent wheat field by a narrow strip of riparian vegetation. The bank armoring

inhibits channel migration and somewhat limits floodplain connectivity; the channel bottom is relatively low in elevation compared to the field.

The riparian zone is mostly limited to a narrow strip of trees and undergrowth. Riparian trees are mainly deciduous, dominated by cottonwoods and alders. The right bank at RM 31.8 contains some mature deciduous trees growing atop the alluvial fan deposit that provide good shading. Understory vegetation includes groundcover, shrubs, and small trees that provide overhanging vegetation along the channel margins. Some areas have poor diversity and are dominated by one or two understory species.

7.1.2 Conceptual Project Actions

Restoration within this project area includes replacing the bridge span at RM 31.8, removing armoring, and evaluating the necessity of bank armoring adjacent to existing infrastructure and replacing as necessary with bioengineered structures (Figure B-19). ELJs will also be placed to add pools, instream cover, and refuge. Armoring near RM 32.1 and 31.95 will be removed to promote natural channel processes. The low floodplain just upstream of the bridge should be maximized to create off-channel habitat.

7.1.2.1 Geomorphic Implications

Widening the bridge span will regulate velocities upstream, through, and downstream of the bridge during high-flow events. The likelihood of backwater on the upstream side, and high velocities through the opening will be minimized. Widening the span will also minimize the abrupt drop in velocity as water exits the flow constriction downstream of the bridge. Replacing armor with bioengineered structures will create more complex hydraulic conditions at the face of the structure, rather than the accelerated velocities that typically occur adjacent to rock armor. ELJs will force pools and create low-velocity zones in the lee of the structures.

7.1.2.2 Biological Benefits

Widening the bridge span will decrease velocities in the channel and provide better hydraulic conditions for fish during flood events. Increasing off-channel connectivity

upstream of the bridge will provide off-channel refuge, increase habitat diversity, and create more juvenile rearing areas.

7.1.2.3 *Potential Challenges*

Replacing the bridge will be costly and require consultation with regulatory agencies and meeting hydraulic and civil engineering criteria. Bridge construction would likely require a temporary bypass route, which may be costly and impact traffic flow. Some trees and other existing vegetation may be disturbed in the process of gaining access to and placing the LWD structures. Adjacent fields may also experience some temporary disturbance. Project actions upstream of the bridge will involve cooperation and desire of adjacent landowners.

7.2 **Project Area 20 (River Mile 31.8 to 31.5)**

Project Area 20 (PA-20) is located within the floodplain from the bridge at RM 31.8 to RM 31.5.

Table 7-2
Restoration Recommendations for Project Area 20

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Protect natural channel and floodplain processes throughout the project area. Prevent LWD-clearing and cattle grazing in the channel.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	No significant infrastructure was identified that impairs natural processes.
4. Restore riparian processes	Fence livestock from riparian and floodplain areas.
5. Improve instream habitat conditions	No instream improvements are proposed.

7.2.1 *Site Description*

7.2.1.1 *Channel Characterization*

The channel through PA-20 is a dynamic, multiple-thread channel containing a variety of hydraulic conditions, including pools, rapids, and low-velocity side channels. The channel is

actively migrating, expanding, and aggrading in this project area as evidenced by recent channel development and recruitment of trees along the banks (Photograph 7-2). Side channel connectivity is relatively good.



Photograph 7-2

Side channel development via channel expansion occurring near RM 31.7

The multiple-thread channel contains many flow paths with different hydraulic conditions that provide a variety of habitat types from deep pools to slow-moving side channels. A relatively high amount of LWD is present, much of which appeared to be relatively stable. Some LWD was recruited locally and other material appears to be retained from mobile debris transported into the project area from upstream.

7.2.1.2 Floodplain Characterization

Floodplain connectivity is poor to moderate. Although the river is actively migrating and aggrading, the elevation of much of the left floodplain is several feet above the water surface of the channel, resulting in a high cutbank. The channel has good connectivity within the floodplain area to the right valley wall, which is occupied by active side channels. Small sections of remnant levees and spoils are located in a few places; however, the influence of these features to floodplain connectivity and channel migration appears to be insignificant. A tributary channel through a well-shaded, vegetated area was identified along the toe of the right valley slope, entering the main channel near RM 31.5.

The riparian zone is generally in poor condition, with many areas that have been disturbed by development and grazing, or have a poor hyporheic connection to the river. Riparian trees are predominantly deciduous, mainly alders and dogwoods. In several areas there are groves of trees that are unhealthy or dying. Understory vegetation has been disturbed or restricted in many areas by grazing activities and agriculture, resulting in sparse coverage and poor diversity. Exposed areas including the levee at RM 31.8 are populated with dry, weedy plant species.

7.2.2 Conceptual Project Actions

No active restoration is proposed within PA-20. Rather, best management practices (BMPs) should be employed, including fencing off low floodplain and riparian areas to restrict cattle access to the river (Figure B-20). This area should be protected as natural processes continue to recover the project area, improving habitat conditions over time.

7.2.2.1 Geomorphic Implications

Fencing off the low floodplain will allow the riparian zone to recover. A healthy riparian zone benefits natural geomorphic processes long term by providing roughness along the banks and floodplain that decreased velocities during high flows. Mature riparian trees provide a sustainable source of LWD to the channel.

7.2.2.2 *Biological Benefits*

Because the project area is already undergoing natural recovery, protecting the majority of the project area will prevent any disruption of natural processes and valuable habitat. Preventing cattle grazing on the banks of the river will minimize the amount of animal waste entering the river and will allow the riparian zone to recover.

7.2.2.3 *Potential Challenges*

Implementation will require landowner approval and maintenance. This project will result in reduction of grazing area, which may not be desired by the landowner. An alternate water source will likely need to be implemented for cattle.

7.3 **Project Area 21 (River Mile 31.5 to 30.3)**

Project Area 21 (PA-21) is located within the active channel and floodplain from RM 31.5 to the bridge at RM 30.3.

**Table 7-3
Restoration Recommendations for Project Area 21**

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural processes are impaired in this project area.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 1,740 feet of levees and spoils in six locations to increase floodplain connectivity within 0.6 acres of low floodplain and ease channel confinement; relocate pump and access road at RM 30.9.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 1.1 river miles; supplement existing rock structures (weirs) with LWD.

7.3.1 Site Description

7.3.1.1 Channel Characterization

The channel through PA-21 is characterized as a single-thread, plane-bed channel. Overall, the channel is highly impacted by human activities (likely dredging and straightening) and the presence of infrastructure. A majority of the channel is wide and shallow with little complexity. Local rapids and pools are associated with the presence of boulders and rock weirs. Two short split flow sections are present between RM 31.1 and 30.7, where a moderate amount of LWD has accumulated and formed relatively deep pools. Downstream of RM 30.7, the channel may have been dredged historically; the channel bed is several feet below the floodplain surface (Photograph 7-3). Throughout the project area, the right bank flows along the toe of the valley wall. Much of the left bank is lined by levees, riprap, and spoil piles that confine the channel against the valley wall. An access road located at approximately RM 30.9 also confines the left bank at the downstream end of a long dredge-spoil levee that lines the tributary that enters the river at approximately RM 31.0. Several rock weirs and rock structures throughout, and bedrock near RM 31.2, hold the channel grade throughout the project area. Three large rock weirs with deep plunge pools and one large rock barb are located between RM 30.7 and 30.6. Irrigation pumps are located at approximately RM 31.15, 30.9, and 30.5.



Photograph 7-3

An irrigation intake pump near RM 30.5, where the channel grade is several feet below the floodplain surface

Instream habitat is limited by lack of complexity and by hydraulic conditions that result in high velocities and prevent the retention of LWD and sediment. Through much of the project area, the channel is wide and shallow. Pools and instream cover were generally limited to the locations of large weirs. A majority of the weirs appeared to be passable by adult fish but may present difficulty for juvenile passage. The straight, confined conditions likely result in high instream velocities during spring runoff and floods, and there were very few opportunities for fish to seek refuge.

7.3.1.2 Floodplain Characterization

Floodplain connectivity is poor within this project area. The low-lying floodplain is narrow and disconnected in many places by levees, armoring, and the incised channel bed elevation. Between RM 31.5 and 31.35, former channel or flood pathways are apparent on the floodplain. About half of this area is currently within the low-lying floodplain, although the channel appears to be disconnected, with an elevation several feet lower than the floodplain surface. Another section of wider floodplain exists between the tributary at RM 31.1 and RM 30.7. Between RM 31.0 and 30.8, the floodplain area is disconnected by a large spoil-pile levee and pump access road. From RM 30.7 to 30.3, the floodplain is highly disconnected from the channel and contains very little low-lying area.

The riparian zone is generally in a poor to moderately healthy state and highly impacted by poor floodplain connectivity and land-use activities. Riparian trees are predominantly deciduous species, including alder, dogwood, and several willow patches along the river banks. Understory vegetation includes groundcover, shrubs, and small trees that provide overhanging vegetation for leaf drop and shading in the less disturbed sections of the project area. The understory is sparse and lacking diversity where infrastructure and grazing areas are located. These areas are typically dominated by dry grasses with very few trees or overhanging vegetation. Between RM 31.25 and 31.1, the riparian zone is reduced to a narrow stretch of shrubs and grasses by development on the left bank and the valley wall on the right.

7.3.2 Conceptual Project Actions

Restoration actions for PA-21 involve opening new flow pathways and widening the floodplain corridor by setting back levees, armoring, and spoil piles. Additionally, LWD will be placed throughout the project area, including supplementary placements at existing rock structures. The levees and spoils located on the right bank between approximately RM 30.95 and 30.9 would be setback to the edge of the low-lying floodplain, which will require relocation of the pump and access road. Spoils and riprap along the right bank between RM 31.5 and 31.25 will be set back into the low-lying floodplain. Surface water extraction points may be converted to groundwater sources to limit disturbance associated with these practices.

7.3.2.1 *Geomorphic Implications*

Setting back infrastructure will allow better connectivity with the low-lying floodplain and migration and adjustment of the channel that will lead to locally decreased channel velocities during high flows, and dispersion of sediment and debris across the floodplain. Addition of LWD will initiate a geomorphic response resulting in bed scour and sorting of sediment that form critical habitat features (e.g., pools, cover, and spawning gravels). Over time, LWD will promote retention of bedload sediment throughout the project area, reversing some of the effects of channel incision. LWD will promote erosion and widening of the bank and the building of gravel bars and low-lying floodplain area.

7.3.2.2 *Biological Benefits*

Setting back armoring and easing channel confinement will decrease velocities along the face of the bank to create low-velocity channel margin habitat, and decrease overall channel velocities during high flows. Adding complexity to the project area via LWD will provide hydraulic diversity and refuge in the mainstem, significantly improving habitat conditions and carrying capacity for juveniles. In the short term, the pools that form at the structures will increase the available area for holding, especially in the upper half of the project area. Increased hydraulic diversity will provide high-flow refuge and low-flow cover for juveniles. The structures will also increase sediment retention and sort sediment, enhancing the quality of spawning areas.

7.3.2.3 *Potential Challenges*

The land adjacent to the river is used for agriculture and grazing. Setting back infrastructure will likely result in some loss of land and modification of irrigation systems, which may be undesirable to the landowners. Additionally, promoting increased floodplain connectivity and building up the channel bed may be controversial. Some trees and other existing vegetation may be disturbed in the process of removing levees, spoils, and riprap banks and in gaining access to LWD placement sites. Any wood that must be removed for access could be incorporated into the LWD placements or used to decommission access routes.

7.4 Project Area 22 (River Mile 30.3 to 29.3)

Project Area 22 (PA-22) is located within the active channel and floodplain from the bridge at RM 30.3 to the bridge at RM 29.3.

Table 7-4
Restoration Recommendations for Project Area 22

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural processes are impaired in this project area.
2. Reconnect isolated habitats	Isolated habitats near RM 30.2 to 30.1, 29.9, and 29.6 will be reconnected.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 2,950 feet of levees and spoil piles in four locations to re-establish or increase floodplain connectivity of 2.45 acres of low floodplain. Set back approximately 190 feet of levee.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 1.0 river miles; supplement existing rock structures (weirs) with LWD.

7.4.1 Site Description

7.4.1.1 Channel Characterization

The channel through PA-22 is characterized as a single-thread, plane-bed channel with local rapid sections and forced pools at weirs placed in the channel. The sinuosity of the channel is very low. The channel is primarily wide and shallow throughout the project area, except for a few local areas with boulder weirs and large plunge pools at rock weirs (Photograph 7-4). From the RM 30.3 bridge to the weir at RM 30.1, the channel is incised where it is confined between two large levees, as evidenced by undercutting of the bridge abutments. Throughout the project area, the channel is confined between the valley wall and levee and riprap infrastructure along adjacent farmland. Large levees are located along the majority of the right bank. Riprap and boulders were also observed throughout the project area, along both banks, and in the channel bed. Remnant spoil piles indicate that dredging and channel straightening may have occurred historically. At least nine rock weirs are located between RM 30.1 to 29.4 that control the channel grade throughout the area. There are multiple

irrigation pumps located throughout the project area, which are typically correlated with levees or bank armoring. A few small side channels are present, but overall off-channel areas are limited.



Photograph 7-4

A large rock weir near RM 29.4

Instream habitat is limited by lack of complexity and by hydraulic conditions that result in accelerated velocities during high flows that prevent the retention of LWD and sediment. Through much of the project area, the channel is wide and shallow. There are several deep pools at the rock weirs, but very little cover or other complexity. A majority of the weirs appeared to be passable by adult fish but may present difficulty for juvenile passage. The straight, confined channel likely has high instream velocities during spring runoff and floods, and very few opportunities for fish to seek refuge were identified.

7.4.1.2 Floodplain Characterization

Floodplain connectivity is poor within a majority of the project area. The low-lying floodplain is narrow and disconnected in many places by levees and armoring. Some wide areas of low floodplain are present between RM 30.1 and 29.85. A low area in the right floodplain that is currently used as a burn pile is disconnected from the channel by a large armored levee between RM 30.2 and 30.1.

The riparian zone is in a moderately healthy state but is generally limited to a narrow corridor. Local areas have been degraded by development and poor floodplain connectivity. Riparian trees are predominantly deciduous species, including dogwood, alder, and cottonwood. Between RM 30.1 and 29.95, there are several tall, mature cottonwoods in the floodplain. Understory vegetation in this area is fairly dense and diverse with groundcover, shrubs, and small trees that provide overhanging vegetation for leaf drop and shading. The riparian area between RM 29.95 and the downstream end of the project area generally has poor species diversity, sparse understory, and many invasive plants, including dense patches of poison hemlock.

The disconnected low-lying area at RM 30.3 is mainly vegetated with grasses and weedy plants, but contains some patches of wetland plants.

7.4.2 Conceptual Project Actions

Restoration actions proposed for PA-22 involve infrastructure removal and LWD placement. Removal of the large levee to the edge of the low-lying area along the right bank at approximately RM 30.3 to 30.1 is recommended, as well as removal of spoils and other armoring that constrict the channel throughout the remainder of the project area (Figure B-21). Existing weirs would be supplemented with LWD, and placing other structures throughout the plane-bed sections of the channel is recommended.

7.4.2.1 Geomorphic Implications

Removing infrastructure will allow better connectivity with the low-lying floodplain that will lead to locally decreased channel velocities during high flows and dispersion of sediment across the floodplain. Addition of LWD will initiate a geomorphic response resulting in bed

scour and sorting of sediment that form critical habitat features (e.g., pools, cover, and spawning gravels). Over time, LWD will promote development of bedforms in the plane-bed reaches of the channel and retention of bedload sediment throughout the project area, reversing some of the effects of channel incision, and will promote erosion at the top of the area, widening of the bank, and building of gravel bars and low-lying floodplain.

7.4.2.2 *Biological Benefits*

Increasing the available floodplain area will decrease instream velocities during high-flow events. Adding complexity to the project area via LWD will add hydraulic diversity that will provide additional holding area for adults, as well as high-flow refuge and low-flow cover for juveniles. The structures also sort bedload sediment, leading to the formation of spawning areas. Supplementing the existing rock structures with LWD will create better passage conditions for juveniles. Removing armoring and easing channel confinement will decrease velocities along the face of the banks to create low-velocity channel margin habitat, and decrease overall channel velocities during high flows.

7.4.2.3 *Potential Challenges*

Removal of some portions of the existing infrastructure will require modification of irrigation systems and may allow the river to flood adjacent to agriculture fields, which may be undesirable to the landowner. Removing the levee at the upstream end of the project area may not be desired, as it will result in some loss of farmland. Promoting increased floodplain connectivity and building up of the channel bed at this location may be controversial. Some trees and other existing vegetation may be disturbed in the process of removing levees, spoils, and riprap banks and in gaining access to LWD placement sites. Access to the heavily vegetated area between RM 30.05 and 28.85 will be difficult and require disturbance of existing vegetation. Any wood that must be removed for access may be incorporated into the LWD placements or used to decommission access routes.

7.5 Project Area 23 (River Mile 29.3 to 28.25)

Project Area 23 (PA-23) is located within the active channel and floodplain from the bridge at RM 29.3 to the bridge at RM 28.25.

Table 7-5
Restoration Recommendations for Project Area 23

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural processes are impaired in this project area.
2. Reconnect isolated habitats	Isolated habitats will be reconnected in many places throughout the project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 2,160 feet of levees to re-establish floodplain connectivity of 9.5 acres of low floodplain. Set back approximately 890 feet of levee.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 0.95 river miles; supplement existing rock structures (weirs and barbs) with LWD.

7.5.1 Site Description

7.5.1.1 Channel Characterization

The channel through PA-23 is a single-thread, plane-bed channel that is highly confined to a straight alignment between infrastructure and the valley wall (Photograph 7-5). Levees and spoil piles confine the upper project area between approximately RM 29.3 to 29.1, and much of the right bank downstream of this point is lined by levees. At approximately RM 28.6, a series of rock barbs are located along the bank, followed by a large rock weir at RM 28.45. Levees confine the channel between the weir and the downstream end of the area. One small spring or tributary is present in the left floodplain near RM 29.1, and a small alcove is present at the downstream end of this area. The low-lying floodplain area is disconnected from the channel at the upstream end by a large armored levee along the left bank that constricts the channel to a tight bend at RM 28.35.



Photograph 7-5

A wide, shallow section of the channel near RM 29.4

The quality and availability of instream habitat in this stretch is limited by lack of complexity and hydraulic conditions that prevent the retention of sufficient volumes of LWD and sediment. The channel is wide and shallow with little complexity except at rock placements that provide some adult pool habitat. There was very little LWD observed and little opportunity for cover except for some overhanging vegetation and undercut root masses along the channel margins. The project area lacks an adequate quantity of secondary flow paths and off-channel areas that are preferred by juvenile fish. The straight, confined channel likely has high instream velocities during spring runoff and floods. Very few opportunities for fish to seek refuge were identified.

7.5.1.2 Floodplain Characterization

Floodplain connectivity is poor and highly impacted by infrastructure. Relative to upstream project areas, the amount of low-lying floodplain in PA-23 is relatively high and the channel is less incised. Between RM 28.8 and 28.25, a majority of the valley bottom is low-lying. This area is currently used as a horse pasture and contains many wetland plants.

The riparian zone is in a poor to moderate health. Riparian trees are predominantly deciduous species, including dogwood, alder, willow, and cottonwood. Some mature trees are present in the floodplain between RM 29.15 and 28.8, with a moderately diverse understory. The remainder of the project area mostly contains smaller trees, with many patches of immature trees in poor health and a sparse understory dominated by groundcover such as Himalayan blackberry and reed canarygrass. Along the levees at the downstream end of the area, there is little shading except for willows that have been planted along the banks. The levees are populated with dry, weedy species, including large patches of yellow starthistle.

7.5.2 Conceptual Project Actions

Restoration actions for PA-23 focus on removing or setting back infrastructure to widen the available floodplain corridor and adding channel complexity via LWD placement. Setting back the lower section of the right bank levee between RM 29.15 and 29.1 to the edge of the field will open up low-lying floodplain and ease confinement through the bend. Spoil-pile levees along the left bank would be removed between RM 29.1 and 28.6. Within the area downstream of RM 28.6, infrastructure should be set back to establish an appropriate floodplain width through the bend as shown (Figure B-23). The levee along the left bank at RM 28.45 would be set back to ease the confinement around the channel bend allow the channel to occupy the low alcove area. LWD placement is recommended throughout the plane-bed channel and to supplement existing rock structures.

7.5.2.1 Geomorphic Implications

Widening the floodplain corridor by removing and setting back infrastructure will allow the channel to migrate and establish a complex channel network and a more natural, meandering planform through this project area. Placing ELJs throughout will additionally

promote the formation of side channels while providing instream complexity in the short term. Increasing connectivity with the low-lying floodplain will lead to lowered channel velocities during high flows and dispersion of sediment across the floodplain, particularly around the highly confined bend at RM 28.4. Addition of LWD will initiate a geomorphic response resulting in bed scour, bank erosion, and sorting of sediment that form critical habitat features (e.g., pools, cover, and spawning gravels). Over time, LWD will promote retention of bedload sediment and additional LWD, and the development of gravel bars and low-lying floodplain areas.

7.5.2.2 *Biological Benefits*

Immediate biological benefits of the project include decreased instream velocities during high flows from better connectivity with the floodplain, and additional pool development and cover provided by the LWD placements. As the channel is able to establish a more complex planform, more diverse habitat areas will be available to support the carrying capacity for juvenile salmonids. Deposition of sediment and formation of side channels will create additional spawning area. Over time, greater floodplain connectivity will also lead to a healthier riparian zone and, in turn, drive many ecosystem processes.

7.5.2.3 *Potential Challenges*

Access through the vegetated floodplain to place the LWD structures and remove infrastructure will disturb some existing trees and vegetation and require multiple access routes. The recommended levee setback location through the horse pasture in the downstream half of the project area may not be desired as some area of the pasture will be lost. This area may be appropriate for conversion to a conservation easement. The landowner may not desire increased floodplain connectivity, channel migration, and building up the channel bed.

7.6 Project Area 24 (River Mile 28.25 to 27.5)

Project Area 24 (PA-24) is located within the active channel and floodplain from the bridge at RM 28.25 to RM 27.5.

Table 7-6
Restoration Recommendations for Project Area 24

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Natural processes are impaired in this project area.
2. Reconnect isolated habitats	Isolated habitats will be reconnected within the project area in several locations via levee setback.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove and set back approximately 2,530 feet of levees in three locations to re-establish floodplain connectivity to approximately 1.32 acres.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout the 0.75-mile project area.

7.6.1 Site Description

7.6.1.1 Channel Characterization

The channel through PA-24 is primarily a single-thread, plane-bed channel. A rapid section is located between RM 28.1 and 27.95, and a short depositional split flow section is present at RM 27.85. The upper portion of the project area is confined on the right bank by riprap along a majority of the bank. Bedrock is present in the channel bed throughout this area, which acts as natural grade control. Between RM 27.95 and 27.8, two large armored levees located along the left bank separate the channel from low-lying area on the opposite side (Photograph 7-6). These areas contain alcove pools that were mainly dry except for a few shallow and disconnected pools. The features were formerly built to create off-channel areas for fish but do not appear to function as intended at this point in time. Two large rock weirs hold the channel grade between RM 27.9 and 27.7. Between RM 27.8 and 27.5, the channel is lined with an armored levee along the right bank and a relatively resistant terrace along the right bank. With the exception of the short braided section near RM 27.85, the river contains no significant side channels.



Photograph 7-6

A large rock levee on the left bank near RM 27.9, looking upstream

Instream habitat in this project area lacks instream complexity, high-flow refuge, and off-channel rearing habitat. Some pool habitat is available at the weir structures, at large riprap boulders in the channel, and in the area around RM 27.85. Despite the perturbations in the channel bottom created by bedrock and boulders, a majority of the channel is wide and shallow. Juvenile habitat is generally limited to the channel margins, although much of the banks are lined with armor, which accelerates velocities. Very little LWD was observed except for a log jam at RM 27.85 and a recently recruited tree that had fallen near RM 27.7. Instream cover is limited to overhanging vegetation and voids in angular rock infrastructure.

7.6.1.2 Floodplain Characterization

The low-lying floodplain in this project area is relatively narrow and contains two significant areas that are disconnected by infrastructure. The large levees along the left bank between RM 27.95 and 27.8 disconnect the low-lying floodplain and prevent channel migration along the outside of the meander bend. The levees along the right bank between RM 27.8 to 27.5 disconnect low areas of floodplain between the levees and Tucannon Road.

The riparian zone is generally in poor health and has been highly impacted by the presence of infrastructure. Riparian vegetation is typically sparse through much of the area. Riparian trees are generally immature deciduous species, including cottonwoods, dogwoods, and alders. Some larger, mature trees are present in the left floodplain between RM 28.25 and 28.1. The understory provides some overhanging vegetation. Species diversity is poor and a high number of invasive plants were observed, including St. John's wart, common teasel, Himalayan blackberry, and creeping buttercup.

The connected wetland at RM 27.9 appears to be connected to a groundwater source. The wetland is in moderate health and has adequate shading provided by woody plants. The disconnected wetland habitat on the right bank at RM 27.6 is in moderate health with shade provided by woody plants. The wetland contains cattails, sedge, and nettle.

7.6.2 Conceptual Project Actions

Restoration actions for PA-24 involve levee and armored bank setbacks and LWD placement. The large levees adjacent to the alcove areas between RM 27.9 to 27.8 would be set back to the toe of the terrace and agricultural fields. The right bank levees between RM 27.8 and 27.5 would be setback to the edge of Tucannon Road to reconnect the low floodplain areas adjacent to the road. LWD placements will be placed throughout the project area, including supplementary placements at the existing rock weirs.

7.6.2.1 Geomorphic Implications

Setting back infrastructure will allow a wider corridor for channel migration and accessible floodplain area. Increased connectivity with the low-lying floodplain will lead to decreased channel velocities during high flows and dispersion of sediment across the floodplain.

Addition of LWD will initiate a geomorphic response resulting in bed scour and sorting of sediment, which forms critical habitat features (e.g., pools, cover, and spawning gravels). Because the channel profile is controlled by man-made features and bedrock, the wood placements are not expected to significantly affect the channel grade. However, the ELJs will influence the development of additional pools and depositional areas in the plane-bed sections of the channel. In addition, large wood structures will promote development of a more complex channel network by splitting flow, initiating gravel bar and island development, and promoting channel migration within the reconnected floodplain area.

7.6.2.2 Biological Benefits

Immediate biological benefits of the project include decreased instream velocities during high flows from better connectivity with the floodplain, and pool development and cover provided by the LWD placements. As the channel is able to establish a more complex planform through the reconnected floodplain, more diverse habitat areas will be available to increase the carrying capacity for juvenile salmonids. Deposition of sediment and formation of side channels will create additional spawning area. Over time, greater floodplain connectivity will also lead to a healthier riparian zone and, in turn, drive many ecosystem processes.

7.6.2.3 Potential Challenges

Multiple access points will be necessary to place LWD and remove infrastructure. These actions will disturb some existing trees and other vegetation. The project will require the landowner's acceptance.

8 REACH 6 CONCEPTUAL PROJECTS

Reach 6 is located from approximately 0.5 miles upstream of the Turner Road/Marengo Bridge crossing (RM 27.5) to RM 20.0 (Figure 2). The reach is within the downstream extent of the area that is used by spring Chinook for spawning, rearing, and holding. The reach is used extensively by steelhead for spawning and juvenile rearing. Migratory bull trout likely only use this reach during migration periods.

The valley is primarily occupied by pastures but has large herbaceous, wetland, and forested riparian areas where the forested area is located throughout much of the valley bottom. No significant hydrologic inputs are located within Reach 6. The area was identified as a losing reach in the upstream end of the site, transitioning to a gaining reach downstream of King Grade (RM 22.8).

Overall, the reach is relatively unconfined but it does contain some significant areas of confinement, in particular between Turner Road (RM 26.9) and King Grade, where several levees disconnect the channel from large areas of low-lying floodplain. In general, the confined reaches are characterized by a single-thread, plane-bed channel with little complexity. Weirs, rock structures, and other armoring are present throughout these areas. The unconfined reaches are typically highly dynamic with many side channels that were initiated by active channel migration and wood recruitment.

Reach 6 includes four conceptual project areas. Restoration strategies focus primarily on reconnecting low-lying floodplain and protecting active channel processes that are presently contributing to recovering habitat conditions. Removing remnant infrastructure that impedes natural processes and setting back other features will allow the channel to create a complex channel network and increase floodplain connectivity to the wide, low-lying floodplain areas that are currently disconnected. Key habitat quantity and high temperatures were identified in the EDT assessment as habitat limiting factors for this area (Appendix J, CCD 2004). Reconnecting the floodplain will contribute to a healthy riparian zone that will provide good shading and reduce instream temperatures. Allowing the channel to migrate into the reconnected areas will recruit riparian trees that fall into the channel and create

deep pools for adult holding. LWD contributes to channel complexity by splitting flow and initiating side channels that are preferred for juvenile rearing.

8.1 Project Area 25 (River Mile 27.5 to 26.9)

Project Area 25 (PA-25) is located within the active channel and floodplain from RM 27.5 to Turner Road (RM 26.9).

Table 8-1
Restoration Recommendations for Project Area 25

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Protect natural channel and floodplain processes between RM 27.5 and 27.15. Prevent LWD-clearing from the channel.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	No significant infrastructure that impairs natural processes will be modified by this project.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD in the channel upstream of Turner bridge, approximately RM 27.1 to 26.9 (0.2 miles).

8.1.1 Site Description

8.1.1.1 Channel Characterization

The channel through the upstream portion of PA-25 between RM 27.5 and 27.15 is characterized by a wide active channel with multiple flow paths, a forced pool-riffle configuration associated with LWD, and a high volume of temporary sediment storage in the form of gravel bars and low-lying floodplain areas. This portion of the channel contains areas of active channel migration where wood is being recruited into the channel, resulting in the development of pools (Photograph 8-1). Downstream of RM 27.15, the channel is a straight, single-thread, plane-bed channel confined against the toe of the southeast valley wall. This portion of the channel is wide and shallow with little complexity. Some riprap is present near RM 27.4 along the right bank that prevents channel migration towards

Tucannon Road. Additional riprap is located on both sides of the channel at the approach to the Turner Road bridge crossing. Possible spoils are located along the right bank through the lower portion of the project area; the channel bottom is located several feet below the floodplain elevation through this area. The upper project area has several side channels that appear to be well-connected at various stages. One off-channel area was identified in the lower project area.



Photograph 8-1

Recently recruited trees along the left bank near RM 27.25

Instream habitat conditions between RM 27.5 and RM 27.15 are relatively good, due to the presence of ample LWD and a complex channel pattern. Log jams retain additional mobile wood and force deep pools, and the presence of multiple flow paths provides variable habitat conditions for juvenile fish during a range of flows. The wide, active channel contains a high

amount potential spawning area. From RM 27.15 to Turner Bridge, the channel contains little complexity other than boulders contributed from the hillside. Very little cover, pools, or high-flow refuge is available in this portion of the channel.

8.1.1.2 Floodplain Characterization

This project area is characterized by moderate floodplain connectivity. A large quantity of low-lying floodplain available between RM 27.5 and 27.15 appears to be relatively well connected and largely unaffected by infrastructure, with the exception of the riprap at RM 27.4. Downstream of RM 27.15, there is less low-lying floodplain and it is mostly disconnected from the channel by likely channel incision and the possible remnant spoil piles.

The riparian zone is in moderately good health. Overall, the riparian corridor is fairly wide, except for the outside bends at RM 27.3 and 27.2 where the channel abuts adjacent fields, and within the area just upstream of the Turner bridge crossing. Riparian trees are predominantly deciduous, including dogwood, cottonwood, and alder, many of which are relatively mature. Understory vegetation includes groundcover, shrubs, and small trees that provide overhanging vegetation along much of the channel. Some areas have sparse understory other than grasses and other groundcover, including the relatively high portion of the floodplain at the spoil piles between RM 27.1 and 26.9.

8.1.2 Conceptual Project Actions

Recommendations for PA-25 are to protect ongoing processes between RM 27.5 to 27.15 and to place LWD between RM 27.15 and the Turner Road Bridge.

8.1.2.1 Geomorphic Implications

Natural processes are currently creating and maintaining diverse habitat conditions in the upper portion of the project area. Addition of LWD in the lower segment will initiate a local geomorphic response resulting in bed scour and sorting of sediment that form critical habitat features (e.g., pools, cover, and spawning gravels). The LWD will diversify the thalweg to create more complex hydraulic conditions in the channel. Over time, LWD will promote

retention of bedload sediment, reversing some of the effects of channel incision between RM 27.1 and 26.95 and eventually resulting in better floodplain connectivity.

8.1.2.2 *Biological Benefits*

Adding complexity to the plane-bed reach will diversify hydraulic conditions in the channel to provide additional pool habitat, high-flow refuge, and cover for juvenile fish. Applying LWD to this straight section of the channel will also reduce instream velocities during high flows. Deposition of sediment and formation of side channels will create additional spawning area. Over time, better floodplain connectivity will lead to a healthier riparian zone.

8.1.2.3 *Potential Challenges*

Access to place LWD is expected to be relatively straightforward, but it will disturb some existing vegetation. The project will require the landowner's acceptance.

8.2 Project Area 26 (River Mile 26.9 to 23.65)

Project Area 26 (PA-26) is located within the active channel and floodplain from Turner Road (RM 26.9) to RM 23.65.

Table 8-2
Restoration Recommendations for Project Area 26

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Protect natural channel and floodplain processes from RM 24.6 to 23.65, and RM 26.05 to 25.6. Prevent LWD-clearing from the channel.
2. Reconnect isolated habitats	Levee removals will reconnect existing wetland areas throughout the project area, most notably an approximately 12-acre area in the north floodplain near RM 25.4.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove 8,300 feet and set back approximately 12,200 feet of bank armoring in seven locations to re-establish floodplain connectivity of approximately 29 acres of low floodplain.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 1.8 miles of the channel through the project area.

8.2.1 Site Description

8.2.1.1 Channel Characterization

The channel through PA-26 contains both sections of dynamic and complex channel networks, as well as wide, plane-bed stretches with little complexity. In the upper portion of the project area, from Turner Road to approximately RM 26.0, the river is confined against the valley wall by bank armoring and levees to a single-thread, plane-bed channel (Photograph 8-2a). The levee materials are typically composed of angular armor rock, as well as a rock/wood revetment just downstream of the Turner Road Bridge. Three large vortex rock weirs located between RM 26.3 and 26.2 control the channel grade.



Photograph 8-2a
The right bank levee near RM 26.6, looking downstream

From RM 26 to 25.6, the active channel becomes wider and less confined, except for the section between RM 26.0 and 25.85 where the channel contains multiple rock weirs and barbs that control the grade and planform. Within this portion of the channel there is a higher amount of temporary sediment storage in the form of islands and gravel bars, multiple-channel pathways, and active channel migration. Multiple rock placements and restoration features were also observed through this section. From approximately RM 25.6 to 25.25, the channel becomes wide and shallow where it is lined on either bank by a large levee. Multiple rock weirs and rock barbs control the grade throughout this section.

There is a wide depositional area between RM 25.25 and 25.1 as the river exits the confined levee section. The channel is braided with many channel pathways and a high amount of

sediment deposition. The river makes a tight bend around a resistant fine-grained deposit at RM 25.0 and is confined against the valley wall by a levee to RM 24.85. Between RM 24.85 and 24.3, the main channel flows parallel to the valley wall but has a wide, aggrading active channel area. Moderate to high LWD is present in this section where wood is being recruited as the channel expands (Photograph 8-2b). Several deep alcove pools are present along the margins of the channel, as well as pools that have scoured out at fallen LWD and root masses of standing trees. Some short sections of riprap were observed within this portion of the channel at RM 24.8 and 24.6. At RM 24.6, the river flowed through the riprap into a low area on the opposite side.



Photograph 8-2b

An unconfined, aggrading section of the channel near RM 24.5

Between RM 24.2 and 23.65, the river is characterized as a highly dynamic, meandering, forced pool-riffle channel. The channel has multiple secondary flow paths and side channels and contains many deep pools at LWD and along the outside of meander bends (Photograph 8-2c). Remnant alluvial fans and terraces that are relatively resistant to erosion compared to the recent alluvium in the active channel create tight bends in the channel planform. A pump and short armored levee are located along the left bank at approximately RM 23.8.



Photograph 8-2c

A deep pool and recruited tree along the outside of a meander bend near RM 24.1

Instream habitat conditions in the main channel are generally good in the dynamic portions of the channel, due to the presence of large recruited LWD, active channel migration, and the availability of side channels. Ample deep holding pools are present at LWD and along eroding bends. The riffles formed between the pools and sediment deposits in the lee

provide good spawning areas. The alcoves and side channels are preferred habitat for juvenile fish, and several were observed using these areas during field observation. Some areas, such as between RM 25.25 to 25.1 and RM 24.8 and 24.4, are fairly exposed with poor shading.

The plane-bed and confined sections of the project area have limited complexity and, therefore, poor habitat quality. Deep pools are typically only present at rock weirs and fallen riprap boulders. The confined conditions of the channel likely result in high-velocity conditions during spring runoff and high flows that may scour redds and flush small fish downstream. These areas have very few off-channel areas for juvenile rearing and high-flow refuge. There is little LWD or other forms of cover.

8.2.1.2 Floodplain Characterization

Floodplain connectivity in this project area is relatively good in the complex sections and poor in the confined sections. Low-lying floodplain is disconnected throughout a majority of the confined reaches. The most significant of these areas include north of the channel near RM 26.2, which is currently a dry, cobble surface that supports little vegetation, and an forested area near RM 25.4 that contains dense patches of Himalayan blackberry, stinging nettle, and some wetland plants. Between RM 24.8 and 24.3, much of the irrigated field is at the low-lying floodplain elevation. Within this reach, the channel is aggrading and expanding into the edge of the field.

Throughout the project area, typical riparian trees include cottonwoods, alders, and locust trees, as well as willow and alder saplings. The width of the riparian corridor ranges from less than 50 feet to more than 500 feet. At the upstream end of the project area, the riparian zone is generally in poor health down to approximately RM 25.8. Some relatively mature trees are present that provide shade to the channel, but understory vegetation is sparse and lacks diversity along the long levee section. The low-lying floodplain adjacent to RM 26.2 is sparsely vegetated except by weedy species, including large patches of thistles and knapweed. The riparian corridor is wider, with denser vegetation and more mature trees between RM 25.8 and 24.8. The surfaces of the levees confining the channel near RM 25.5 are populated with weeds, including a large quantity of yellow starthistle and knapweed.

Willows planted amongst the armor rock line the edges of the channel. Between approximately RM 24.8 and 24.4, the riparian area is relatively narrow adjacent to the fields along the northeast side of the channel. Many dead or dying trees and sparse understory are characteristic of this area. The remainder of the project area has relatively dense understory and tree cover, with some locally exposed areas that abut fields such as at RM 23.9 and 23.7.

8.2.2 Conceptual Project Actions

Restoration actions for PA-26 involve a number of levee setbacks and removals, as well as LWD placement in the plane-bed sections of the channel downstream of Turner Road Bridge adjacent to significant levee removals. Throughout the area, setting back existing levees to the edge of the low-lying floodplain is recommended. Some of the levee setbacks would require modification of existing irrigation systems, including pump sites, access roads, and pivot systems. An adequate floodplain corridor width should be established throughout in order to minimize channel constriction that may cause adverse hydraulic conditions both through and downstream of the constricted portion of the channel.

8.2.2.1 Geomorphic Implications

In several sections of this project area, the channel is naturally recovering from historic modifications to establish a more complex channel configuration and depositional areas are located downstream of highly confined river segments. Setting back the levees that cause channel confinement is expected to initiate additional natural recovery in those areas. As the channel is able to migrate and expand, LWD will likely be recruited as the channel occupies areas of the low-lying floodplain. Decreased velocities by creating better floodplain connectivity will allow mobile LWD transported from upstream to be deposited and retained. Over time, channel processes will maintain a variety of hydraulic conditions and habitat elements.

8.2.2.2 Biological Benefits

In the confined reaches, immediate biological benefits of levee setback include decreased instream velocities during high flows from better connectivity with the floodplain. Channel migration through the low-lying floodplain areas will drive the formation and maintenance of habitat elements such as LWD recruitment, pools, and side channels. The availability of

ample and diverse habitats will increase the carrying capacity for juvenile salmonids and support habitat needs throughout the lifecycle. Greater floodplain connectivity will also lead to a healthier riparian zone and, in turn, drive many ecosystem processes.

8.2.2.3 Potential Challenges

In many levee setback areas, access will be difficult and will require disturbance to existing vegetation. Many of the levees are more than 50 years old and contain relatively large trees; these may be incorporated into setback revetments or placed in the channel. Many areas, in particular RM 24.8 to 24.5, are located adjacent to irrigated fields that contain only a small amount of confining infrastructure. In this location, it may be necessary to build a new length of levee or armor rather than only setting back the original material. Placement of this material will need to be carefully considered to prevent damage to the field as the channel evolves.

8.3 Project Area 27 (River Mile 23.65 to 22.85)

Project Area 27 (PA-27) is located within the active channel and floodplain from RM 23.65 to King Grade (RM 22.85).

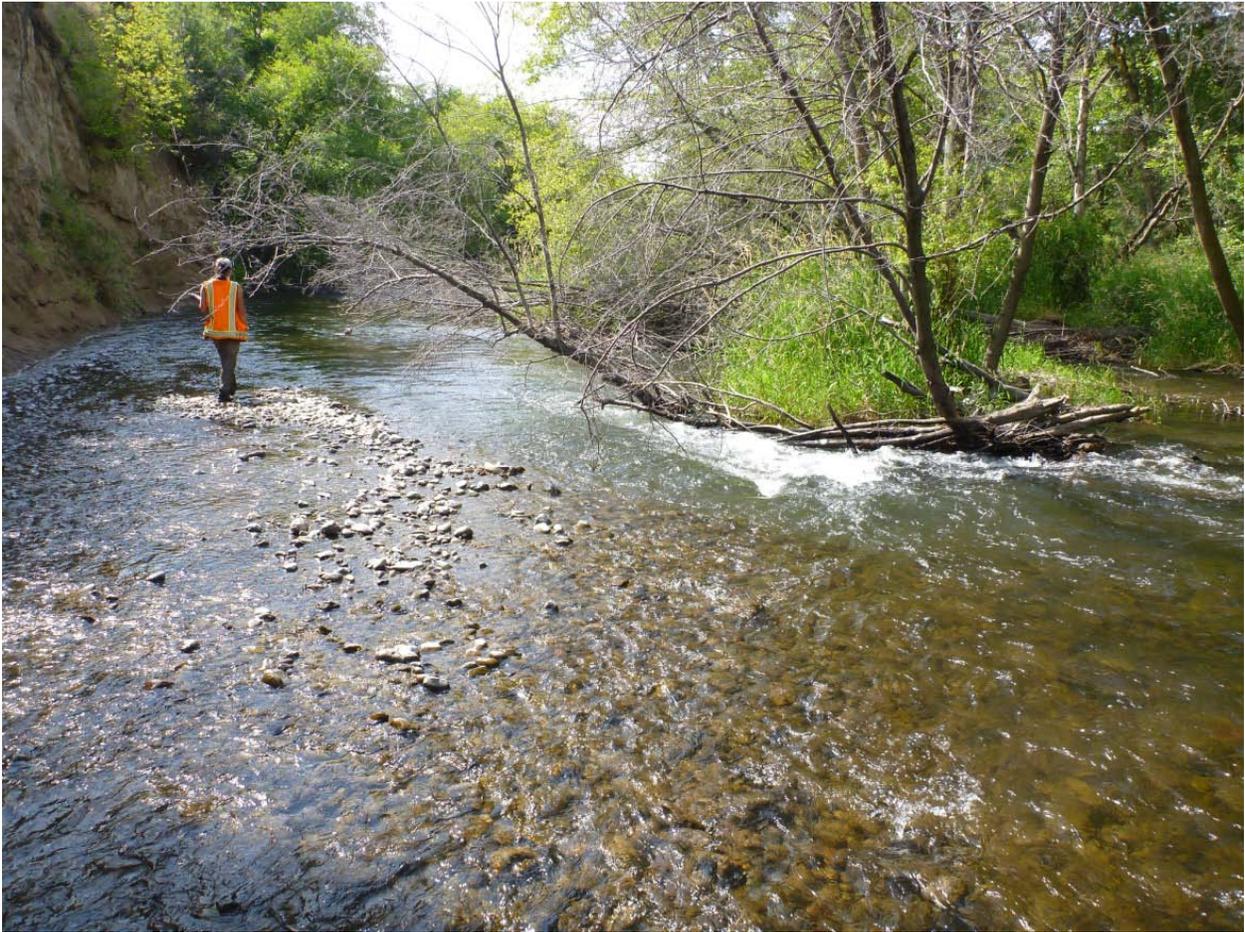
Table 8-3
Restoration Recommendations for Project Area 27

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Maintain natural channel and floodplain processes throughout the project area.
2. Reconnect isolated habitats	No significant isolated habitats would be directly modified in this project area.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove 270 feet and set back approximately 2,800 linear feet of bank armoring to allow the channel to evolve through the low floodplain.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout 0.25 river miles.

8.3.1 Site Description

8.3.1.1 Channel Characterization

The channel through PA-27 is characterized as a single-thread, plane-bed channel in the upper end of the project area between approximately RM 23.65 and 23.4. Downstream of RM 23.4, the river contains downed trees and resistant fine-grained banks that force deep pools and some small side channels (Photograph 8-3). One rock habitat structure along the right bank near RM 22.95 also created a deep pool. Some evidence of channel migration and expansion was observed, such as within the area shown in Photograph 8-3. Riprap and levees are located in some portions of the project area, along with possible historic spoil piles that could not be verified upon observation. Riprap along the left bank at the approach to King Grade results in a steep, straight channel bank that showed some signs of undercutting of the riprap and tree roots along the toe of the bank. The upstream end of the project area contained no available off-channel habitat at the time of observation. The middle to lower project area between RM 23.4 and King Grade contained some short sections of side channels and slow-moving backwater alcoves, such as at RM 23.25.



Photograph 8-3

A deep pool formed at a tree root and at a resistant bank near RM 23.1

The channel between RM 23.65 and 23.4 is wide and shallow with limited complexity. There is little LWD or pools available to provide holding habitat. No side channels were observed in this portion of the project area, limiting juvenile habitat to the margins of the channel, which contains little cover other than overhanging vegetation and a few fallen trees. Downstream of RM 23.4, several log jams and fallen trees with rootwads create deep pools that provide holding areas with cover. Some secondary flow paths, side channels, and alcoves are available that provide a moderate amount of juvenile rearing habitat and high-flow refuge.

8.3.1.2 Floodplain Characterization

Floodplain connectivity is moderate to good. Between RM 23.65 and 23.4, the channel is somewhat confined to the south side of the valley with a steep right bank that lies several feet above the channel grade. There is a large area of low-lying floodplain in the project area, particularly downstream of RM 23.4. Much of this area is forested, although some of the field and grassy area within the Conservation Restoration Easement Program (CREP) boundary between RM 23.4 and 23.1 is within this area. Several flow paths are located throughout the floodplain; some of these areas contain stagnant or slow-moving water that is disconnected from the channel.

The riparian zone is in moderately good health. Some patches of sparse understory and grassy areas without tree cover are present. Riparian trees are predominantly deciduous species, including dogwoods, alders, and cottonwoods. The understory is sparse in much of the project area, containing mostly reed canarygrass, blackberry vines, and other groundcover. Between RM 23.4 and 23.25, the riparian zone becomes very narrow. A wetland area on the right bank between RM 23.5 and RM 23.3 has ample shading provided by woody plants and cattails. The water is slow-moving and covered with duckweed, and juvenile salmonids were observed in the pool.

8.3.2 Conceptual Project Actions

Restoration actions for PA-27 involve improving channel complexity by removing levees and armoring and placing LWD. LWD would be placed within the plane-bed section of the project area between RM 23.65 to 23.4, in addition to grading the steep bank to a shallower slope. Armoring at RM 23.4 and 23.25 would be removed where it is impairing channel migration. Setback levees are recommended along the edge of the low pathways in the floodplain or to the edge of the CREP boundary to create a consistent, wide corridor for floodplain connectivity and channel migration to occur. Long-term planning should consider replacement of the bridge at King Grade with a longer-spanning and higher elevation bridge that would allow for better conveyance of floodwaters, sediment, and LWD, as well as the allow the channel to migrate across the low floodplain.

8.3.2.1 *Geomorphic Implications*

Setting back confining infrastructure will allow the channel to migrate into the low floodplain and promote continued natural process recovery that is ongoing in the downstream portion of the project area. As the channel continues to migrate and expand, LWD will continue to be recruited, creating additional side channels, pools, and deposition of sediment. Over time, channel processes will maintain a variety of hydraulic conditions and habitat elements. Addition of LWD in the plane-bed section of the channel will initiate this geomorphic response where the channel currently lacks complexity, resulting in bed scour and sorting of sediment, which form critical habitat features (e.g., pools, cover, and spawning gravels). The LWD will diversify the thalweg to create more complex hydraulic conditions in the channel. Over time, LWD will promote retention of bedload sediment and building up of the channel bed, which may create better connectivity to the adjacent floodplain.

8.3.2.2 *Biological Benefits*

Adding complexity to the plane-bed section of the channel will provide hydraulic diversity and refuge in the mainstem, improving instream habitat conditions. Increased hydraulic diversity will provide high-flow refuge and low-flow cover for juveniles, and pools will scour out at the structures for use during adult holding. The structures will also increase sediment retention, enhancing the size and quality of spawning areas. In the long term, ELJs will promote channel complexity by splitting flow and encouraging natural processes, driving the formation of habitat elements such as pools and side channels. The diversification of habitats will increase the carrying capacity of juvenile salmonids. In the downstream end of the project area, removing infrastructure will allow the channel to continue migrating and creating habitat features such as side channels and pools. Easing confinement will decrease instream velocities, improving mainstem hydraulic conditions during high flows.

8.3.2.3 *Potential Challenges*

The floodplain adjacent to the LWD placement area is heavily forested and some disturbance of existing vegetation is likely required to gain access to the placement locations. This project will require the cooperation of adjacent landowners. Future channel migration and its effect on the bridge crossing should be evaluated during the design process.

8.4 Project Area 28 (River Mile 22.85 to 20.0)

Project Area 28 (PA-28) is located within the active channel and floodplain from King Grade (RM 22.85) to RM 20.0.

Table 8-4
Restoration Recommendations for Project Area 28

Restoration Framework Actions	Project Recommendations
1. Protect and maintain natural processes	Protect natural channel and floodplain processes through RM 22.8 to 22.1 and RM 21.7 to 20.5.
2. Reconnect isolated habitats	Reconnect a former side channel near RM 21.8.
3. Address roads, levees, and other anthropogenic infrastructure impairing processes	Remove approximately 660 linear feet of riprap and levees in three locations to re-establish floodplain connectivity and allow channel evolution through 22 acres of low floodplain.
4. Restore riparian processes	Restore riparian areas as needed when associated with other restoration actions in the project area.
5. Improve instream habitat conditions	Place LWD throughout approximately 0.2 river miles of plane-bed channel.

8.4.1 Site Description

8.4.1.1 Channel Characterization

The channel through PA-28 contains primarily a dynamic, multiple-thread channel with forced pools, riffles, and rapid sections (Photograph 8-4a). Some portions of the project area contain a relatively straight and single-thread channel with little complexity; these areas are typically influenced by the presence of infrastructure. From King Grade to RM 22.1, the channel is actively migrating and aggrading. Several recently recruited trees and newly formed side channels were observed throughout this area, along with a high volume of temporary sediment storage in the form of gravel point bars and islands. Deep pools were observed at rootwad logs, larger log jams, and along the outside of meander bends. One ELJ was observed at RM 22.6 that contained a very large pool and ample cover that many fish were utilizing. This section of the project area did not contain any significant bank armoring, but some remnant spoil piles or pushup levees were present in the floodplain.

However, these did not appear to significantly impair channel migration or floodplain connectivity.



Photograph 8-4a
Forced pools and riffles near RM 22.5

Between RM 22.7 and 21.1, the channel is confined by infrastructure along both banks. The right bank is lined with riprap and large rock barbs with deep scour pools. The left bank is along the toe of a relatively resistant alluvial fan that transitions to a spoil-pile levee and riprap between RM 21.85 and 21.75. This feature disconnects the channel from a low-lying area that is currently occupied by a large beaver complex. Within this area, the channel is straight and the thalweg meanders around the rock structures. A ford is located at approximately RM 21.9; it is unclear if this crossing is still used.

Between RM 21.7 and 20.35, the river transitions back to a dynamic channel with signs of aggradation and migration throughout. A relatively recent channel avulsion was observed at RM 21.4 that resulted in the main channel flowing adjacent to an open field for approximately 1,000 feet (Photograph 8-4b). Bank armoring and spoil piles are present throughout this section. Some of this infrastructure influences channel process, but many have been damaged and mobilized by channel migration. The most significant infrastructure that affects the channel is located along the right bank adjacent to the field between RM 21.0 and 20.9, as well as an armored levee along the left bank that is associated with a power line crossing at RM 20.6.



Photograph 8-4b

A recent avulsion of the main channel to a position adjacent to an agricultural field near RM 21.35

The channel between RM 20.35 and 20.0 is relatively straight with a wide, plane-bed section with multiple rapid sections created by bedrock in the channel. The rock weir located at RM 20.35 and the bedrock in the channel throughout much of the remainder of the project area hold the channel grade. Between RM 20.15 and 20.1, the channel is located through a knob of bedrock (Photograph 8-4c); this likely was the result of a historic management action to place the channel against the valley wall because of the multiple-channel pathways that are located through the floodplain north of the bedrock. A levee is located off the downstream end of the bedrock between RM 20.1 and 20.05. A steep drop in the channel grade at a bedrock protrusion is present adjacent to the levee.



Photograph 8-4c

Bedrock in the channel and along the right bank where the channel flows through a bedrock knob near RM 20.15

Instream habitat conditions are generally good in the dynamic portions of the project area where the channel is in a recovery state. Channel migration has recruited a significant amount of LWD in several areas and there are many side channels with various hydraulic conditions. Ample deep holding pools are present at LWD and along eroding bends. The riffles formed between the pools and the sediment deposits in the lee of LWD and on point bars provide good spawning areas. The many alcoves and side channels observed are preferred habitat for juvenile fish.

Some areas, such as between RM 25.25 to 25.1, and RM 24.8 and 24.4, are fairly exposed with poor shading. The shorter sections of plane-bed and confined channel have relatively poor habitat conditions. Between RM 22.0 and 21.75, the rock structures provide deep holding pools, but no off-channel habitat is available for juvenile rearing or high-flow refuge. The plane-bed section between RM 20.35 and 20.2 is wide and shallow with a lack of deep pools, side channels, or adequate cover. In some areas, the banks are degraded by cattle grazing where the livestock are not fenced off from the river.

8.4.1.2 Floodplain Characterization

The project area contains a wide, low-lying floodplain area that takes up much of the valley bottom in several areas. Between King Grade and RM 22.0, the width of the low-lying floodplain is dictated by alluvial fan and hillslope deposits. Some of the field north of the river between King Grade and RM 22.3 is located at a relatively low elevation. Between RM 22.0 and 21.75 the valley is naturally confined between an alluvial fan deposits and the bedrock formation on the south side of the valley. Several flow paths are located throughout the project area in the low-lying floodplain areas with various levels of connectivity, including a flowing hyporheic connection, frequently-accessed overbank flow paths, and dry areas with poor or infrequent connectivity.

In some locations, infrastructure restricts connectivity to the low-lying floodplain. Along the left bank from RM 21.85 to 21.75, the existing infrastructure disconnects the channel from a former channel path on the downstream side. A large levee in the left floodplain near RM 20.5 disconnects the low-lying floodplain on the far north side of the valley where a former ditch is located. The sparsely vegetated portion of the riparian zone between this low

area of the floodplain and the main channel (RM 20.5 to 20.1) was formerly used for agriculture but is currently within the CREP. A short section of spoils or levee in the left floodplain at RM 20.25 affects connectivity to the floodplain north of the bedrock knob section.

Throughout this large project area, the condition of the riparian zone is variable. Within much of the area, riparian conditions appear to be recovering over the last several decades as more of the corridor is protected within easements. Riparian trees are predominantly dogwood, cottonwood, big-leafed maple, and alder. Many areas have sparse understory that is dominated by reed canarygrass and other groundcover; cattle grazing activities appeared to be occurring in many of these areas. In other areas, there was a dense understory but it was dominated by two or three species. Some patches of dying trees were observed, but several areas of regeneration were also present where the channel was unconfined and had good connectivity to the floodplain.

Between RM 22.0 and 21.7, the riparian zone is restricted to a narrow buffer of approximately 50 feet on either side of the channel. Willows have been planted through this section but the channel is largely exposed. From approximately RM 21.4 to 20.9, there is little to no vegetation along the right bank where the channel flows adjacent to an open field. The field creates a large gap in the riparian buffer along the right bank of the channel. The channel is particularly open and exposed between RM 20.35 and 20.2. Little vegetation exists along the bedrock that composes much the right bank in this area. The bedrock knob and levee is populated with many weedy plants dominated by yellow starthistle.

8.4.2 Conceptual Project Actions

Restoration actions for PA-28 include selective levee removals and LWD placement. Because much of the area is in a recovery state and is heavily forested with difficult access to the river, it is recommended that protection be a high priority for this project area. Removing or breaching the levee along the left bank levee at RM 21.8 to reconnect the former mainstem channel pathway, and removing the levee in the north floodplain near RM 20.5 are proposed. Upstream of the bedrock knob, removing the spoil pile at RM 20.25 will allow better connectivity and future channel migration through the north floodplain. LWD

placements are recommended in the shallow and exposed section between RM 20.35 and 20.2, where cover is limited. In the rest of the area, it is assumed that wood currently being recruited in the dynamic portions of the channel will be distributed through any sections lacking LWD. In addition, repairs or upgrades to fencing should be made along the right bank to prevent cattle access to the river.

8.4.2.1 *Geomorphic Implications*

Setting back the proposed infrastructure will allow long-term channel migration to occur throughout much larger areas of low-lying floodplain. Better floodplain connectivity with these areas will promote continued recovery of the riparian zone. Addition of LWD in the short plane-bed section of the channel will create bed scour and sorting of sediment to form hydraulic complexity. The LWD will diversify the thalweg to create more complex hydraulic conditions in the channel. Over time, LWD will promote retention of bedload sediment, which may create better connectivity to the channels through the north floodplain. In the protection areas, geomorphic processes that are occurring are expected to continue developing increased channel complexity and recovery over time.

8.4.2.2 *Biological Benefits*

Removing the proposed infrastructure will allow the channel to continue migrating and creating complex habitat features, such as side channels and pools. Increased floodplain connectivity in the long term will contribute to recovery of a riparian zone that will in turn drive many ecosystem processes. At the downstream end of the project area, adding complexity to the plane-bed section of the channel will provide hydraulic diversity and refuge where it is currently shallow and exposed. This complexity will provide high-flow refuge and low-flow cover for juveniles. Additionally, pools will scour out at the structures for use during adult holding. Protecting a majority of the project area will prevent any disruption of existing natural processes and valuable habitat.

8.4.2.3 *Potential Challenges*

Access to the levee at RM 21.8 can likely be gained across the existing ford, but will require crossing the channel. Access to the lower end of the channel is expected to be relatively simple through the open fields between the road and the river. As the channel gains better

connectivity through the floodplain north of the bedrock knob, it may be necessary to protect the irrigated field downstream of this area with a levee or armoring.

9 PROJECT EVALUATION

Projects were evaluated and placed into implementation tiers based on four criteria: expected biological response, consistency with natural processes, benefit-to-cost, and reach priority. Biologic and geomorphic criteria were assigned qualitative values of high, moderate, or low value and benefit-to-cost was given a qualitative ratio using high, moderate, or low values. Reaches were prioritized into three levels of relative importance. The following sections of this report describe the prioritization criteria and process. As projects are implemented, it may be appropriate to revisit projects and re-evaluate tier levels. This evaluation does not consider feasibility in terms of landowner willingness to participate. The information presented in this report is intended to provide an objective look at the conceptual projects that would most benefit target species based on biological benefit and physical effects.

9.1 Evaluation Criteria

9.1.1 *Expected Biologic Response*

The expected biological benefit was scored based on the expected magnitude of benefits and the likelihood that project objectives would be met. Those projects that most directly address limiting factors and critical life stages, while creating the greatest volume of quantifiable habitat, received the highest scoring. The diversity of existing habitat and the functionality of the existing and proposed habitat during target life stages were included in the evaluation. The juvenile life history stage (egg to parr) was identified as critical to improving spring Chinook populations in the Tucannon River. In particular, the persistent lack of adequate juvenile rearing habitat during winter and spring runoff (post-emergence to parr), bed scour during stochastic winter/spring flows, and summer water temperature have been identified as limiting to juvenile populations. Therefore, projects that improve the quality and quantity of juvenile habitat during these periods or create rearing habitat in areas where it does not currently exist received a higher rating.

The expected biologic response of each project was evaluated within the following categories:

- Provides immediate habitat benefits for critical life history stages

- Reconnects isolated habitats or improves existing habitats and promotes floodplain connectivity
- Provides diversity throughout the active channel and low-lying floodplain for all life history stages

9.1.2 Consistency with Natural Geomorphic Process

Natural geomorphic processes are the primary factor in creating and maintaining high-quality habitat in properly functioning rivers and streams. Designing for geomorphic process or removing inhibitors to geomorphic processes are important considerations in project prioritization. The sustainability and functionality of the project is highly dependent on consistency with geomorphic processes, and it is the restoration of these processes that will create and maintain habitat features in the long term. The projects that are expected to most effectively address the rehabilitation of natural processes will receive the highest qualitative rating.

For each project, consistency with natural geomorphic processes was evaluated within the following categories:

- Removes stressors that promote habitat degradation or inhibit natural channel and floodplain processes
- Promotes reach-scale geomorphic response consistent with natural processes
- Promotes the retention of LWD and sediment and forces pool-riffle morphology and complex channel planform

9.1.3 Benefit-to-Cost Ratio

A qualitative evaluation of the magnitude of biological and physical benefits of the project was determined, as was a rough opinion of the probable implementation cost. The result of this estimate is a qualitative ranking of the benefit-to-cost ratio. Those projects that achieve the greatest benefit for the least amount of money received the highest ratings. This criterion also considers whether the benefit is achieved on a short-term or long-term timeline.

9.1.4 Reach Priority

Reaches were prioritized using a variety of biologic and physical data (Table 9-1). High priority was given to reaches where existing fish use is high and the restoration potential has also been determined to be high. Physical characteristics included the area of low-lying floodplain, the amount of disconnected low-lying floodplain, and the percent of the reach that is a gaining reach versus a losing reach. Biological data included redd surveys (Gallinat and Ross 2010) and juvenile distribution (SRSRB 2006) that provide a relative density of spawning and juvenile presence in each reach.

Table 9-1
Summary of Physical Reach Characteristics, Reaches 6 to 10

Reach	Length (mi)	Low-lying Floodplain Area (acres)	Low Floodplain per River Mile (acres/mi)	Degree of Confinement (%)			Disconnected Low Floodplain (acres/RM)	Groundwater Input	
				Confined	Moderate	Unconfined		Gaining	Losing
10	6.2	135	22	24%	76%	0%	4.2	79%	21%
9	4	128	32	0%	51%	50%	1.3	8%	92%
8	7.9	247	31	11%	82%	8%	10.5	22%	78%
7	4.6	130	28	52%	48%	0%	12.2	0%	100%
6	7.5	454	61	5%	68%	28%	15.5	36%	64%

Table 9-2
Summary of Biological Reach Characteristics, Reaches 6 to 10

Reach	Length (mi)	Spawning Use (redds/RM)	Spawning Presence (qualitative)	Juvenile Density (per/100 m ²)	Juvenile Presence (qualitative)
10	6.2	7.7	Med	9.0/3.3	Med
9	4	7.7	High	9.0	High
8	7.9	5.2	High	11.9	High
7	4.6	2.7	Med	8.5	High
6	7.5	0.2	Low	8.5/3.3	Low-med

Sources: Spawning data from Gallinat and Ross (2010). Juvenile data from SRSRB (2006).

Four of the above characteristics were chosen to collectively represent the relative restoration potential of the reaches and achieve watershed-scale restoration objectives:

- **Available low-lying floodplain:** The total amount of low-lying floodplain within the reach represents the maximum habitat that could be available if a “full build-out” condition with respect to restoration actions were realized. Hence, those reaches with naturally wider low-lying floodplain areas were scored higher than reaches with floodplains that are higher and naturally confined. Low-lying floodplain was calculated by determining an average height of the 5-year flood elevation within each reach using the basin-scale hydraulic model (Anchor QEA 2011). This elevation value was projected out across the LiDAR surface to create a floodplain polygon. These areas were then calculated for each reach and compared to the length of the reach in RM. The low-lying floodplain area was refined and updated from the values presented in the *Geomorphic Assessment* (Anchor QEA 2011).
- **Disconnected low-lying floodplain:** The potential for additional floodplain connection is represented by the relative amount of disconnected low-lying floodplain in a reach. The channel alignment was broken out into sections that are disconnected from the low-lying floodplain by infrastructure and sections that are not influenced by infrastructure. A percent length within each category was calculated and compared to acres of available low-lying floodplain per RM as described above. These values were refined and updated from the values presented in the *Geomorphic Assessment* (Anchor QEA 2011); revisions were based on field observations and refined spatial analysis.
- **Distribution of spring Chinook spawning areas:** Redd distribution for spring Chinook, as presented in Gallinat and Ross (2010), was compared to the Tucannon River geomorphic reaches. A relative weight was assigned to each reach to represent the density of existing spawning.
- **Distribution of spring Chinook juveniles:** Estimates of juvenile Chinook distribution for spring Chinook, as presented in the *Snake River Salmon Recovery Plan* (2006), was compared to the Tucannon River geomorphic reaches. A relative weight was assigned to each reach to represent the density of existing juvenile use.

Based on the quantitative values shown in Tables 9-1 and 9-2, the reaches were assigned a relative value between 1 and 5 for each of the four criteria above. The higher values

represent a greater potential for restoration benefit. Low-lying floodplain was assumed to be slightly less beneficial in the near-term relative to the presence of spring Chinook in a reach. Therefore, the physical and biological values were weighted at 40 percent and 60 percent, respectively; Table 9-3 summarizes these values and provides the reach priorities. This methodology resulted in Reaches 8 and 9 having the highest priority. These reaches have high fish use and a large area of low-lying floodplain per mile. Reaches 6 and 7 are in the second priority category, primarily because of a lower fish presence. Reach 10 had a lower priority value primarily because there are fewer juvenile fish and less low-lying floodplain.

Table 9-3
Ranked Reach Characteristic Values to Determine Reach Priority, Reaches 6 to 10

Reach	Physical Characteristics <i>weight = 40%</i>		Biological Characteristics <i>weight = 60%</i>		Total	Weighted Total	Reach Priority
	Low-lying Floodplain	Disconnected Low-lying Floodplain	Relative Spring Chinook Spawning Use	Relative Spring Chinook Juvenile Rearing Use			
10	1	1	5	3	10	5.6	P3
9	3	1	5	4	13	7.0	P1
8	3	3	4	5	15	7.8	P1
7	2	4	3	4	13	6.6	P2
6	5	5	1	3	14	6.4	P2

Note: Relative values between 1 and 5 are based on the quantities provided in Tables 9-1 and 9-2

9.2 Project Prioritization

Table 9-4 summarizes the ratings assigned to each project within the four evaluation criteria categories: Expected Biologic Response, Consistency with Natural Geomorphic Processes, Benefit-to-Cost Ratio, and Reach Priority. Table 9-5 provides the relevant quantities of reconnected floodplain area, levee removals, and other project actions that were considered in developing the qualitative ranking for each project. This information was used to place each project within one of three tier levels that reflect the relative priority of project implementation. The following sections describe the general attributes of each tier level and how the tier levels should be considered within the overall restoration planning process, as well as providing the tier level of the 28 conceptual projects.

**Table 9-4
Project Prioritization**

Project	Reach	Expected Biologic Response			Consistency with Natural Geomorphic Processes			Benefit-to-Cost Ratio		Reach Priority
		Provides immediate benefit for critical life history stages	Reconnects or enhances off-channel habitat; promotes floodplain connectivity	Promotes diversity throughout the active channel and low-lying floodplain	Removes stressors that promote degradation or inhibit natural channel processes	Promotes reach-scale geomorphic response consistent with natural process	Promotes retention of LWD and sediment; forces pool-riffle morphology and complex planform	Magnitude of benefit vs. cost of implementation	Timeline for achieving benefit	Long-term potential value for restoration in the reach
1	10	H	M	M	L	H	H	M/M	H	P3
2	10	H	H	M	L	L	L	H/L	H	P3
3	10	H	L	M	L	H	H	M/M	H	P3
4	10	M	M	M	H	M	L	M/M	H	P3
5	10	L	H	H	M	M	L	M/H	M	P3
6	10	L	M	M	M	M	L	M/H	M	P3
7	10	H	L	M	M	M	H	M/H	M	P3
8	10	M	M	M	M	M	M	M/L	H	P3
9	10	M	L	M	L	L	H	M/M	M	P3
10	9	H	M	H	L	H	H	M/M	M	P1
11	9	H	M	M	L	M	H	M/M	H	P1
12	9	H	L	L	L	L	L	L/L	H	P1
13	8	H	M	H	H	H	H	H/M	H	P1
14	8	H	M	M	L	M	H	M/M	M	P1
15	8	H	M	M	M	M	H	M/L	H	P1
16	8	L	M	M	L	L	L	L/L	H	P1
17	8	H	M	M	H	M	H	M/H	H	P1
18	8	M	M	M	L	L	M	M/L	M	P1
19	7	M	M	M	M	M	M	M/H	H	P2
20	7	L	L	M	L	L	L	L/L	L	P2
21	7	H	L	M	L	M	M	M/M	M	P2
22	7	H	M	M	M	M	M	M/M	H	P2
23	7	H	M	M	M	M	M	M/M	H	P2

Project	Reach	Expected Biologic Response			Consistency with Natural Geomorphic Processes			Benefit-to-Cost Ratio		Reach Priority
		Provides immediate benefit for critical life history stages	Reconnects or enhances off-channel habitat; promotes floodplain connectivity	Promotes diversity throughout the active channel and low-lying floodplain	Removes stressors that promote degradation or inhibit natural channel processes	Promotes reach-scale geomorphic response consistent with natural process	Promotes retention of LWD and sediment; forces pool-riffle morphology and complex planform	Magnitude of benefit vs. cost of implementation	Timeline for achieving benefit	Long-term potential value for restoration in the reach
24	7	H	M	M	H	H	H	M/M	H	P2
25	6	L	L	M	L	L	M	L/L	H	P2
26	6	H	H	H	H	H	H	H/H	H	P2
27	6	M	M	M	L	M	M	M/L	H	P2
28	6	L	M	L	M	M	L	M/L	H	P2

Table 9-5
Approximate Physical and Habitat Quantities for Conceptual Projects

Reach	Project Area	RM		Project Actions (in ft)								Reconnected Low Floodplain (in acres)	Riparian Enhancement (in acres)	Protection Area
				LWD Addition	Levees/Riprap		Side Channels			Roads				
					Remove	Set Back	Enhance	New	Reconnect	Remove	Realign			
10	1	50	48.9	6713.64	-	-	-	-	-	-	-	-	-	-
	2	49.1	48.65	1097.31	-	-	1412.08	202.79	-	-	-	-	-	-
	3	48.65	46.8	6907.95	377.11	-	-	-	-	-	-	0.59	-	-
	4	46.8	46.4	2385.57	1190.66	1028.47 ^a	1968.88	256.37	821.86	-	-	1.63	-	-
	5	46.4	45.95	2459.74	988.02	95.05	-	-	-	2326.92	-	10.73	-	-
	6	45.95	45.3	1134.14	144.86	-	-	-	-	-	-	-	-	RM 45.3-45.7
	7	45.3	44.85	2443.23	337.29	-	-	-	-	2706.46	2467.63	-	-	-
	8	44.85	44.4	1504.17	684.07	329.13	445.28	-	545.71	-	-	1.01	-	-
	9	44.4	44	2969.59	2563.46	-	-	-	-	-	-	-	-	-
9	10	44	42.4	8173.62	1304.93	-	-	-	-	-	-	5.83	39.37	-
	11	42.3	40.7	9716.34	1108.07	-	-	-	-	1539.64	652.09	1.43	39.79	-
	12	40.7	40	1965.14	-	-	-	-	-	-	-	-	17.81	RM 40.0-40.7
8	13	40	39.2	3555.66	3191.74	758.96	-	-	-	-	-	3.91	-	-
	14	39.2	37.15	10309.25	162.26	-	-	-	-	-	-	17.77	-	-
	15	37.15	36.35	4027.30	864.80	-	-	-	-	-	-	-	-	-
	16	36.35	34.9	1708.14	524.03	-	-	1118.20	-	-	-	4.59	-	-
	17	34.9	34.3	2935.69	706.19	-	1614.14	-	-	663.92	724.17	2.25	17.26	-
	18	34.3	32.1	3558.36	-	-	-	-	-	-	-	-	-	RM 33.65-34.3, 32.1-33.1
7	19	32.1	31.8	1432.45	639.32	-	-	-	-	-	-	-	-	-
	20	31.8	31.5	-	-	-	-	-	-	-	-	-	-	RM 31.5-31.8
	21	31.5	30.3	5976.68	1742.74	2551.07	-	-	-	-	-	0.59	-	-
	22	30.3	29.3	5338.39	2945.17	193.14	-	-	-	-	-	2.45	-	-
	23	29.3	28.25	5059.00	2159.49	888.67	-	-	-	-	-	9.48	-	-
	24	28.25	27.5	3972.34	2532.41	2924.26	-	-	-	-	-	1.32	-	-
6	25	27.5	26.9	1177.05	-	-	-	-	-	-	-	-	-	RM 27.15-27.5
	26	26.9	23.65	9578.38	8304.91	12217.65	-	-	-	-	-	29.26	-	-
	27	23.65	22.85	1256.78	265.91	2819.50	-	-	-	-	-	-	-	-
	28	22.85	20	1037.01	657.03	-	-	-	-	-	-	22.12	-	RM 20.5-21.7, 22.1-22.8

^a The levee set back calculation includes the road realignment; this section of road is located on top of the levee embankment

9.2.1 Tier 1 Projects

Tier 1 projects are those projects that should be considered for early implementation within basin restoration planning. In general, the actions recommended in these projects are expected to provide an immediate biological response for the identified critical life history stages within a relatively large area of impact. Nine Tier 1 projects were identified, with six of the projects in the high-priority reaches (Table 9-6).

Table 9-6
Tier 1 Projects

Project	Reach	River Miles	Description
2	10	49.1 to 48.65	The minor amount of earthwork required to achieve enhanced flow to a significant length of off-channel habitat results in a substantial benefit-to-cost ratio.
10	9	44.0 to 42.4	Adding LWD through the incised and simplified channel in this project area results in a high benefit to both instream habitat and physical processes long term.
11	9	42.3 to 40.7	This project removes important stressors and adds LWD to a confined portion of the channel that lacks complexity and cover, resulting in a high expected benefit within one of the high-priority reaches.
13	8	40.0 to 39.2	This project is expected to provide a high biological benefit for a moderate cost in a section of a P1 reach where the river is tightly confined and simplified by infrastructure and channel modification.
14	8	39.2 to 37.15	This project adds LWD and increases floodplain connectivity for a moderate cost.
15	8	37.15 to 36.35	The cost of implementing this project is relatively low and would increase channel complexity and floodplain connectivity within a high-priority reach.
17	8	34.9 to 34.3	Although the cost of this project is relatively high, biological and physical benefits are expected in a degraded section of the river within a high-priority reach.
24	7	28.25 to 27.5	This project will significantly increase the width of the floodplain corridor and promote increased channel complexity for a moderate implementation cost.
26	6	26.9 to 23.65	Removing the levees that confine much of this project area is expected to have a high biological and physical benefit.

9.2.2 Tier 2 Projects

Tier 2 projects are moderate- to high-priority projects that should be considered for strategic implementation as funding and other opportunities arise. These projects are expected to achieve relatively high biologic and physical benefits for target life stages; however, it may take time for the benefits to be fully realized or achieving the results may be contingent upon other actions or have potential challenges that have been identified by local stakeholders. Ten Tier 2 projects were identified that are primarily located within the second and third priority reaches (Table 9-7).

Table 9-7
Tier 2 Projects

Project	Reach	River Miles	Description
1	10	50.0 to 48.9	This project will add LWD throughout an area that lacks cover and hydraulic complexity.
3	10	48.65 to 46.8	This project will add LWD and remove unnecessary bank armoring through this project area, creating instream complexity and promoting natural processes.
4	10	46.8 to 46.4	This project will significantly reduce channel confinement for a moderate cost of implementation.
5	10	46.4 to 45.95	Removing the road through the floodplain will approximately double the width of the floodplain corridor for a relatively high cost.
7	10	45.3 to 44.85	Adding LWD to the channel will provide immediate benefits to critical life stages and, with road relocation, would promote natural processes to reverse the incised channel conditions over time. However, the cost of implementation would be high.
8	10	44.4 to 44.0	The cost of this project is relatively low and will approximately double the floodplain width and create instream complexity.
18	8	34.3 to 32.1	This relatively small project is expected to have moderate biological benefits for a low cost of implementation and is located in a priority reach.
21	7	31.5 to 30.3	This project will add LWD and remove stressors within this incised and plane-bed section of the channel that lacks cover and complexity.
22	7	30.3 to 29.3	This project will reduce channel confinement and promote channel complexity and wood retention in a second priority reach.
23	7	29.3 to 28.75	This project will promote natural processes by significantly increasing floodplain connectivity, and will create immediate instream habitat by adding LWD to the channel.

9.2.3 Tier 3 Projects

The Tier 3 group represents those projects that are appropriate for long-term strategic implementation. The biological and physical response may have less impact or be less certain, or the expected benefit of the project is low compared to the relative cost. Achieving the full benefits of a Tier 3 project may depend on implementing other actions, or it may take place on a relatively long time scale. Nine Tier 3 projects were identified throughout the area of study (Table 9-8). Four of the projects are expected to have a low biological benefit. However, the proposed restoration actions would require a low implementation cost. Alternately, those areas where protection (no action) is proposed received lower ranking than active restoration projects and were ranked as Tier 3 projects. These naturally recovering areas currently provide good biological and physical benefits, but this was not necessary reflected in the prioritization process.

Table 9-8
Tier 3 Projects

Project	Reach	River Miles	Description
6	10	45.95 to 45.3	Although removing the campground is expected to have an overall moderate benefit, the implementation cost may be high and immediate biological benefit is low.
9	10	44.4 to 44.0	Existing habitat and physical conditions in this section of the river are moderate. Lake removal is not expected to have significant impact to existing floodplain processes or critical life stages.
12	9	40.7 to 40.0	This project involves a small amount of active restoration (LWD placement) and is not expected to result in significant benefits or geomorphic response.
16	8	36.35 to 34.9	The high concentration of private homes through this project area greatly limits the possibilities for restoration without incurring risk. The proposed restoration actions are not extensive enough to have significant impacts to natural processes, but they would provide some amount of biologic benefit.
19	7	32.1 to 31.8	This project is expected to have moderate benefit in a second priority reach. However, replacing the bridge will likely involve a long-term effort.
20	7	31.8 to 31.5	This project involves passive restoration efforts and did not rank high in the prioritization process. However, some biological benefit to water quality and the riparian vegetation can be achieved with little effort and low cost.

Project	Reach	River Miles	Description
25	6	27.5 to 26.9	This project involves a small amount of active restoration (LWD placement) and is not expected to result in significant benefits or geomorphic response.
27	6	23.65 to 22.85	Existing habitat conditions are moderate or actively recovering throughout much of the project area. The small amount of proposed restoration actions is expected to have a moderate benefit and low cost.
28	6	22.85 to 20.0	The recommendation for a majority of this project area is protection of recovering sections of the channel. The small amount of active restoration will have a moderate biological response for a relatively low cost of implementation.

10 LIMITATIONS

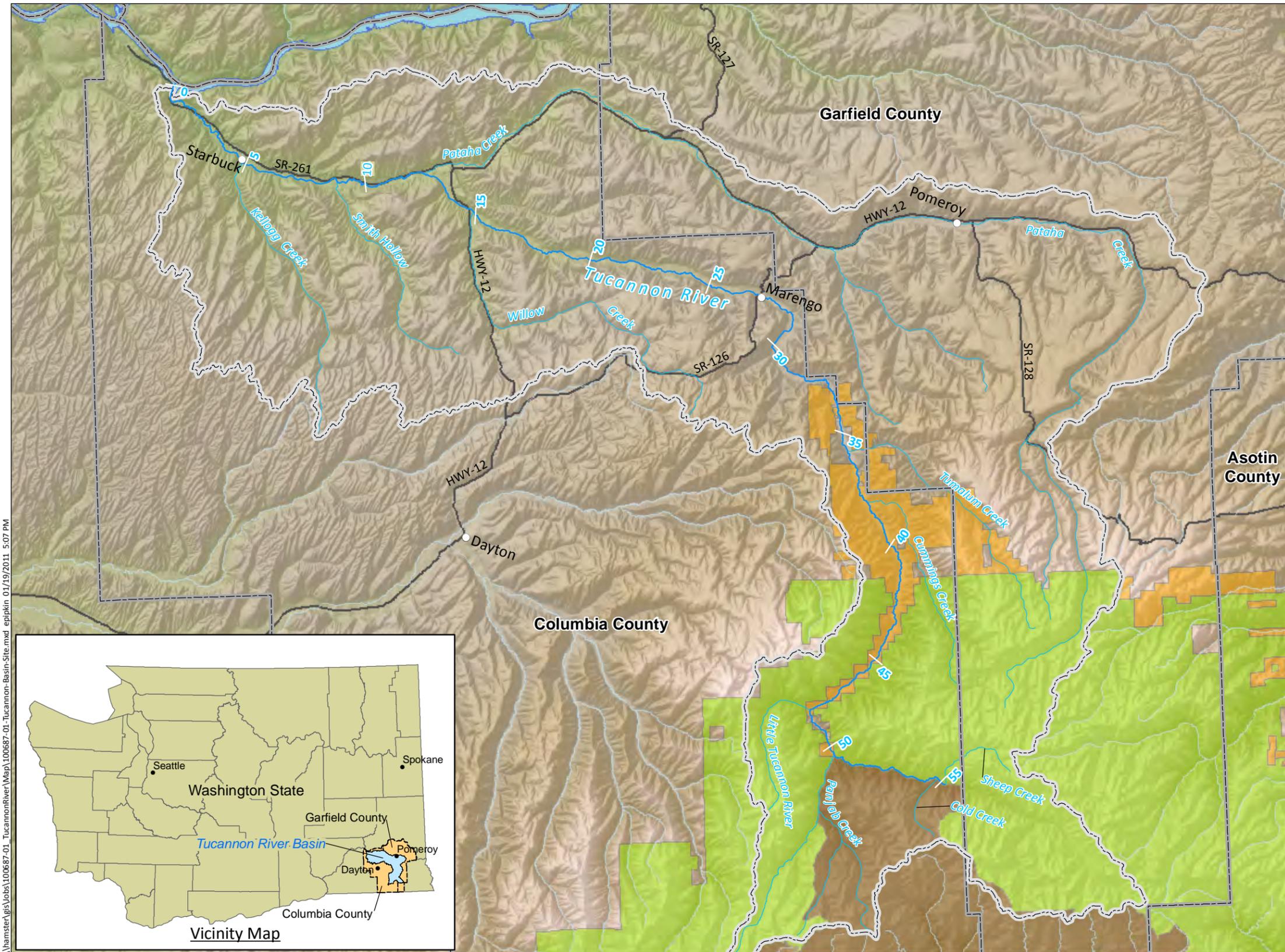
We have prepared this report for use by the CCD to evaluate existing physical conditions in the Tucannon River and to identify appropriate potential restoration opportunities in the study reach. The information presented in this report is based on available data and limited site reconnaissance at the time of report development. Conditions within the study reach may change both spatially and with time, and additional scientific data may become available. Significant changes in site conditions or the available information may require re-evaluation. Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted scientific and engineering practices in this area at the time this report was prepared.

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FIGURES



LEGEND

- Tucannon River Assessment Reaches (Ticks Indicate River Mile)
- Tributary to Tucannon River
- Road
- Tucannon River Basin
- County Boundary
- Public Land Areas**
- Washington State - WDFW Wildlife Area
- U.S. Forest Service - Wenaha Tucannon Wilderness
- U.S. Forest Service - Umatilla National Forest

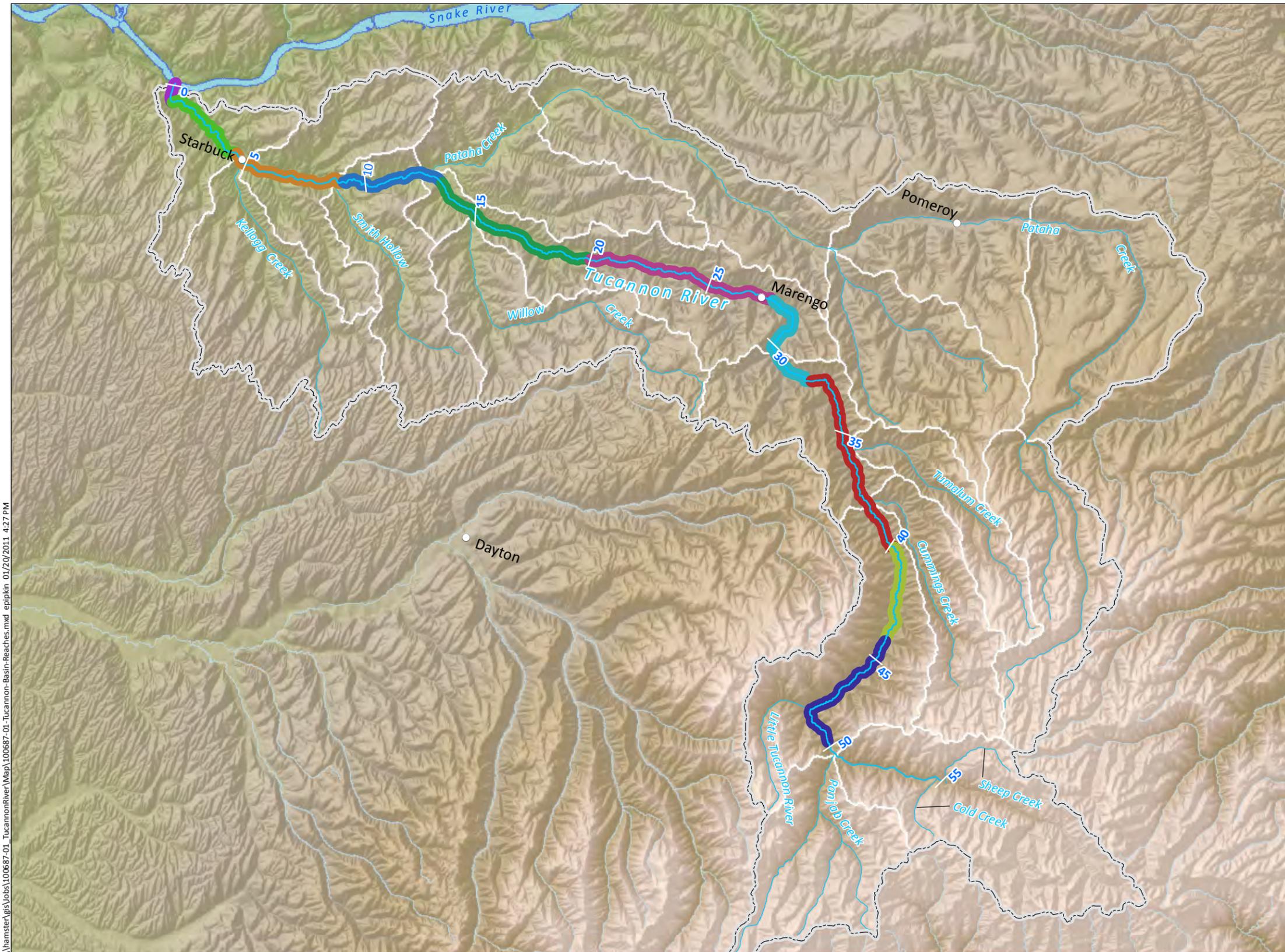


NOTES:

1. Horizontal Datum: WA State Plane South Zone, NAD 83, Feet.
2. Public lands data provided by Washington State Dept. of Natural Resources.

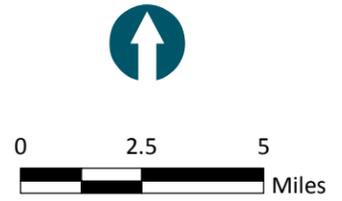
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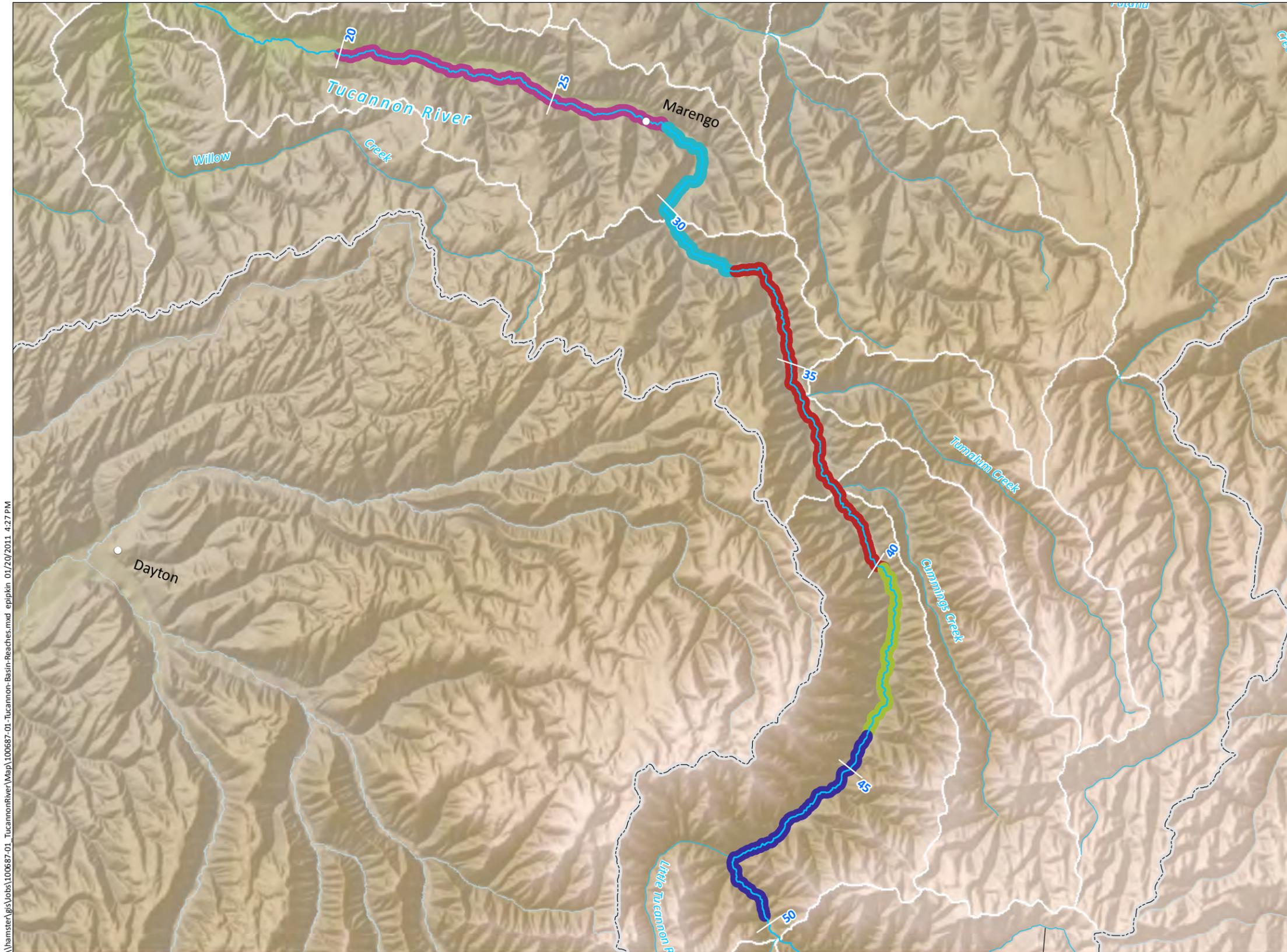
LEGEND

- Tucannon River Assessment Reaches (Ticks Indicate River Mile)
 - Tributary to Tucannon River
 - Tucannon River Basin
 - Tucannon River Sub-Basins
- Geomorphic Reaches**
- Reach 10 (R.M. 50.0 - R.M. 44.0)
 - Reach 9 (R.M. 44.0 - R.M. 40.0)
 - Reach 8 (R.M. 40.0 - R.M. 32.1)
 - Reach 7 (R.M. 32.1 - R.M. 27.5)
 - Reach 6 (R.M. 27.5 - R.M. 20.0)
 - Reach 5 (R.M. 20.0 - R.M. 13.2)
 - Reach 4 (R.M. 13.2 - R.M. 8.9)
 - Reach 3 (R.M. 8.9 - R.M. 4.5)
 - Reach 2 (R.M. 4.5 - R.M. 0.7)
 - Reach 1 (R.M. 0.7 - R.M. 0.0)



- NOTES:**
1. Horizontal Datum: WA State Plane South Zone, NAD 83, Feet.
 2. Sub-basins are based on USGS HUC areas.
 3. R.M. stands for River Mile.

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LEGEND

- Tucannon River Assessment Reaches (Ticks Indicate River Mile)
- Tributary to Tucannon River
- Tucannon River Basin
- Tucannon River Sub-Basins

Geomorphic Reaches

- Reach 10 (R.M. 50.0 - R.M. 44.0)
- Reach 9 (R.M. 44.0 - R.M. 40.0)
- Reach 8 (R.M. 40.0 - R.M. 32.1)
- Reach 7 (R.M. 32.1 - R.M. 27.5)
- Reach 6 (R.M. 27.5 - R.M. 20.0)

NOTES:

1. Horizontal Datum: WA State Plane South Zone, NAD 83, Feet.
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APPENDIX A
CONCEPTUAL RESTORATION ACTIONS

CONCEPTUAL PROJECT ACTIONS

Enhancing instream habitat and initiating the recovery of natural watershed processes will involve a variety of treatment actions within the main channel, along the banks, and within the riparian zone and floodplain. The restoration actions proposed address key restoration objectives identified for the Tucannon River that address limiting factors for focal species and promote long-term recovery of the system.

Passive Restoration and Protection

Passive restoration is recommended for areas of the system where natural processes are actively recovering and habitat conditions are adequate to support critical life history stages. In these locations, processes such as channel migration, wood recruitment, and side channel development are actively creating and maintaining habitat complexity. Although these areas are not fully recovered, it is expected that they are on a positive trajectory and passive means are appropriate. Wood removal, cattle grazing, and other detrimental practices should be prevented by implementing fencing or conservation easements. In some project areas, riparian development or other minor restoration actions may be recommended to address local habitat degradation.

Reconnect Isolated Habitat

Off-channel habitat provides critical holding and rearing habitat for juvenile salmonids during moderate to high flows and often provides preferred habitat conditions to main channel habitat at lower flows. Several isolated features were identified throughout the study extent, including flowing channels, stagnant channels and pools, wetlands, and un-wetted areas within the low-lying floodplain. Some isolated features such as cut-off meander bends are naturally isolated, but many of the areas identified are disconnected from the main channel by infrastructure. Other areas have poor floodplain connectivity and hyporheic exchange with the channel due to incision and channel modification.

Encouraging reconnection of isolated features will increase habitat complexity by providing off-channel habitat and increased floodplain connectivity. Reconnecting these areas will provide additional juvenile carrying capacity and enhance water quality conditions in stagnant areas, particularly during late summer and early fall low flows.

Actions for reactivating disconnected habitat may include earthwork to establish hydraulic connections with the main channel and installation of LWD to provide cover or assist in keeping pathways to the main channel accessible. A perennial surface-water connection at the downstream end of off-channel features will help lessen the possibility of entrapment of fish.

Side Channel Development

Side channels provide preferred rearing habitat during low flows and provide hydraulic refuge and cover during high flows. Encouraging multiple flow paths will increase habitat complexity by diversifying the planform, dissipating stream energy, distributing sediment load, and providing hydraulic complexity. Diverse floodplain and side channel networks often have multiple flow paths at various elevations across the valley bottom. Therefore, different channels are accessed at different water surface elevations. In this manner, off-channel habitat is accessed in different areas of the channel network under changing flow regimes providing a multitude of habitat during a large range of flow conditions.

Infrastructure Removal or Setback

Tens of thousands of linear feet of levees, spoil piles, and armored banks confine the mainstem Tucannon River and prevent or limit floodplain connectivity. In these areas, infrastructure removal or setback may be used to increase the active floodplain area, thereby promoting floodplain and side channel connectivity, and allow for more natural channel migration and planform complexity. In many of the locations identified, widening the floodplain corridor may occur without significant changes to agricultural practice or other private land use.

Removing levees and promoting floodplain connectivity encourages geomorphic processes while dissipating velocities during high flows as floodwaters are distributed onto the floodplain. This also allows fine sediment to deposit on the floodplain, promoting ecological processes. Decreased channel velocities may also lessen erosive energy along the banks in areas of concern for landowners. Allowing the channel to migrate throughout a wider corridor will encourage development of complex channel and planform geometry, distributing energy and sediment load. It will be important to consider the reach-scale

effects of widening the floodplain, particularly at the downstream end of confined reaches. For example, an unconfined floodplain below a tightly confined section will likely result in a large amount of sediment deposition and channel migration.

Develop Instream Habitat Complexity

Instream habitat complexity is correlated to hydraulic complexity created by the channel geometry, bedforms such as gravel bars and pools, hardpoints such as bedrock, and perhaps most importantly to the presence of LWD. The primary biological function of LWD in rivers and streams is to provide complexity that creates hydraulic refuge and cover for adult and juvenile salmonids. Geomorphically, LWD also plays a major role in influencing the channel form.

In natural systems, riparian trees often enter a watercourse as the result of erosion, windfall, disease, beaver activity, or natural mortality. However, in most Pacific Northwest river systems, including the Tucannon River, LWD has been removed from the river channels and cleared from riparian areas. In addition, a significant quantity of natural LWD that would otherwise be recruited from riparian areas has been removed by logging and agricultural practices. Anthropogenic activities in the basin have been detrimental to the system, leading to a decrease in the number, size, and volume of LWD being introduced to the river through natural processes. Therefore, installing LWD is necessary to supplement existing conditions, recognizing that it will take decades of riparian planting and development to begin to provide natural replenishment rates.

In the long term, the added channel and bank roughness created by wood structures will help retain additional mobile wood and sediment, diversifying hydraulic and bedform complexity and contributing to increased floodplain connectivity and functionality of floodplain processes over time. For the Upper Tucannon River MSA, the SRSRP recommended at least one piece of LWD per channel width (2006). Supplementing existing rock structures such as weirs and barbs with LWD is also recommended to add instream complexity and to provide refuge for juvenile fish.

Large Woody Debris Placements

LWD placements that are suitable for placement in the Tucannon River include single-log placements or multiple-log assemblies with rootwads that are installed in the channel bed or bank to create beneficial fish habitat and desired geomorphic effects. These features emulate natural tree fall of mature riparian trees and provide a base for mobile wood to accumulate. In the Tucannon River, a variety of natural trees and log jams were observed, from small accumulations of mobile wood to large, channel-spanning log jams. In almost every location that LWD was observed, whether a single rootwad or a log jam, the feature forced a deep scour pool. In addition, the LWD observed in the Tucannon River was often consistent with the presence of a more complex channel network. The different types of engineered LWD placements have varying levels of design and construction effort and also range in magnitude of physical and biological benefit.

Engineered Log Jams

Engineered log jams (ELJs) are large wood structures that can be placed in the main channel that emulate naturally occurring, stable log jams. Historically, several log jams per mile were likely present in the main channel, but they have either been cleared or are no longer able to become established due to a lack of mature riparian trees being recruited to the system, particularly in reaches where the local riparian conditions are poor. ELJs are typically placed along the bank or mid-channel with the bottom of the structure at the anticipated scour depth and the top built to the approximate height of the 100-year flood water surface elevation. The structure is backfilled with streambed materials for stability, and a gravel bar deposit may be placed in the lee of the structure that emulates the natural sediment deposit that would occur in the lee of this type of structure.

ELJs can create large flow stagnation areas upstream and downstream of the structure and contain a substantial amount of void space within the logs and root masses, providing considerable area for fish refuge. During high flows, the rootwads interact with hydraulic forces from the river and scour large, deep pools that provide holding areas for adults while the void space within the face of the structure is used by juveniles. In addition, these structures are able to retain mobile wood debris. Because of the hydraulic conditions and

hard points created by ELJs, they may also be used as “deflectors” to influence flow direction to promote channel expansion or activation of side channels.

On a reach or subreach scale, installation of multiple ELJs can influence gravel movement and deposition to create localized pool-riffle sequences, increased hydraulic complexity, and a more stable channel profile. Sediment storage and deposition adjacent to the ELJs can create large gravel bars in the active channel allowing for colonization of riparian vegetation and eventually the development of forested islands. The overall roughening of the active channel and aggrading of the riverbed promotes rehabilitation of natural processes by increasing floodplain connectivity and promoting channel migration.

Supplement Existing Rock Structures

Rock structures such as rock weirs and barbs are located throughout the area of study. Rock weirs observed ranged from large structures with deep pools on the downstream side, to perpendicular boulders with a relatively low profile across the channel. Many of the existing rock barbs observed contained a rootwad log, and others were constructed of large angular rock with no cover. Supplementing existing rock structures with LWD is recommended to add complexity and cover to rock features. Although large rock weirs provide holding areas for adult salmonids, juveniles do not have adequate places to hide around these structures, which are typically located in straight and simplified reaches of the channel with little off-channel habitat availability. Addition of LWD to some weirs may also create better passage conditions for both juvenile and adult fish.

Riparian Zone Enhancement

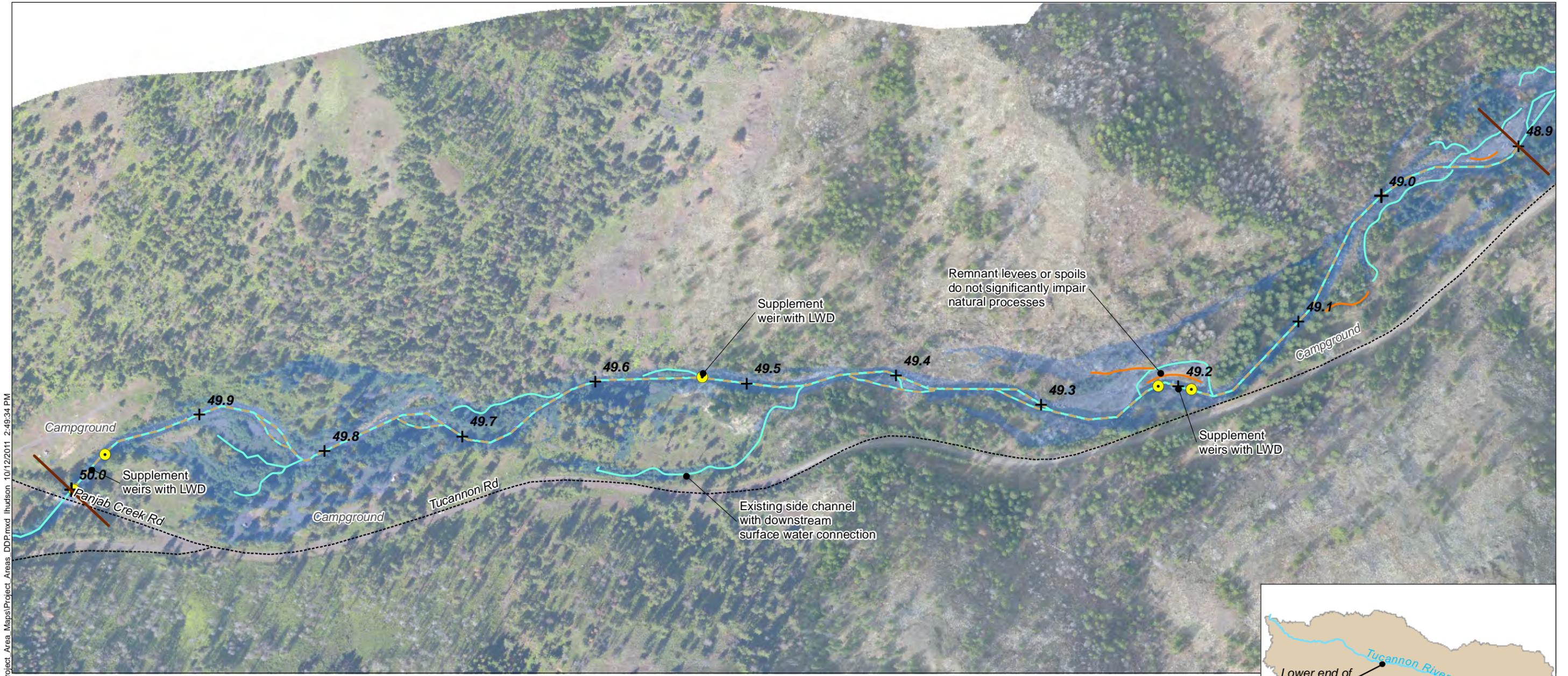
Riparian habitat enhancement involves removal of undesirable vegetation and planting of native riparian communities on the channel banks, on higher elevation gravel bars, and in the floodplain. However, establishment of the ideal riparian buffer width may be limited by the location of agricultural fields, infrastructure, and the feasibility of irrigating and maintaining plantings. Riparian planting may also be conducted in conjunction with LWD structure placement, including ELJs. In areas such as highly incised reaches, the hyporheic connection to the riparian zone is poor and only sparse vegetation is able to grow. In these

areas, it may be more appropriate to conduct riparian planting efforts once better groundwater availability has been established.

The riparian zone provides several habitat and physical process benefits including increased bank and floodplain roughness, cover, and nutrients for instream species and wildlife. Increased roughness encourages sediment deposition and decreased channel and overbank velocities during floods. Additionally, fully developed mature riparian areas are a source of LWD to the river over time. Riparian restoration should begin with protection of existing healthy riparian areas through programs such as Conservation Reserve Enhancement Program (CREP). Where riparian habitat has been degraded, removal of invasive plants and vegetation and replacing with native species in appropriate environments should be performed. Monitoring and maintenance of plantings for at least the first few years after planting, which will greatly contribute to the success of the restoration effort, may be required for permitting approval. Eradication of invasive species will likely require a longer and more involved maintenance and monitoring effort.

APPENDIX B

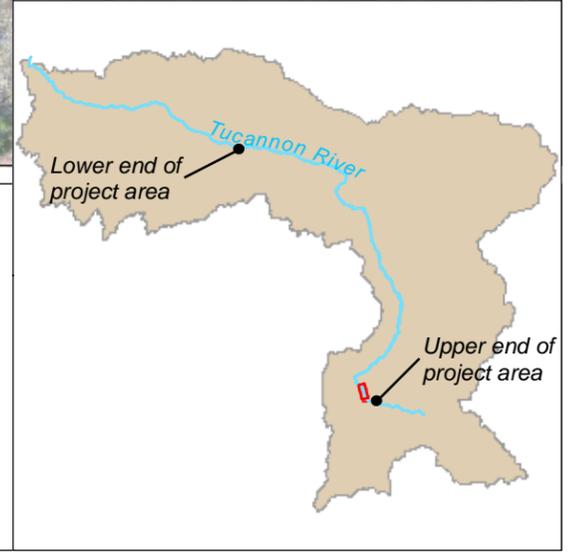
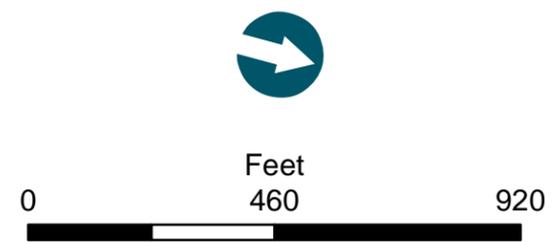
PROJECT AREA FIGURES



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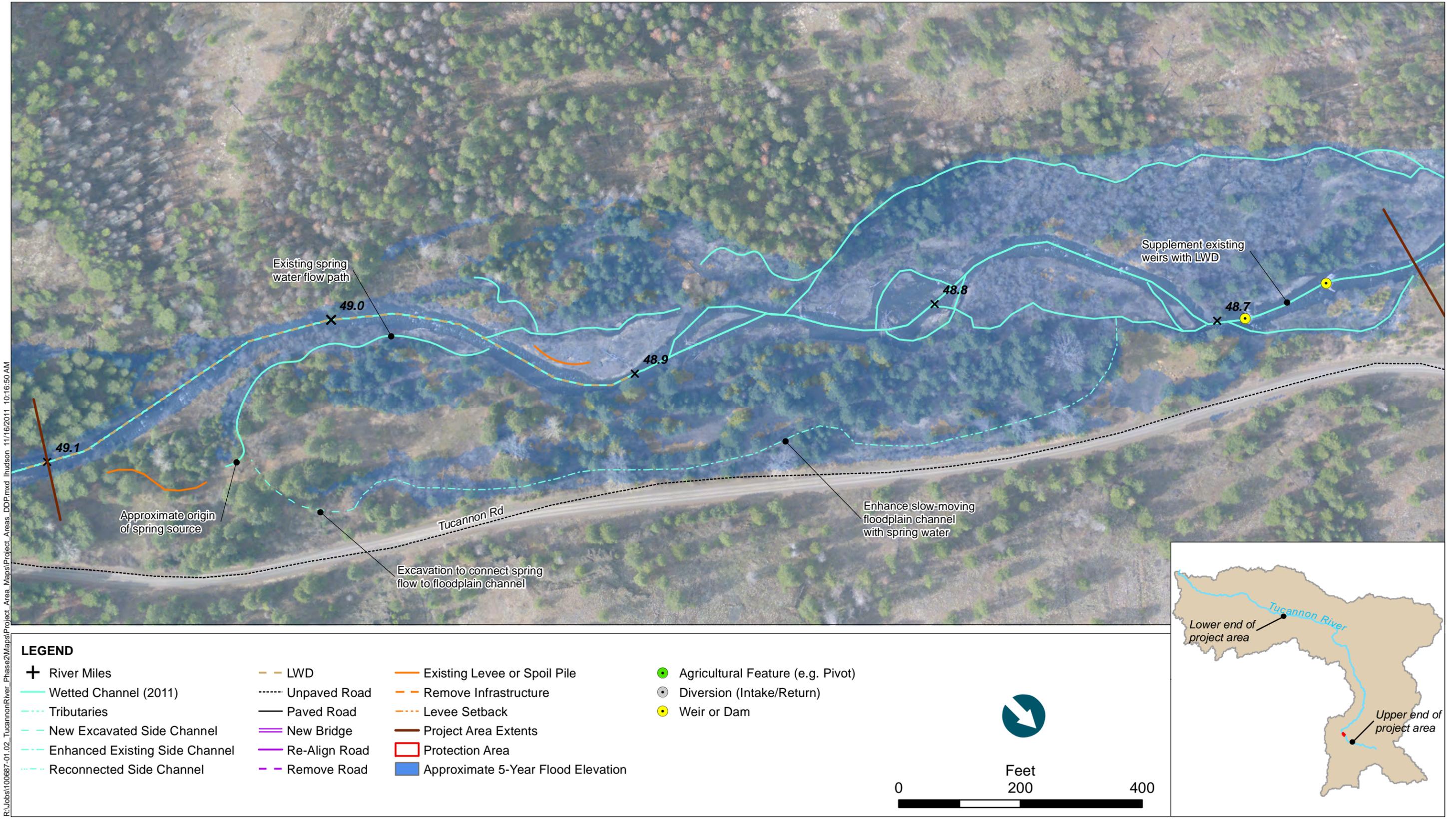
LEGEND

- | | | | | | | | |
|-----|--------------------------------|-----|---------------|-----|------------------------------------|---|-----------------------------------|
| + | River Miles | --- | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | --- | Unpaved Road | — | Remove Infrastructure | ● | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | --- | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | | |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | — | Protection Area | | |
| --- | Reconnected Side Channel | — | Remove Road | — | Approximate 5-Year Flood Elevation | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

Figure B-1
 Project Area 1, River Mile 50.0 to 48.9
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District

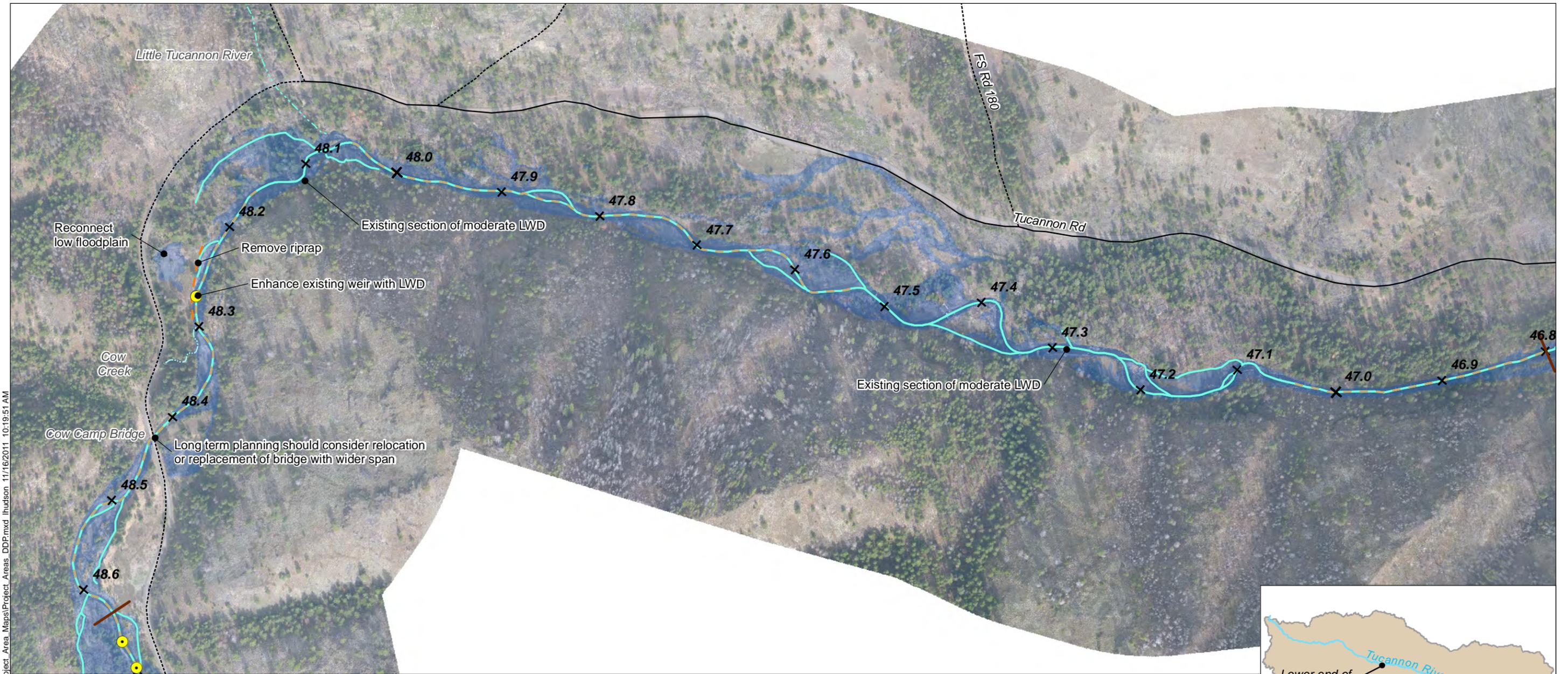


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NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

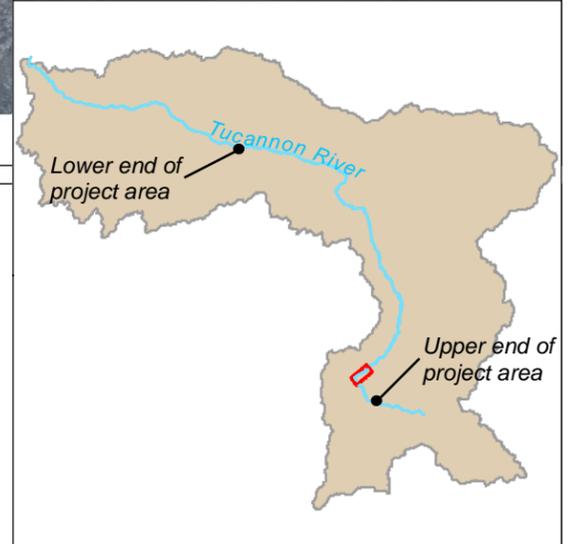
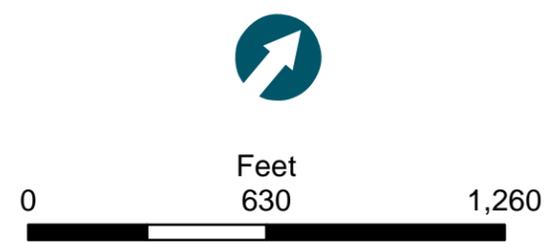
Figure B-2
 Project Area 2, River Mile 49.1 to 48.65
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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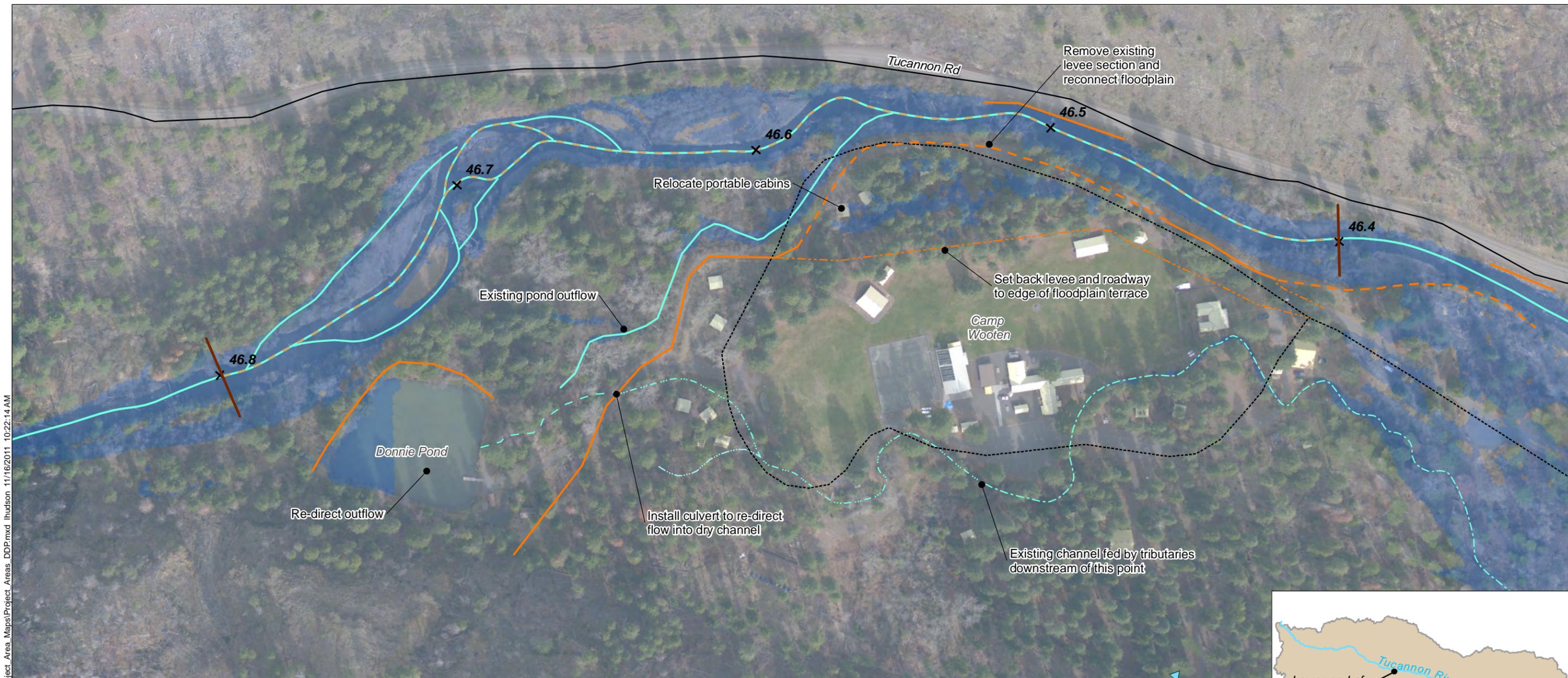
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|-----|--------------------------------|-----|---------------|-----|------------------------------------|---|-----------------------------------|
| + | River Miles | — | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | --- | Unpaved Road | — | Remove Infrastructure | ● | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | --- | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | --- | Project Area Extents | | |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | --- | Protection Area | | |
| --- | Reconnected Side Channel | — | Remove Road | --- | Approximate 5-Year Flood Elevation | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

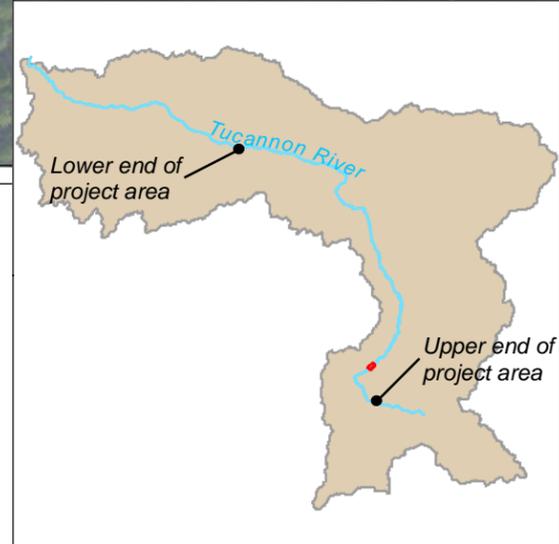
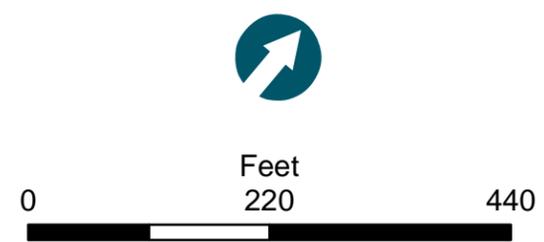
Figure B-3
 Project Area 3, River Mile 48.65 to 46.8
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District

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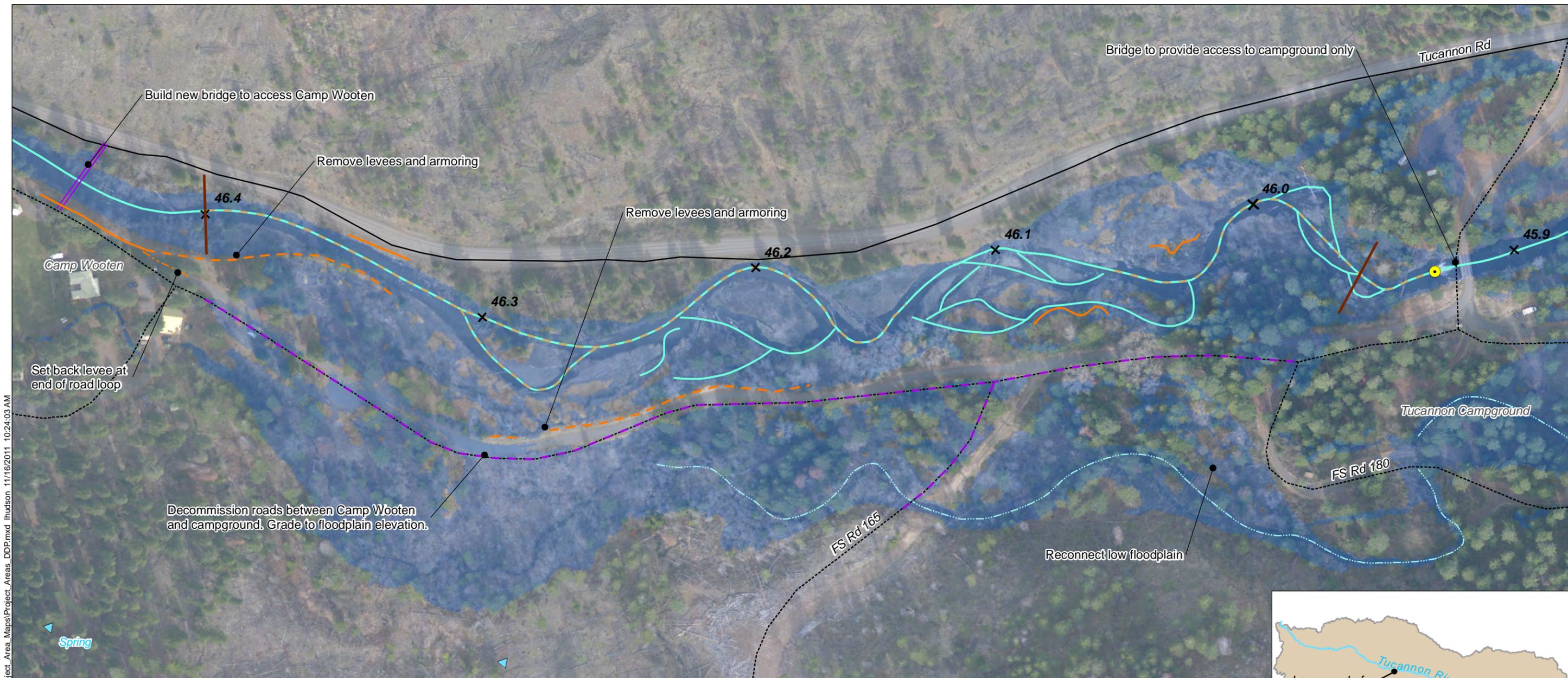
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|-----|--------------------------------|-----|---------------|-------|------------------------------------|---|-----------------------------------|
| + | River Miles | --- | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | --- | Unpaved Road | - - - | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | - - - | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | □ | Protection Area |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | — | Approximate 5-Year Flood Elevation | | |
| --- | Reconnected Side Channel | — | Remove Road | | | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

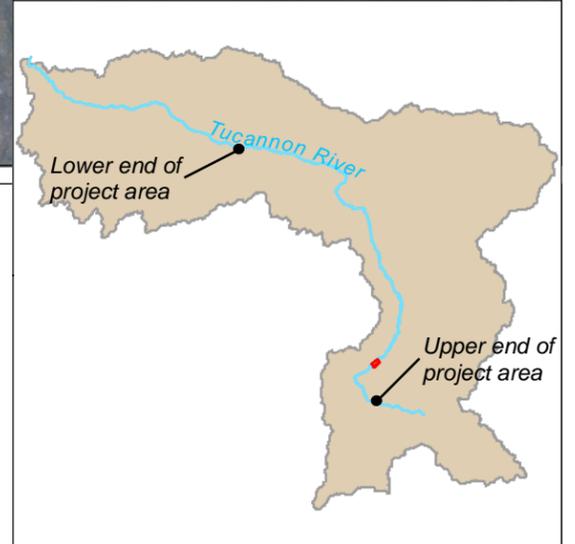
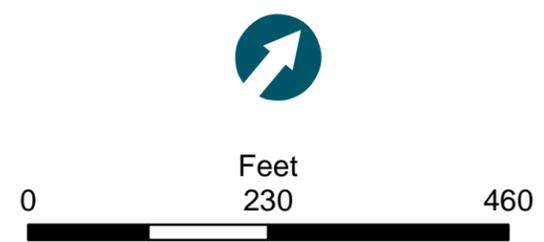
Figure B-4
 Project Area 4, River Mile 46.8 to 46.4
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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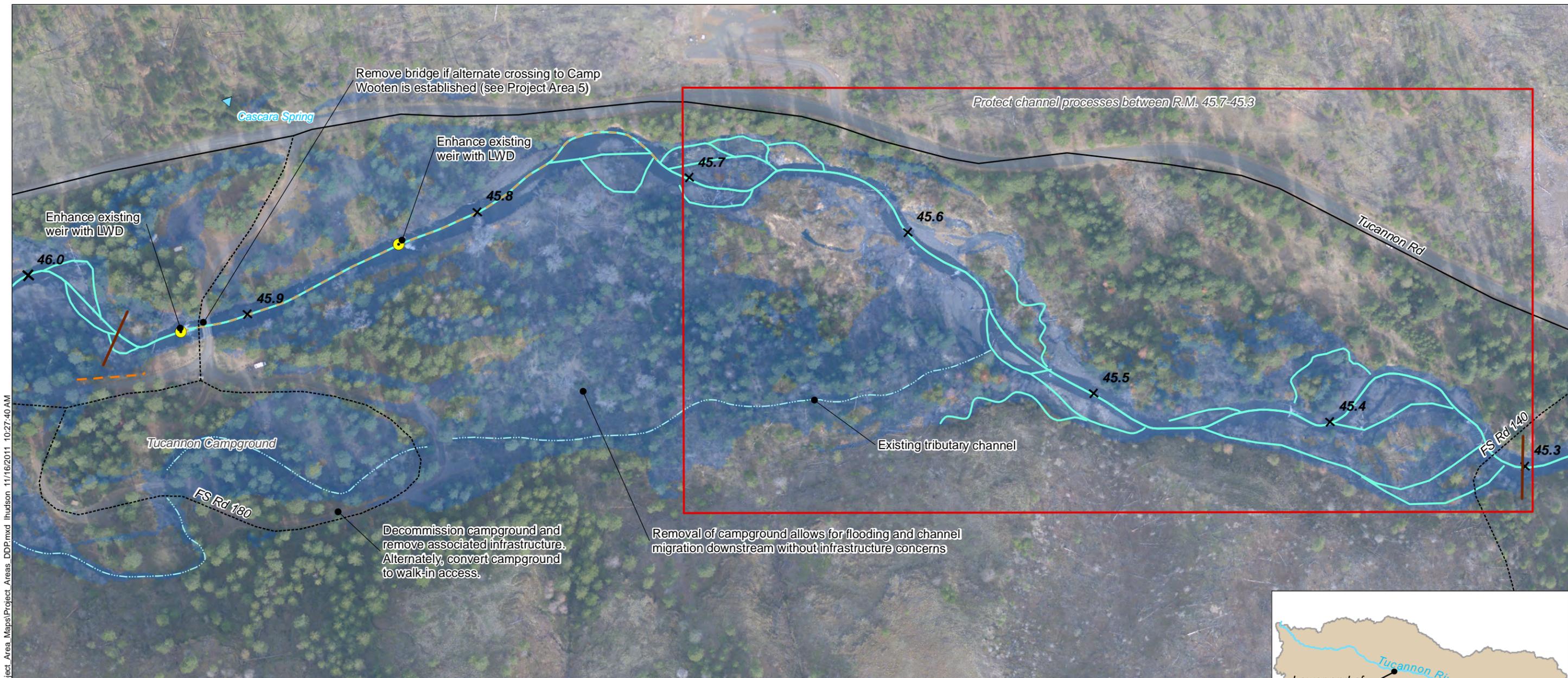
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|-----|--------------------------------|-----|---------------|-----|------------------------------------|---|-----------------------------------|
| + | River Miles | — | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | --- | Unpaved Road | — | Remove Infrastructure | ● | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | --- | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | --- | Project Area Extents | □ | Protection Area |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | --- | Approximate 5-Year Flood Elevation | | |
| --- | Reconnected Side Channel | — | Remove Road | | | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

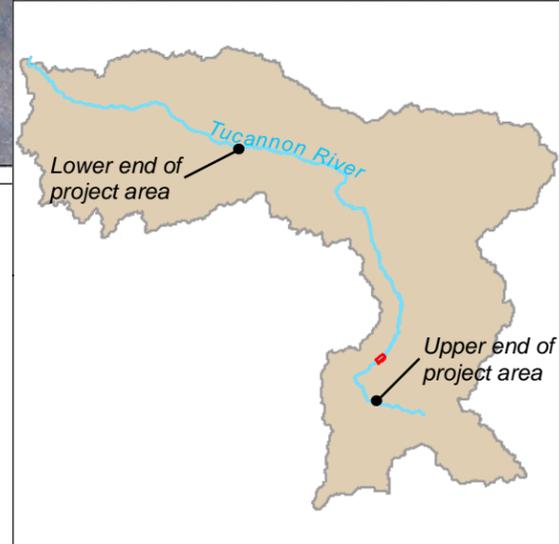
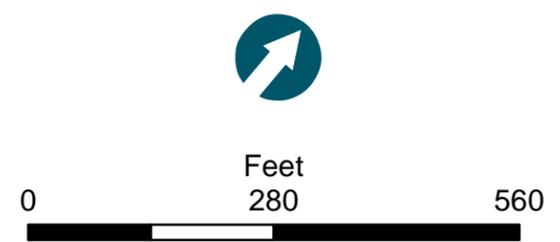
Figure B-5
 Project Area 5, River Mile 46.4 to 45.95
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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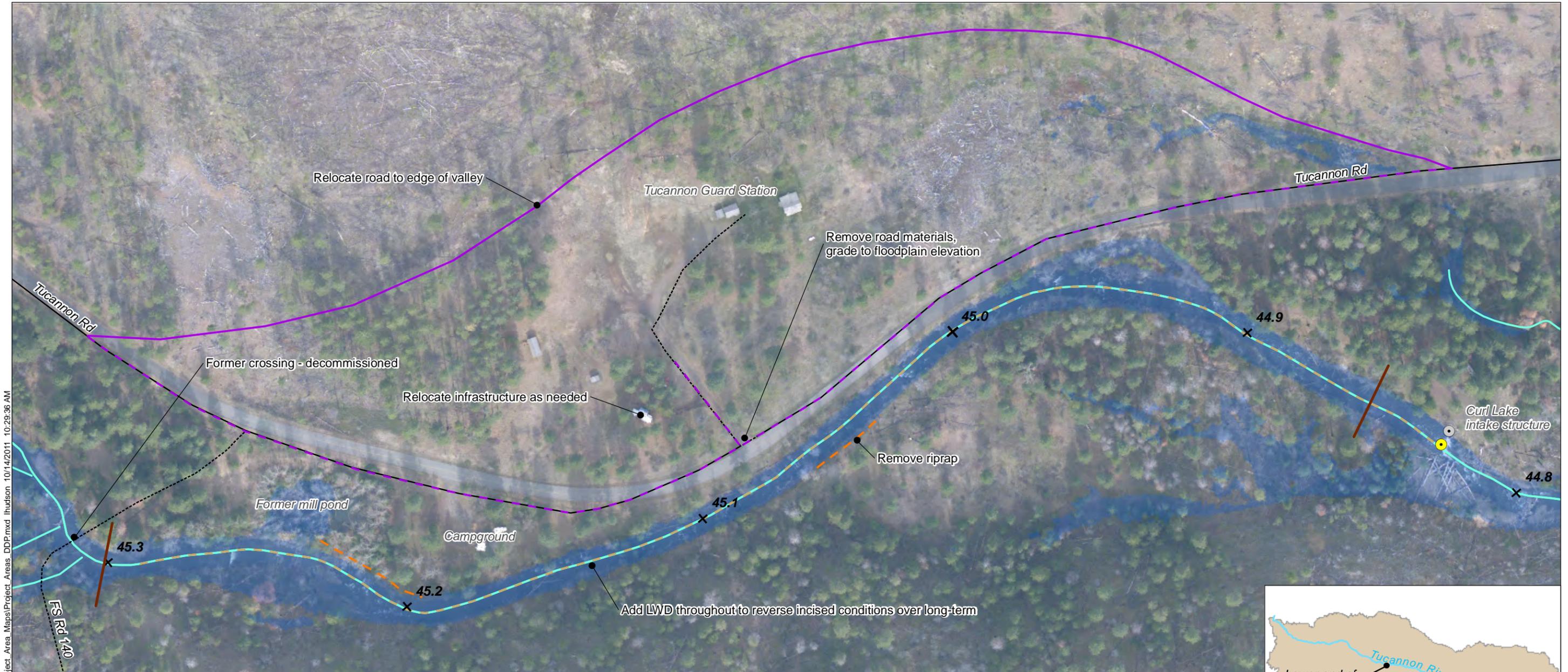
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|---|--------------------------------|-----------------|--------------------------------------|---|-----------------------------------|
| + | River Miles | — LWD | — Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | ⋯ Unpaved Road | — Remove Infrastructure | ○ | Diversion (Intake/Return) |
| ⋯ | Tributaries | — Paved Road | ⋯ Levee Setback | ● | Weir or Dam |
| — | New Excavated Side Channel | — New Bridge | — Project Area Extents | | |
| — | Enhanced Existing Side Channel | — Re-Align Road | □ Protection Area | | |
| ⋯ | Reconnected Side Channel | — Remove Road | ■ Approximate 5-Year Flood Elevation | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

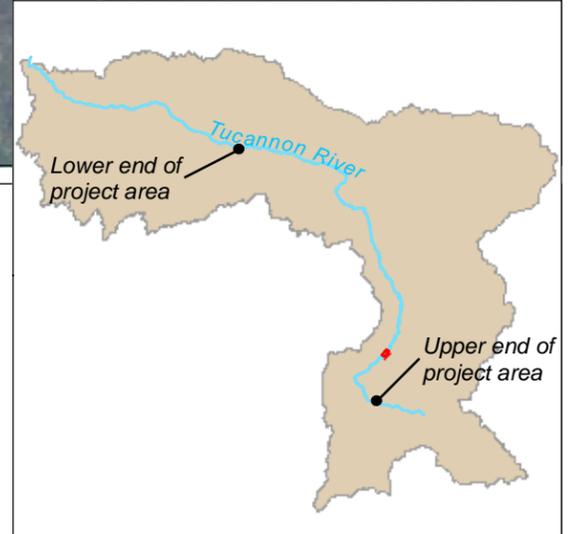
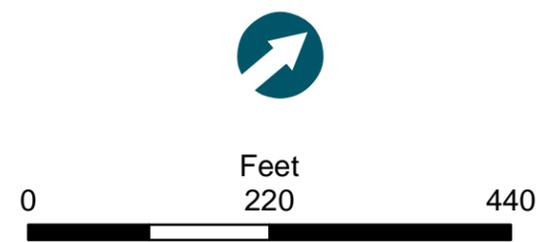
Figure B-6
 Project Area 6, River Mile 45.95 to 45.3
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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| + | River Miles | --- | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | --- | Unpaved Road | — | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | --- | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | □ | Protection Area |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | — | Approximate 5-Year Flood Elevation | | |
| --- | Reconnected Side Channel | — | Remove Road | | | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

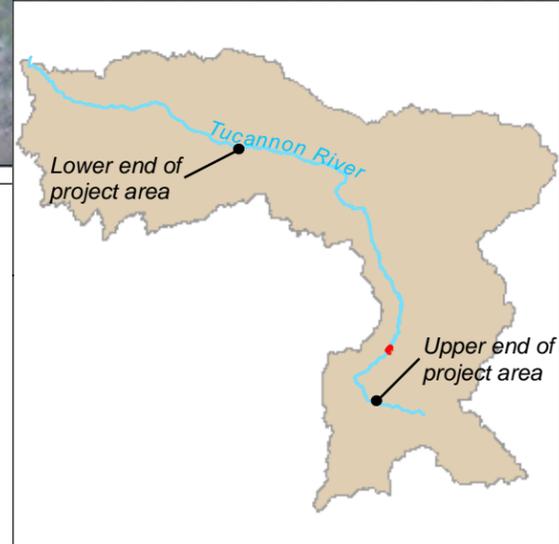
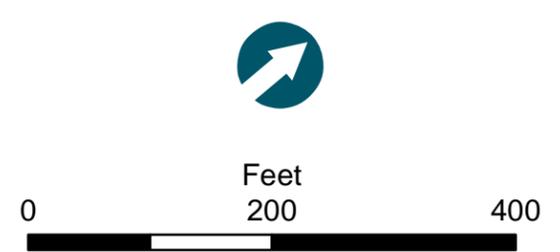
Figure B-7
 Project Area 7, River Mile 45.3 to 44.85
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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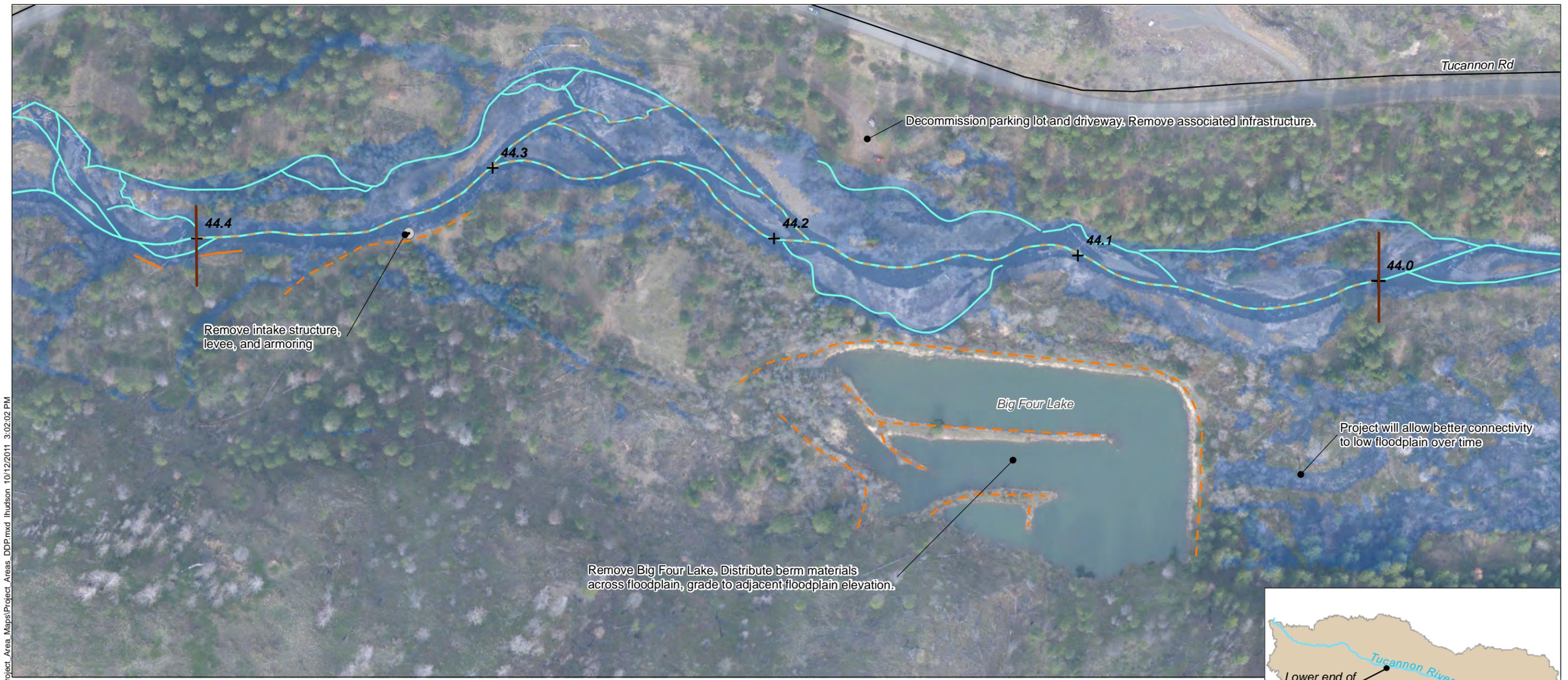
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| + | River Miles | --- | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | --- | Unpaved Road | - - - | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | - - - | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | □ | Protection Area |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | — | Approximate 5-Year Flood Elevation | | |
| --- | Reconnected Side Channel | — | Remove Road | | | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

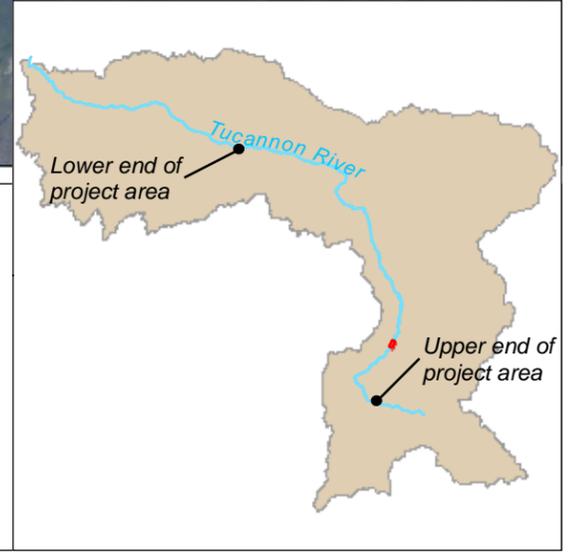
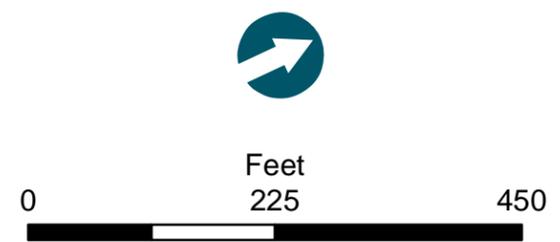
Figure B-8
 Project Area 8, River Mile 44.85 to 44.4
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District

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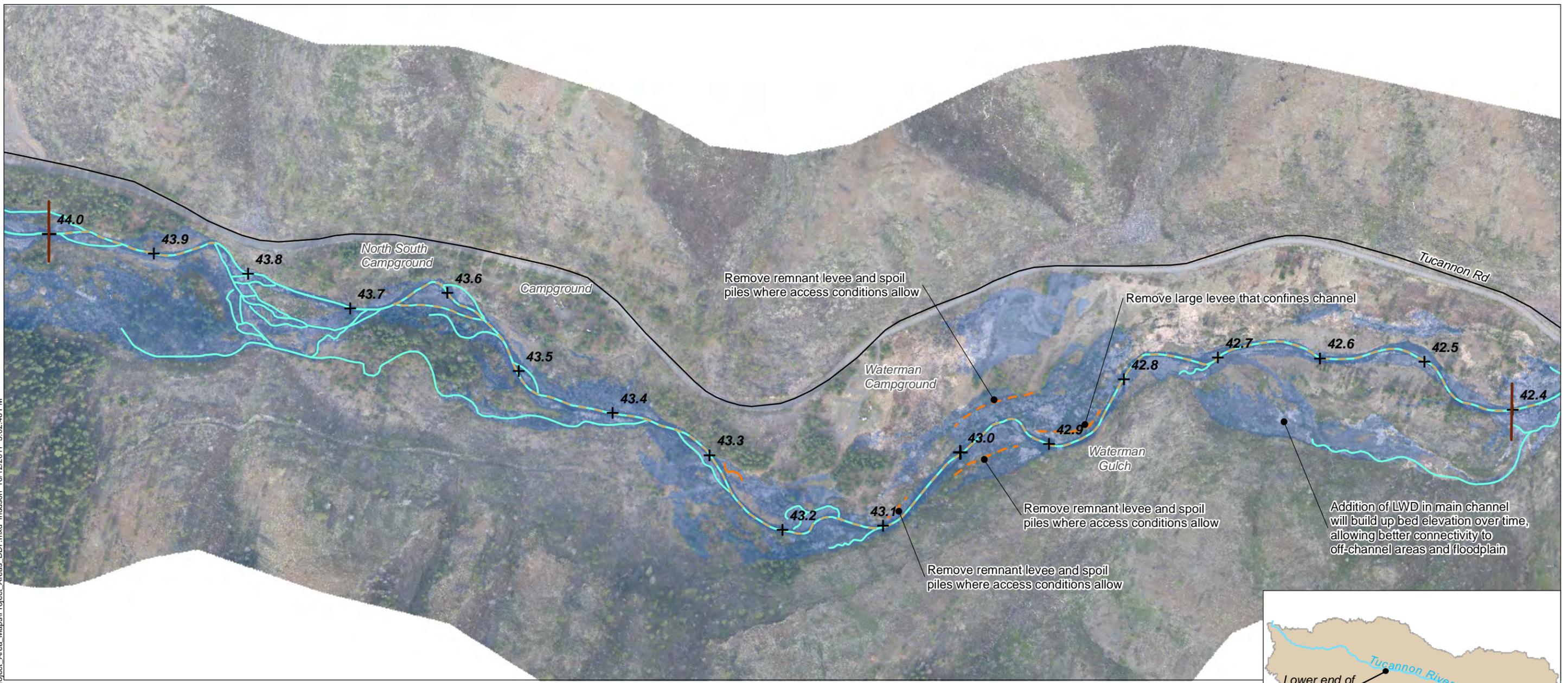
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| + | River Miles | - - - - | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | | Unpaved Road | - - - - | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| - - - - | Tributaries | — | Paved Road | - - - - | Levee Setback | ● | Weir or Dam |
| - - - - | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | □ | Protection Area |
| - - - - | Enhanced Existing Side Channel | — | Re-Align Road | — | Approximate 5-Year Flood Elevation | | |
| - - - - | Reconnected Side Channel | - - - - | Remove Road | | | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

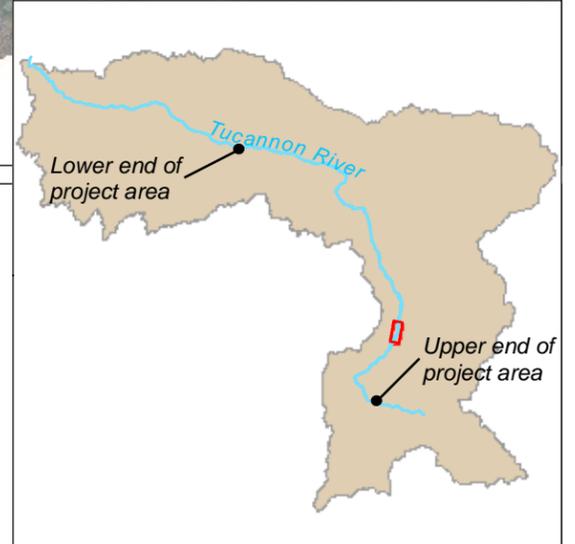
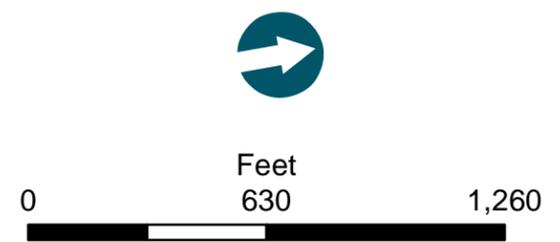
Figure B-9
 Project Area 9, River Mile 44.4 to 44.0
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District

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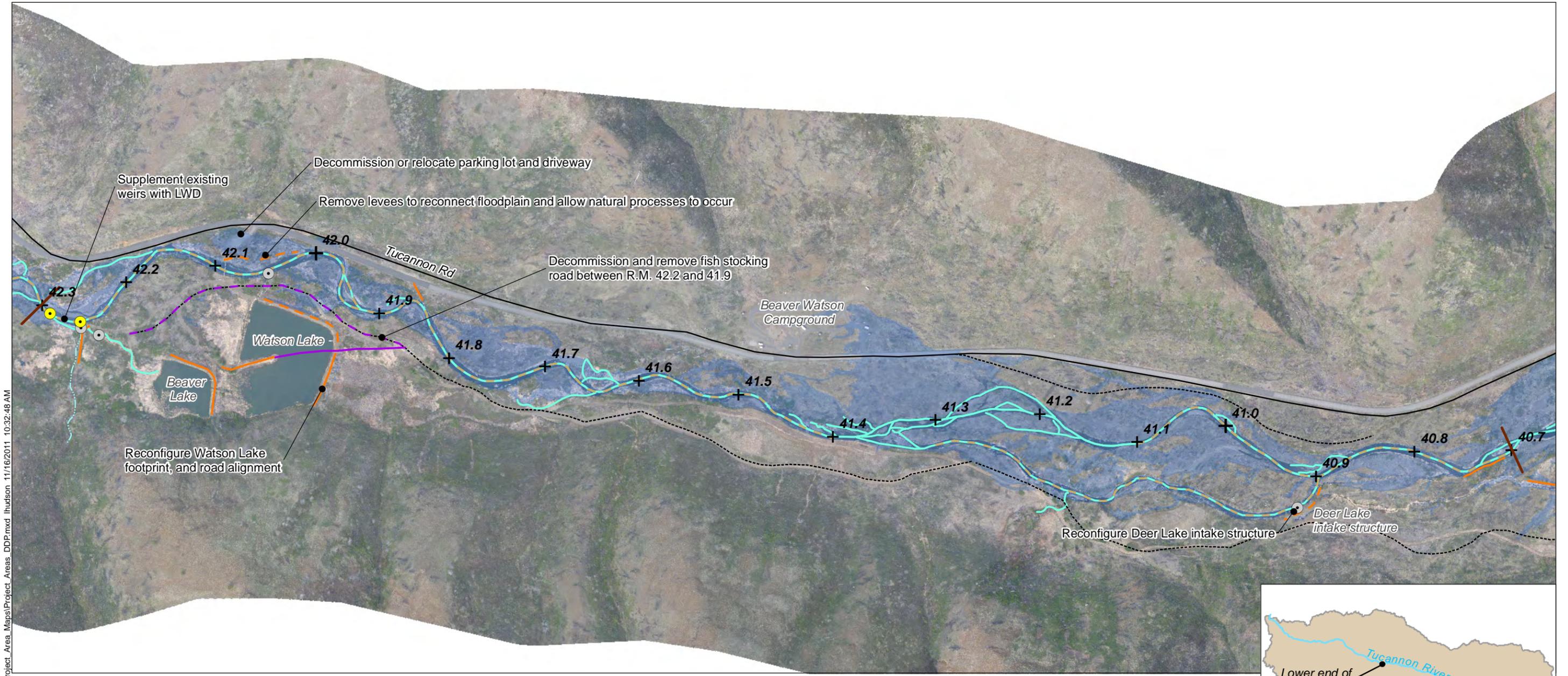
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|-----|--------------------------------|-----|---------------|-------|------------------------------------|---|------------------------------------|
| + | River Miles | --- | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | --- | Unpaved Road | - - - | Remove Infrastructure | ● | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | - - - | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | □ | Protection Area |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | — | Protection Area | □ | Approximate 5-Year Flood Elevation |
| --- | Reconnected Side Channel | — | Remove Road | — | Approximate 5-Year Flood Elevation | □ | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
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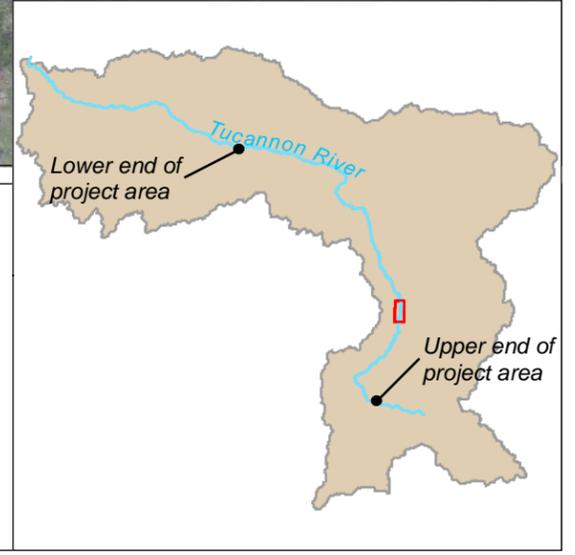
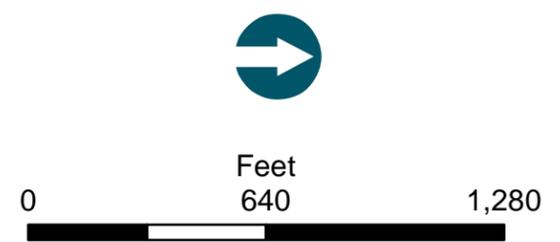
Figure B-10
 Project Area 10, River Mile 44.0 to 42.4
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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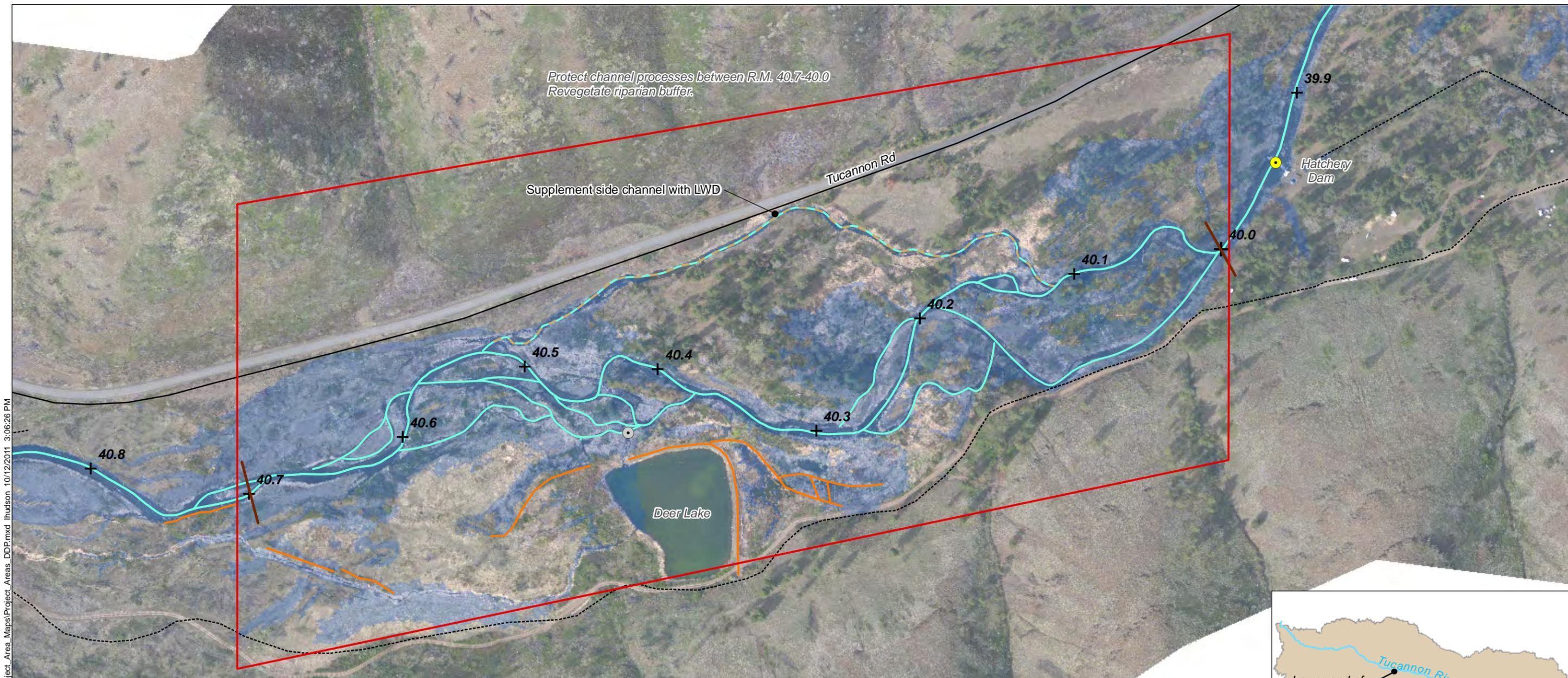
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|---|--------------------------------|-------------------------|---|-----------------------------------|
| + | River Miles | — LWD | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | ⋯ Unpaved Road | ○ | Diversion (Intake/Return) |
| ⋯ | Tributaries | — Paved Road | ● | Weir or Dam |
| — | New Excavated Side Channel | — Remove Infrastructure | | |
| — | Enhanced Existing Side Channel | ⋯ Levee Setback | | |
| ⋯ | Reconnected Side Channel | — Project Area Extents | | |
| | | — Re-Align Road | | |
| | | — Remove Road | | |
| | | □ | | |
| | | ■ | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

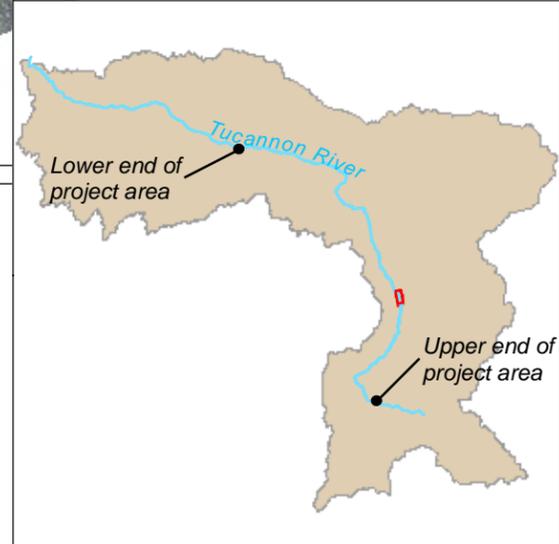
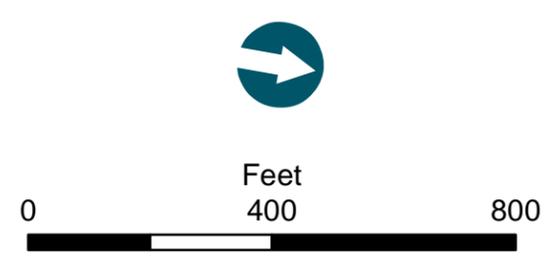
Figure B-11
 Project Area 11, River Mile 42.3 to 40.7
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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| + | River Miles | - - - | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | | Unpaved Road | - - - | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| - - - | Tributaries | — | Paved Road | - - - | Levee Setback | ● | Weir or Dam |
| - - - | New Excavated Side Channel | — | New Bridge | - - - | Project Area Extents | | |
| - - - | Enhanced Existing Side Channel | — | Re-Align Road | — | Protection Area | | |
| - - - | Reconnected Side Channel | — | Remove Road | — | Approximate 5-Year Flood Elevation | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
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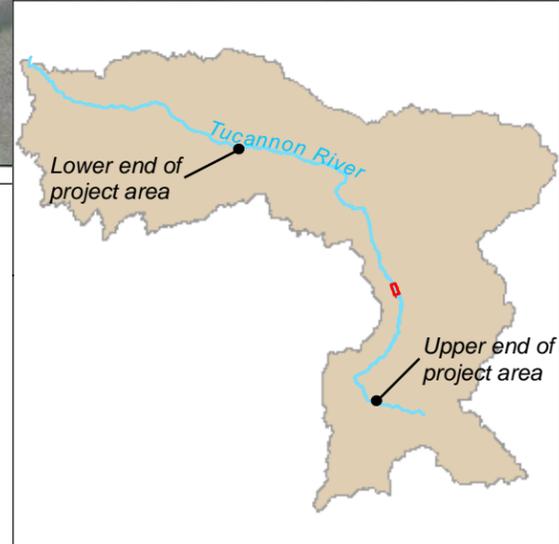
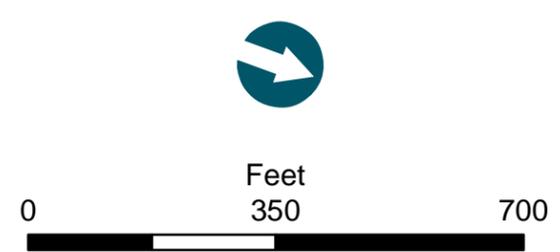
Figure B-12
 Project Area 12, River Mile 40.7 to 40.0
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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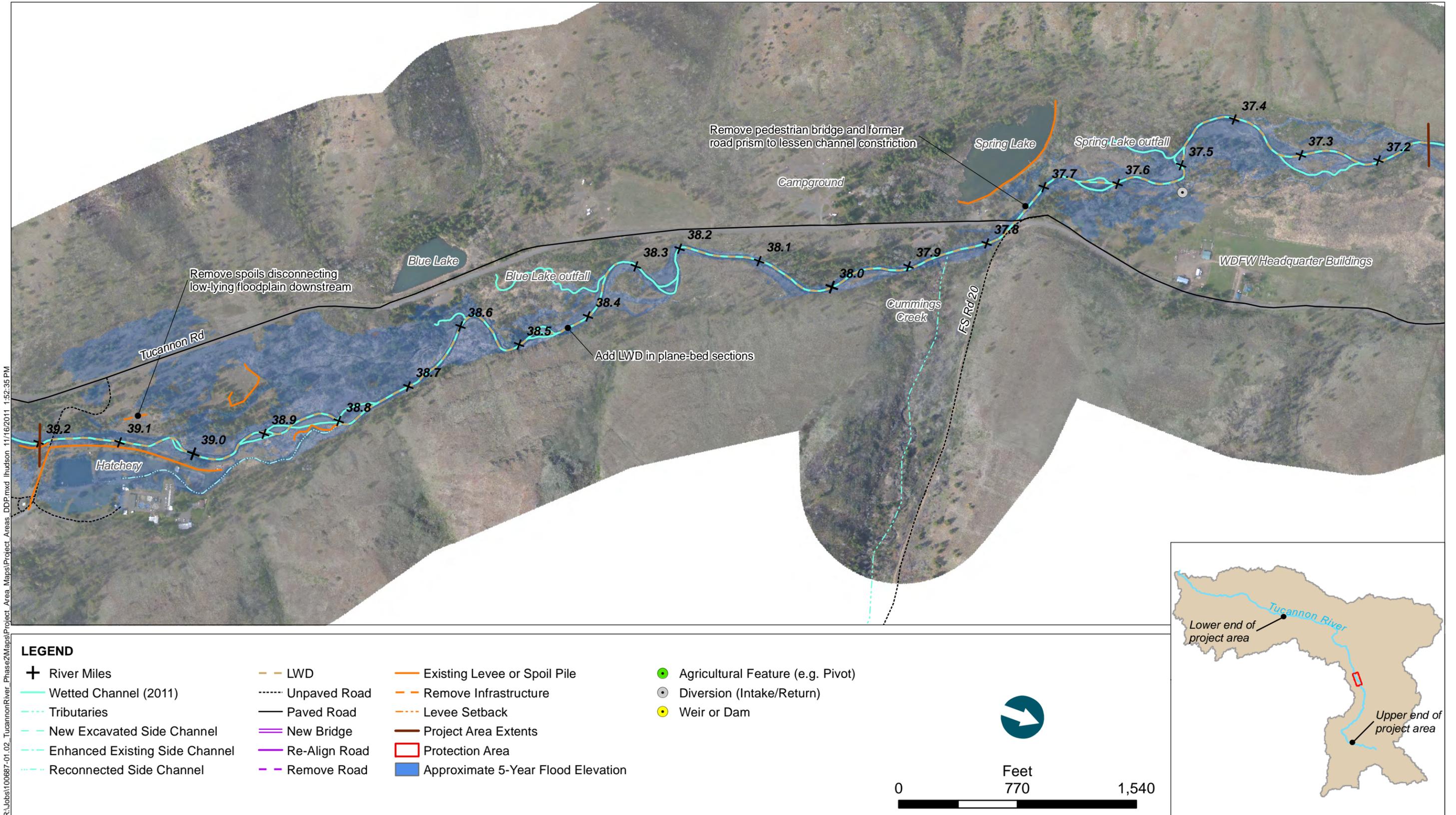
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| + | River Miles | --- | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | --- | Unpaved Road | - - - | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | - - - | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | □ | Protection Area |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | — | Approximate 5-Year Flood Elevation | | |
| --- | Reconnected Side Channel | — | Remove Road | | | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

Figure B-13
 Project Area 13, River Mile 40.0 to 39.2
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District

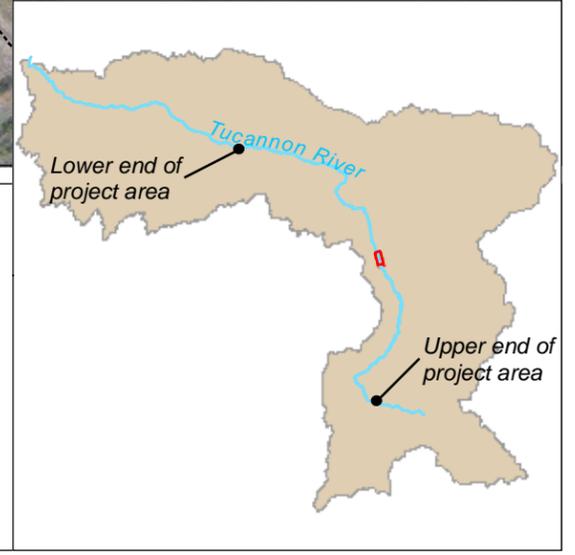
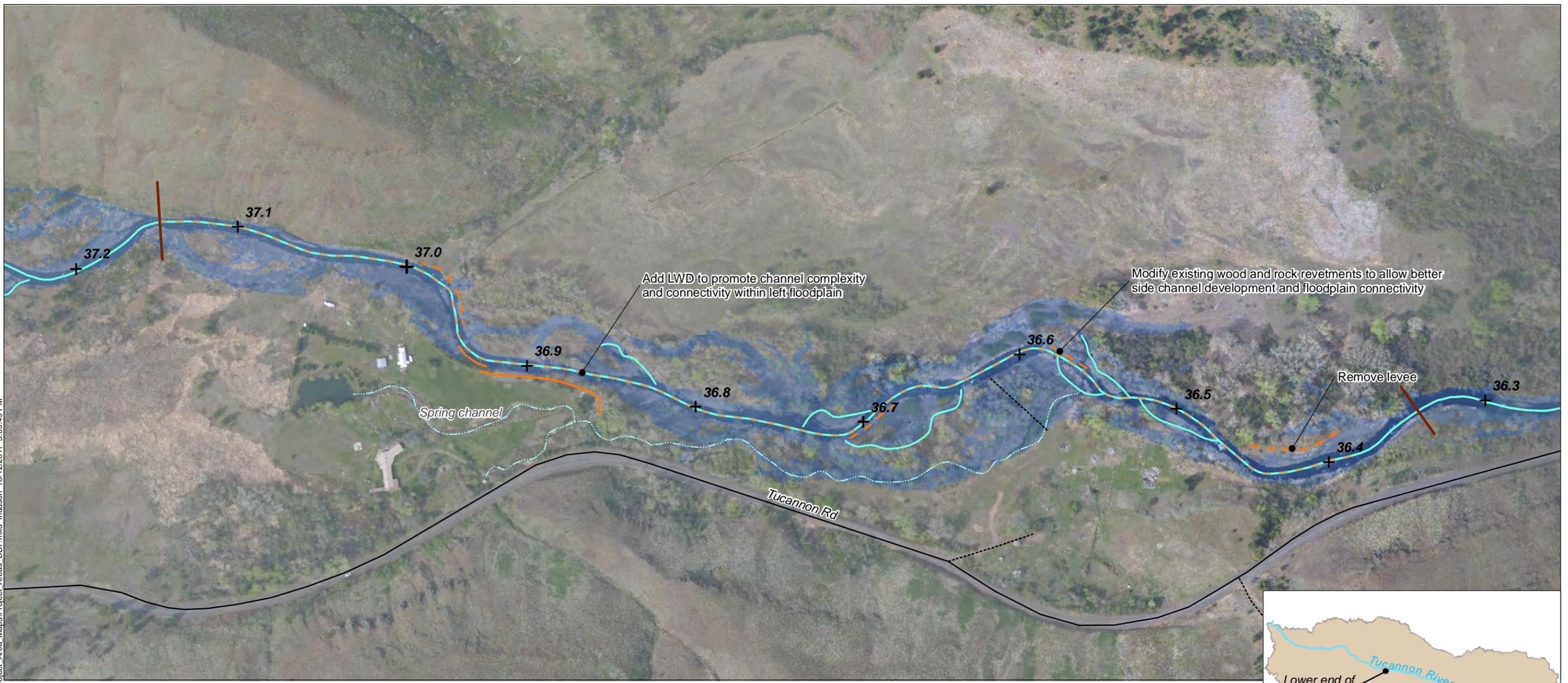


NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.



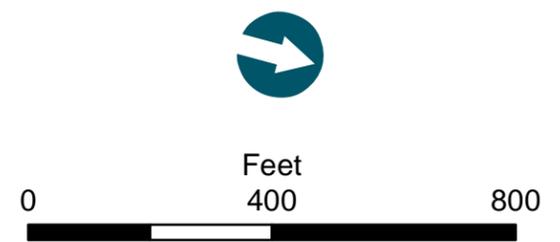
Figure B-14
 Project Area 14, River Mile 39.2 to 37.15
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District

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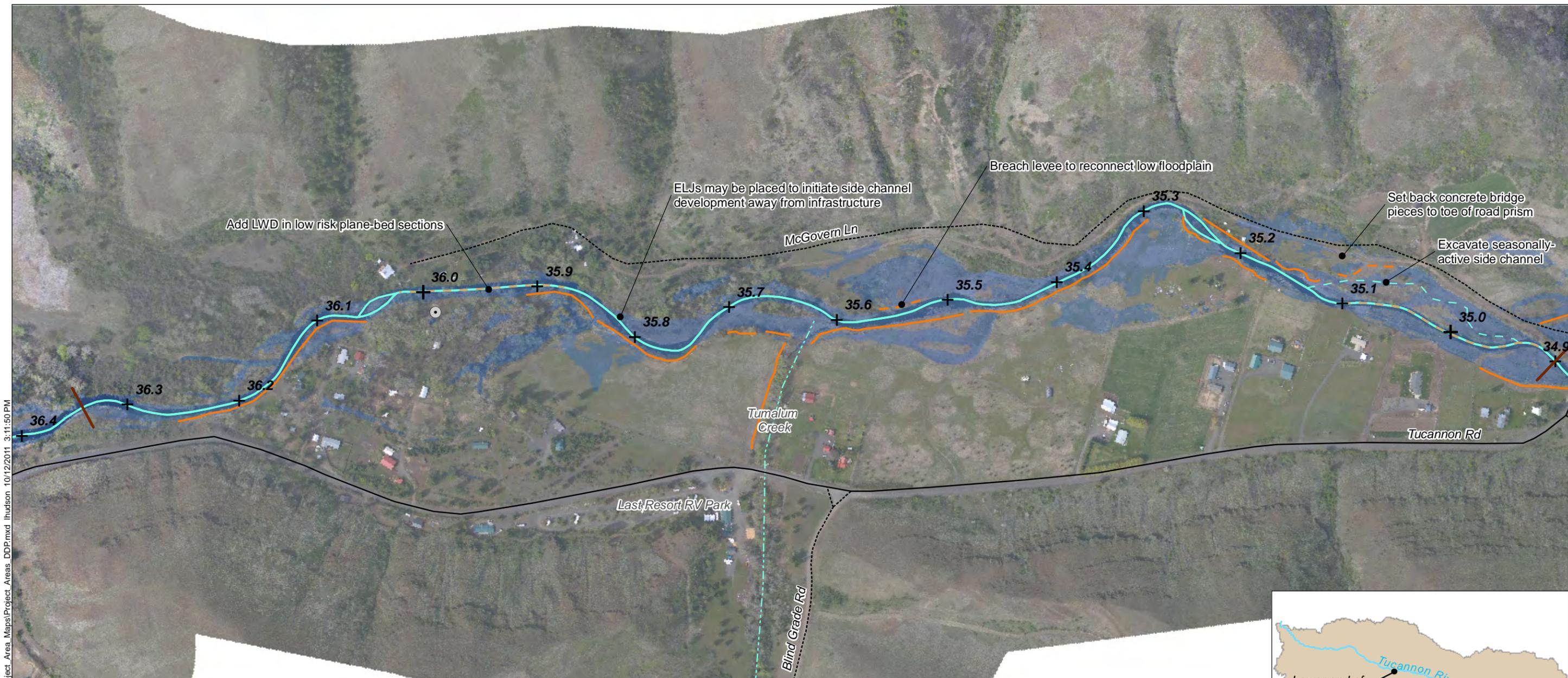
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| + | River Miles | - - - - - | LWD | - - - - - | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | ⋯⋯⋯ | Unpaved Road | - - - - - | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| ⋯⋯⋯ | Tributaries | — | Paved Road | - - - - - | Levee Setback | ● | Weir or Dam |
| — | New Excavated Side Channel | — | New Bridge | - - - - - | Project Area Extents | | |
| ⋯⋯⋯ | Enhanced Existing Side Channel | — | Re-Align Road | □ | Protection Area | | |
| ⋯⋯⋯ | Reconnected Side Channel | - - - - - | Remove Road | ■ | Approximate 5-Year Flood Elevation | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

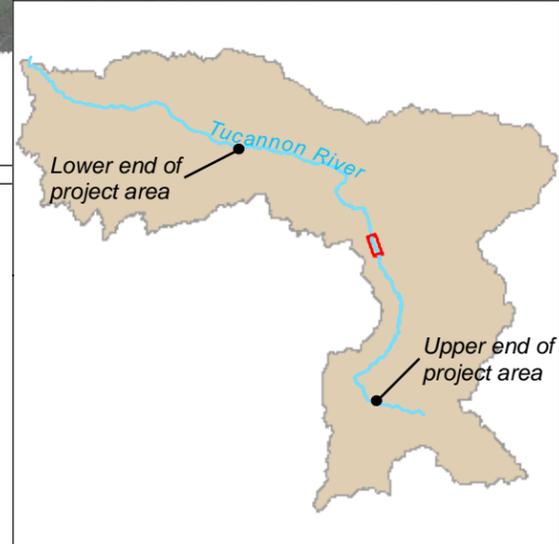
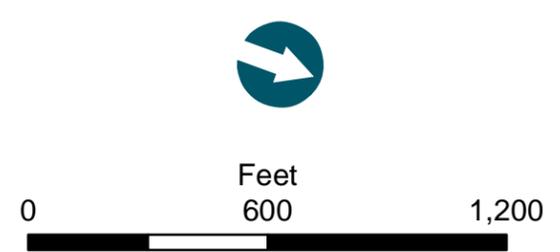
Figure B-15
 Project Area 15, River Mile 37.15 to 36.35
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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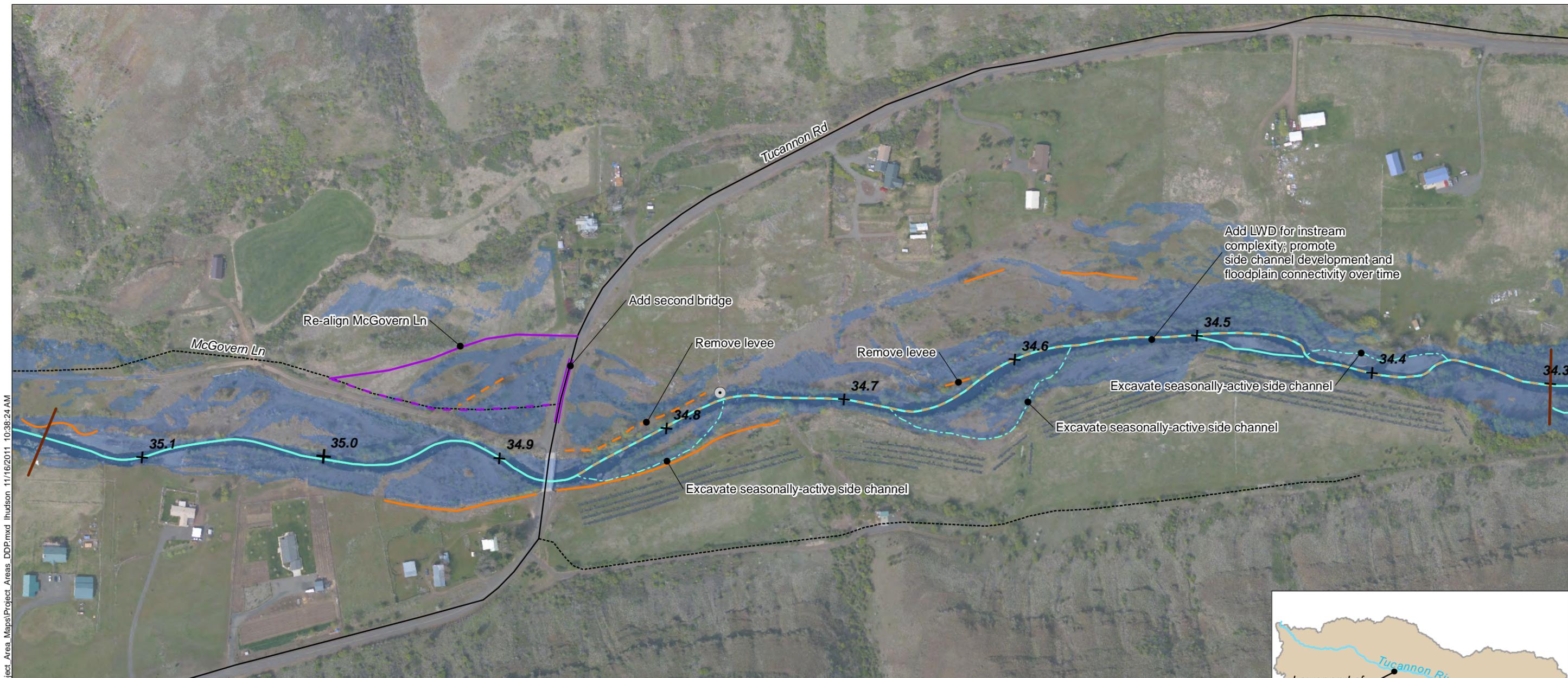
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|-----|--------------------------------|-----|---------------|-------|------------------------------------|---|-----------------------------------|
| + | River Miles | --- | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | --- | Unpaved Road | - - - | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | - - - | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | □ | Protection Area |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | — | Approximate 5-Year Flood Elevation | | |
| --- | Reconnected Side Channel | — | Remove Road | | | | |



NOTES:
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 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
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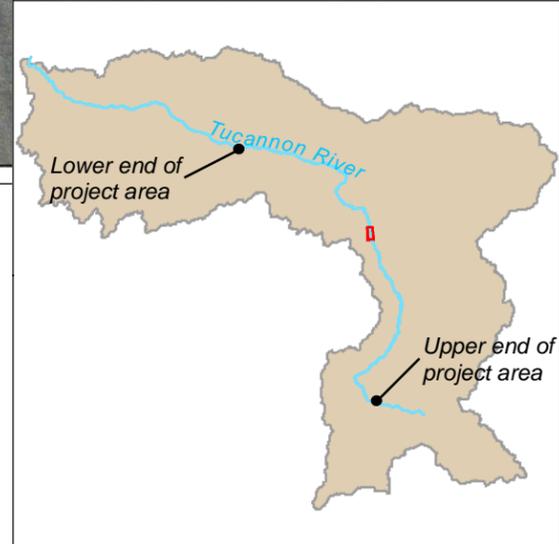
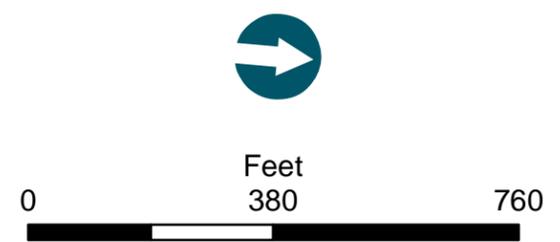
Figure B-16
 Project Area 16, River Mile 36.35 to 34.9
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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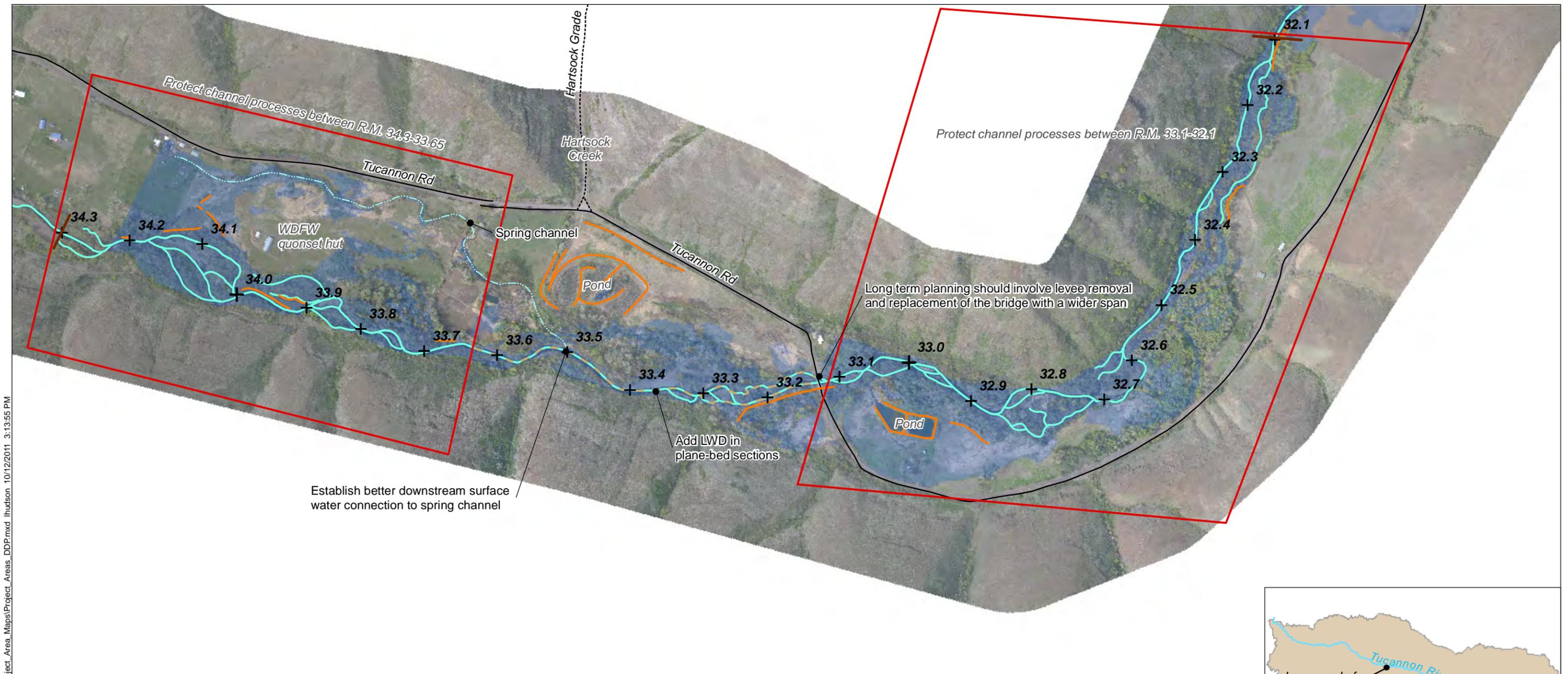
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|---|--------------------------------|--------------------|--------------------------------------|-------------------------------------|
| + | River Miles | — LWD | — Existing Levee or Spoil Pile | ● Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | Unpaved Road | — Remove Infrastructure | ○ Diversion (Intake/Return) |
| — | Tributaries | — Paved Road | --- Levee Setback | ● Weir or Dam |
| — | New Excavated Side Channel | — New Bridge | — Project Area Extents | |
| — | Enhanced Existing Side Channel | — Re-Align Road | □ Protection Area | |
| — | Reconnected Side Channel | — Remove Road | ■ Approximate 5-Year Flood Elevation | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

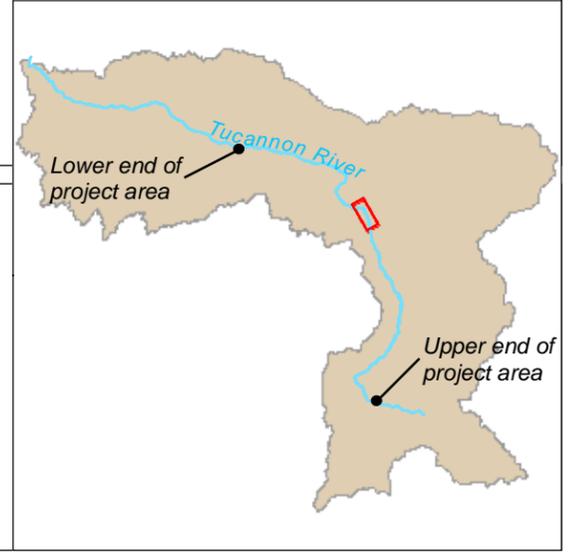
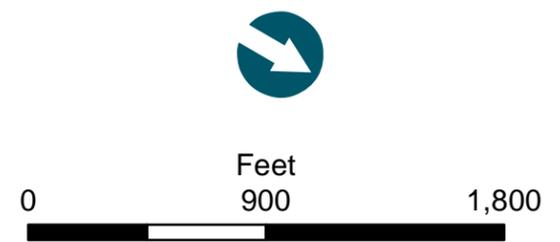
Figure B-17
 Project Area 17, River Mile 35.15 to 34.3
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District

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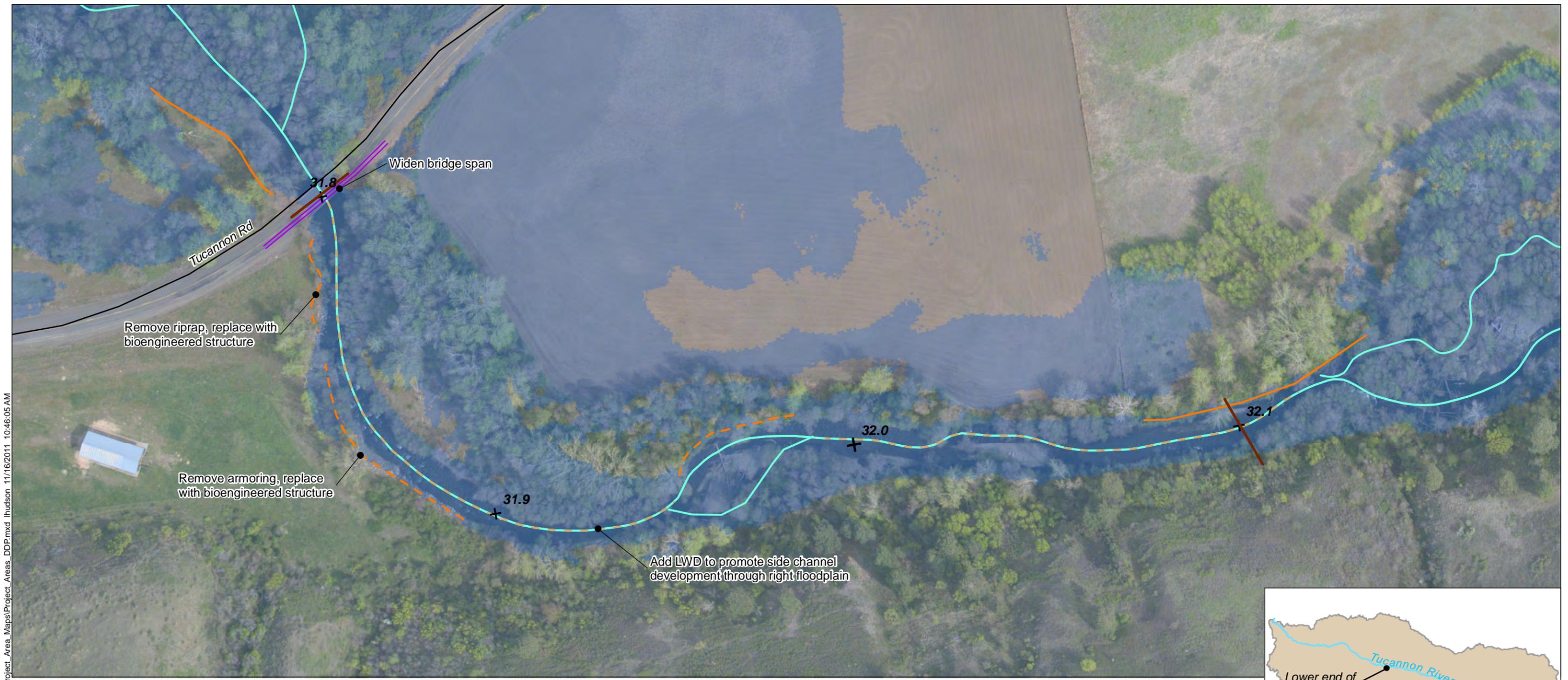
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|-----|--------------------------------|------|---------------|---------|------------------------------------|---|-----------------------------------|
| + | River Miles | --- | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | ---- | Unpaved Road | - - - - | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | - - - - | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | □ | Protection Area |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | — | Approximate 5-Year Flood Elevation | | |
| --- | Reconnected Side Channel | — | Remove Road | | | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

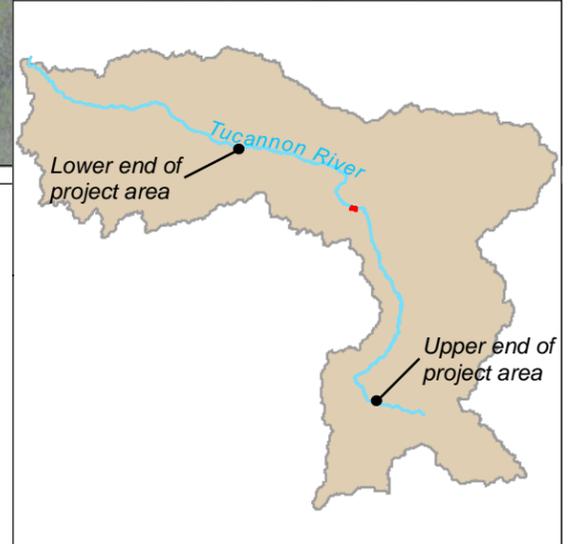
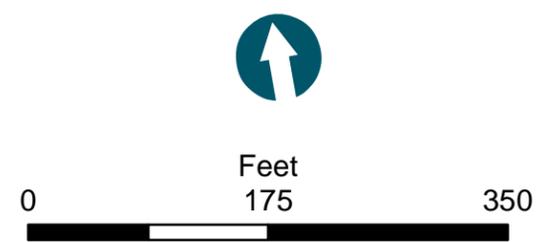
Figure B-18
 Project Area 18, River Mile 34.3 to 32.1
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District

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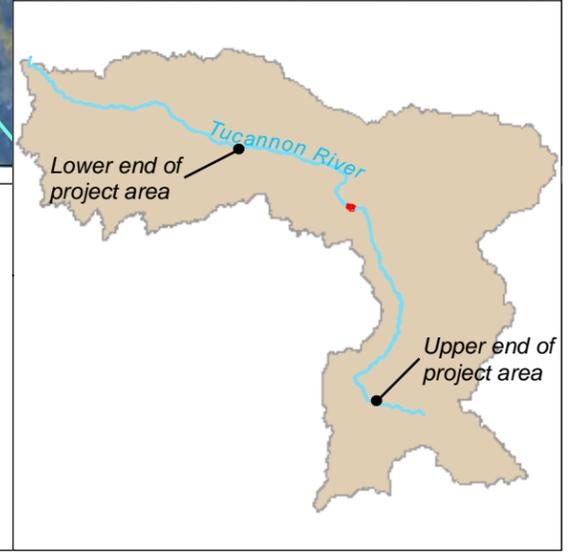
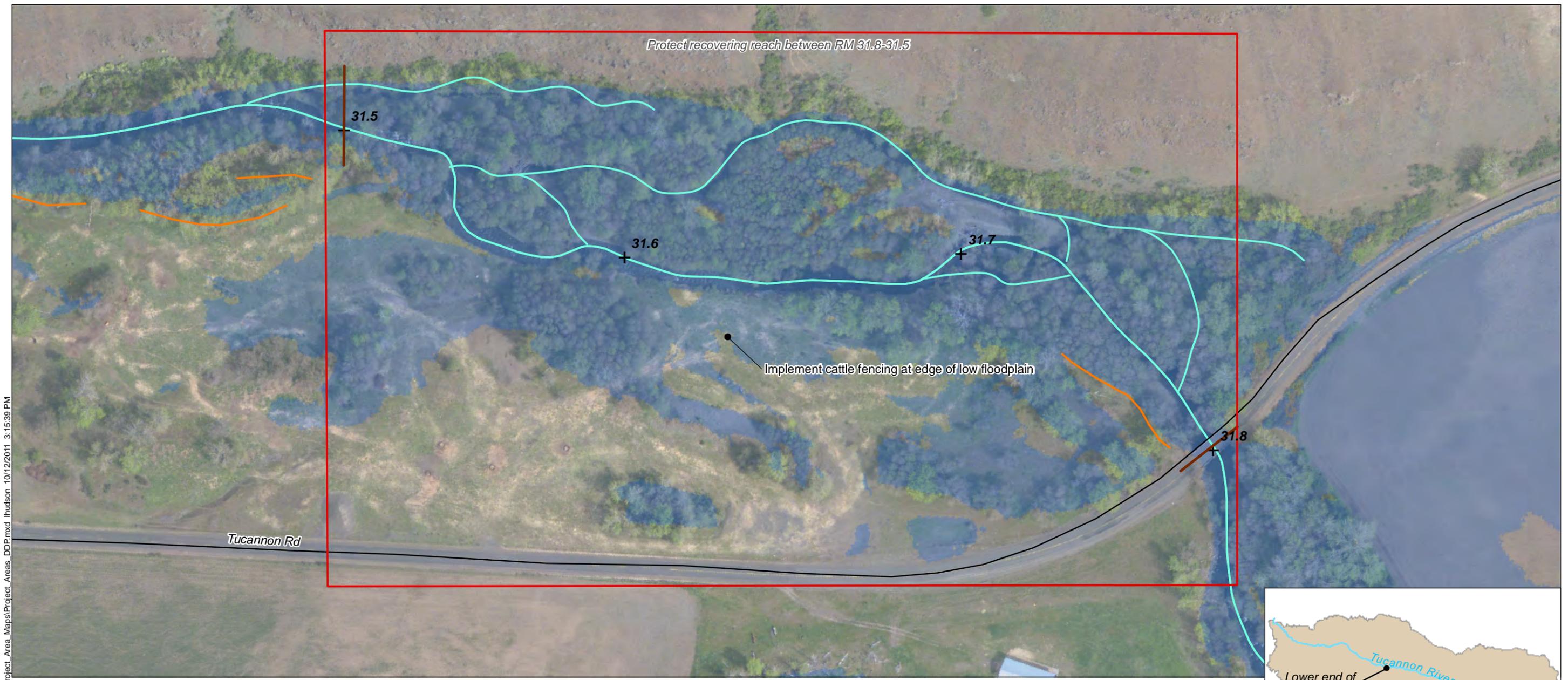
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|---------|--------------------------------|---------|---------------|---------|------------------------------------|---|-----------------------------------|
| + | River Miles | - - - - | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | | Unpaved Road | - - - - | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| - - - - | Tributaries | — | Paved Road | - - - - | Levee Setback | ● | Weir or Dam |
| - - - - | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | □ | Protection Area |
| - - - - | Enhanced Existing Side Channel | — | Re-Align Road | — | Approximate 5-Year Flood Elevation | | |
| - - - - | Reconnected Side Channel | — | Remove Road | | | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

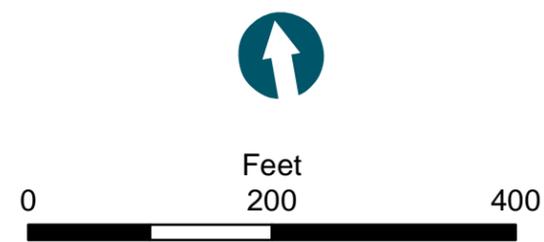
Figure B-19
 Project Area 19, River Mile 32.1 to 31.8
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District

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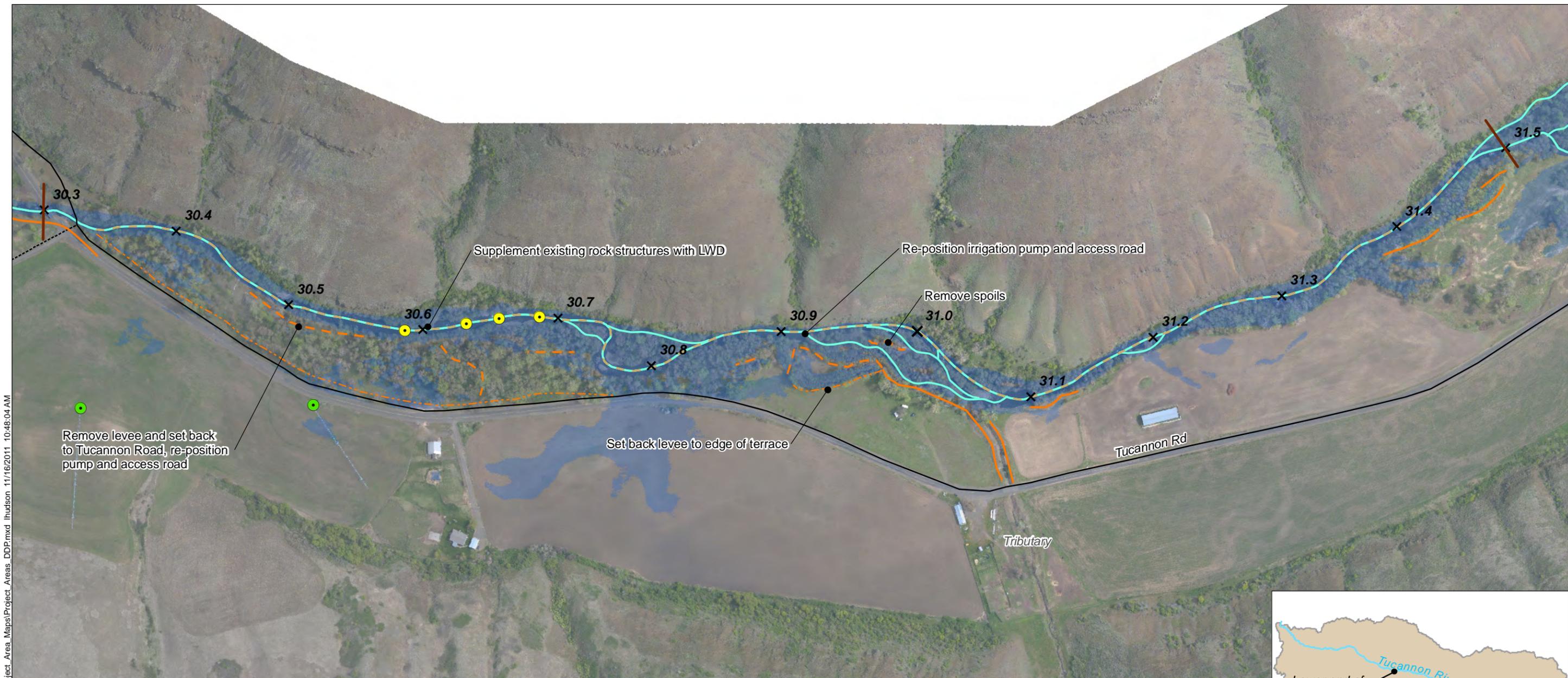
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|-------|--------------------------------|------|---------------|-------|------------------------------------|---|-----------------------------------|
| + | River Miles | --- | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | ---- | Unpaved Road | - - - | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| - - - | Tributaries | — | Paved Road | - - - | Levee Setback | ● | Weir or Dam |
| - - - | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | □ | Protection Area |
| - - - | Enhanced Existing Side Channel | — | Re-Align Road | — | Approximate 5-Year Flood Elevation | | |
| - - - | Reconnected Side Channel | — | Remove Road | | | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

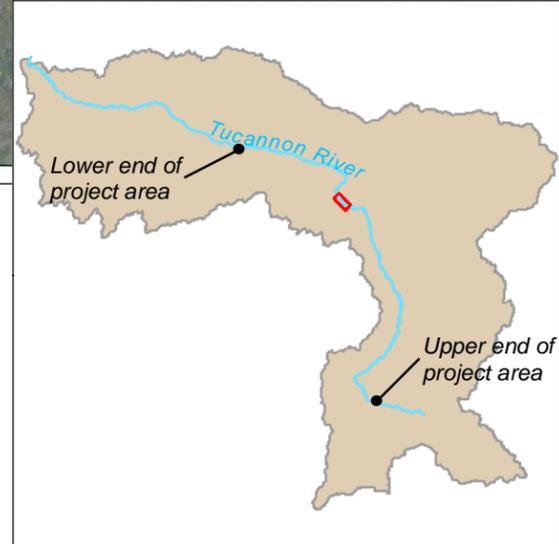
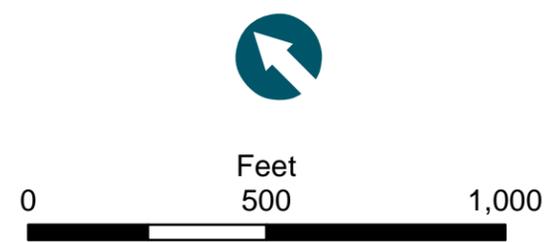
Figure B-20
 Project Area 20, River Mile 31.8 to 31.5
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District

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|-----|--------------------------------|-----|---------------|-------|------------------------------------|---|-----------------------------------|
| + | River Miles | --- | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | --- | Unpaved Road | - - - | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | - - - | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | | |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | — | Protection Area | | |
| --- | Reconnected Side Channel | — | Remove Road | — | Approximate 5-Year Flood Elevation | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

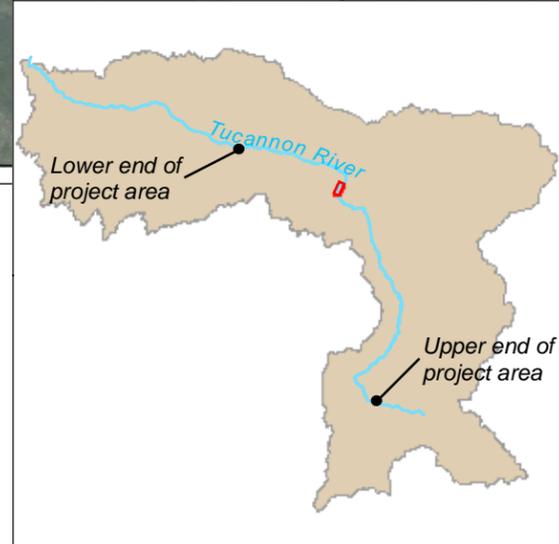
Figure B-21
 Project Area 21, River Mile 31.5 to 30.3
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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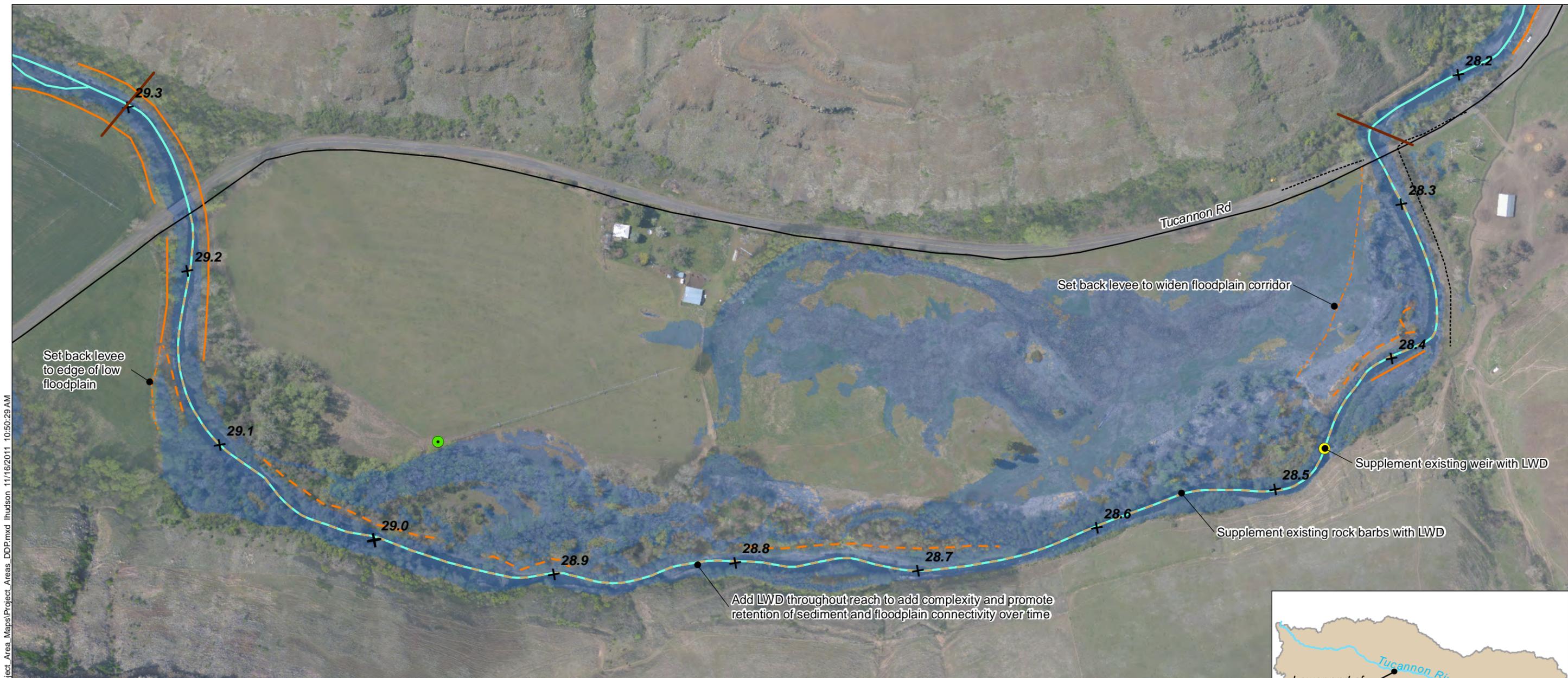
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|-----|--------------------------------|-----|---------------|-------|------------------------------------|---|-----------------------------------|
| + | River Miles | --- | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | --- | Unpaved Road | - - - | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | - - - | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | □ | Protection Area |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | — | Approximate 5-Year Flood Elevation | | |
| --- | Reconnected Side Channel | — | Remove Road | | | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

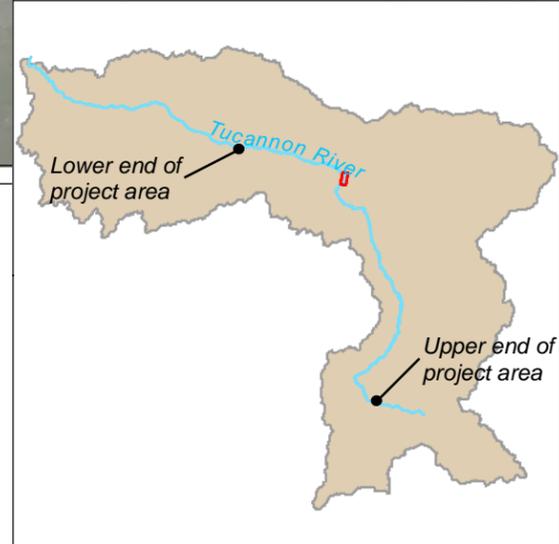
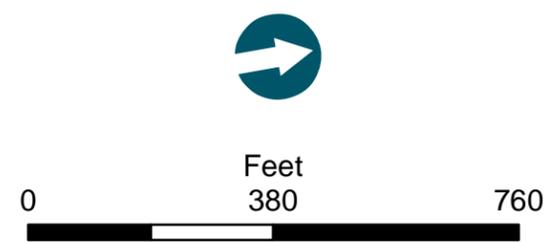
Figure B-22
 Project Area 22, River Mile 30.3 to 29.3
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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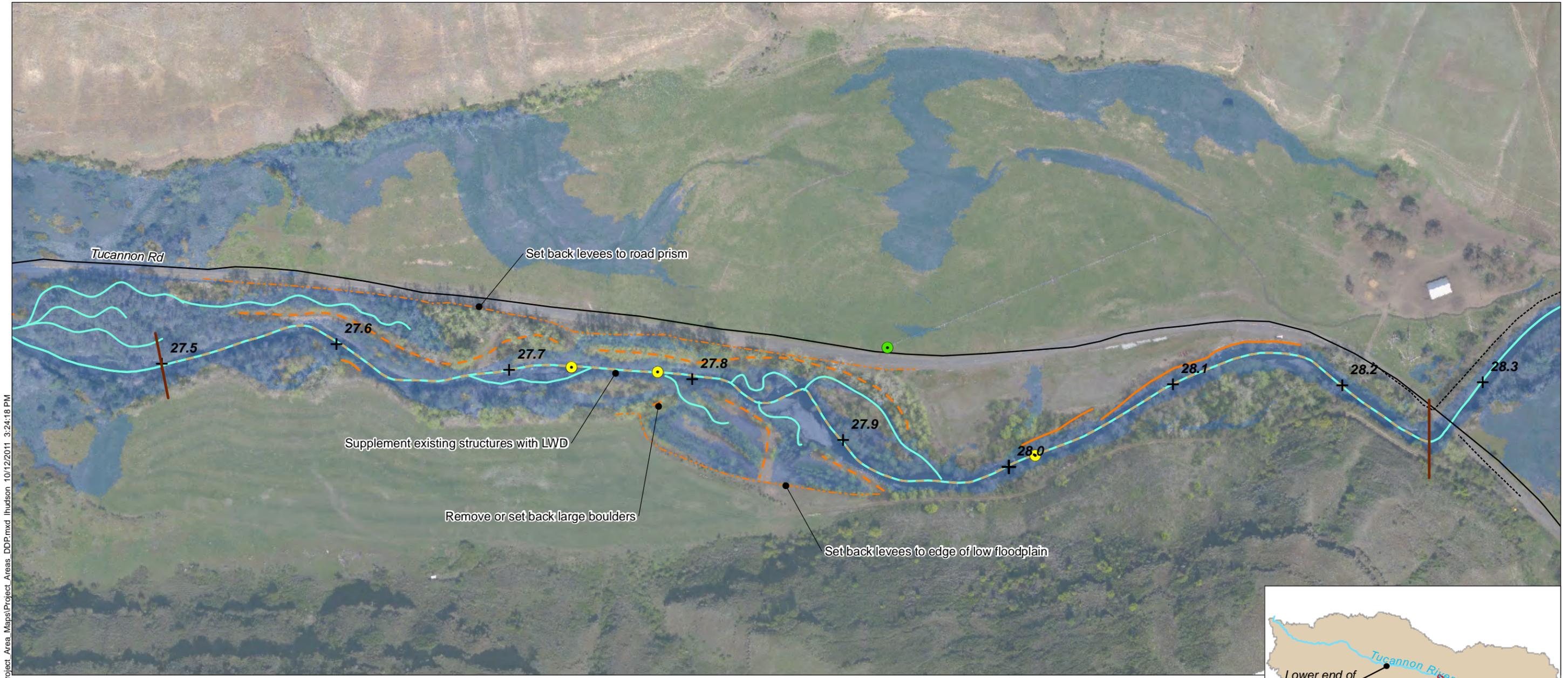
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|-----|--------------------------------|-----|---------------|-----|------------------------------------|---|-----------------------------------|
| + | River Miles | — | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | --- | Unpaved Road | --- | Remove Infrastructure | ● | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | --- | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | --- | Project Area Extents | □ | Protection Area |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | --- | Approximate 5-Year Flood Elevation | | |
| --- | Reconnected Side Channel | --- | Remove Road | | | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

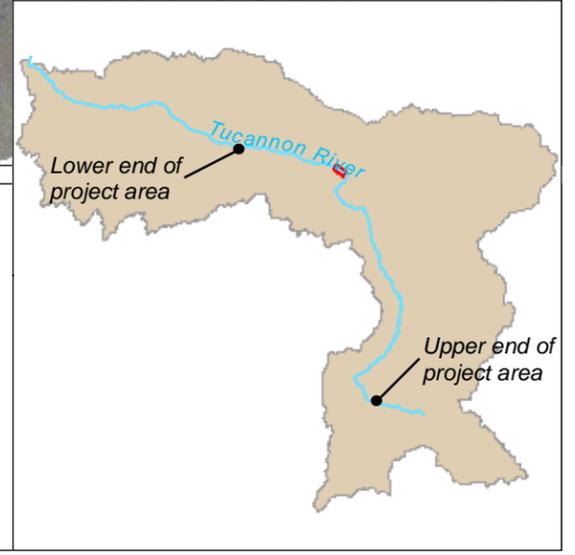
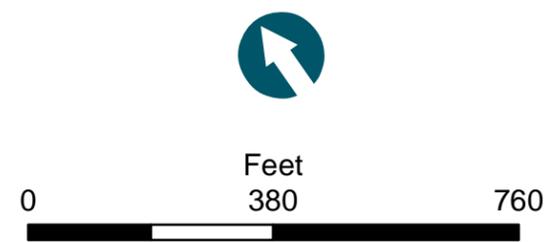
Figure B-23
 Project Area 23, River Mile 29.3 to 28.25
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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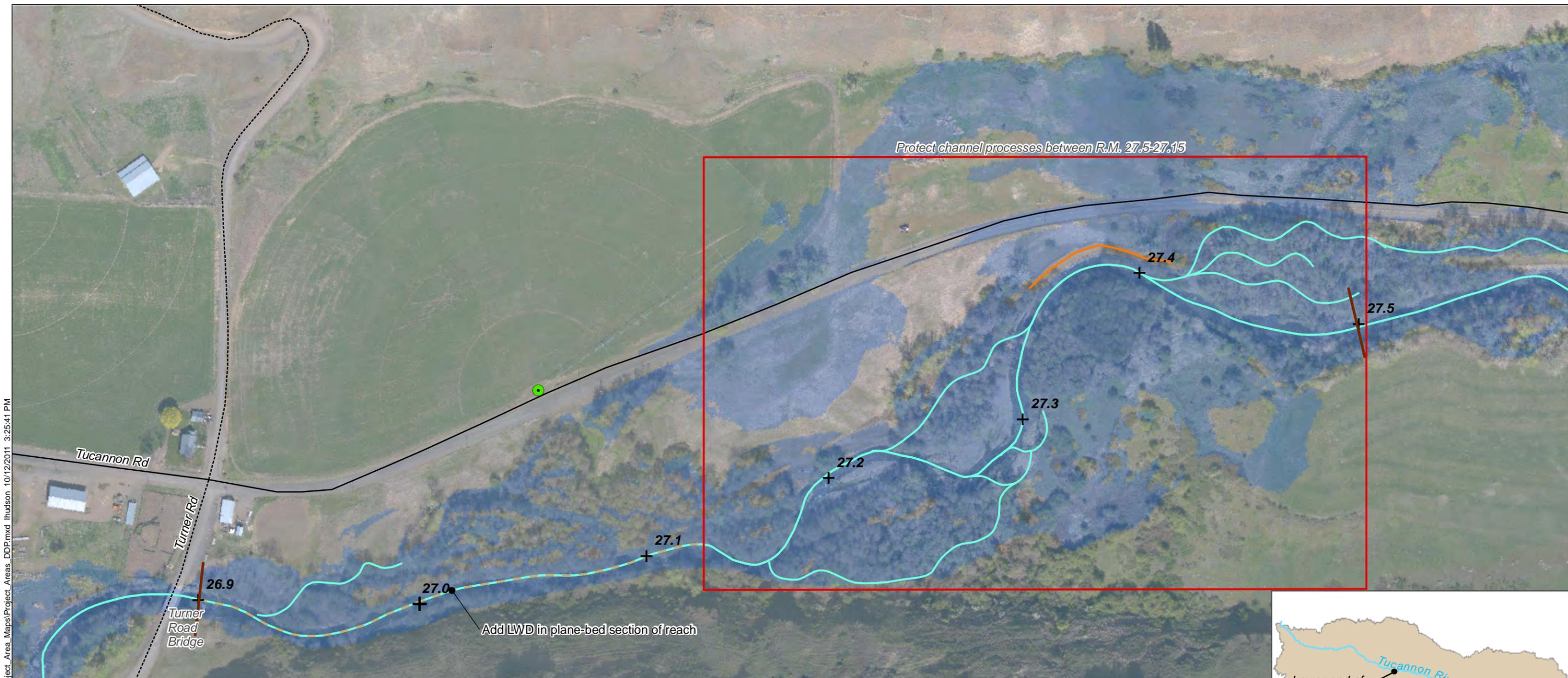
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|-----|--------------------------------|-----|---------------|-------|------------------------------------|---|-----------------------------------|
| + | River Miles | --- | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | --- | Unpaved Road | - - - | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | - - - | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | □ | Protection Area |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | — | Approximate 5-Year Flood Elevation | | |
| --- | Reconnected Side Channel | — | Remove Road | | | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
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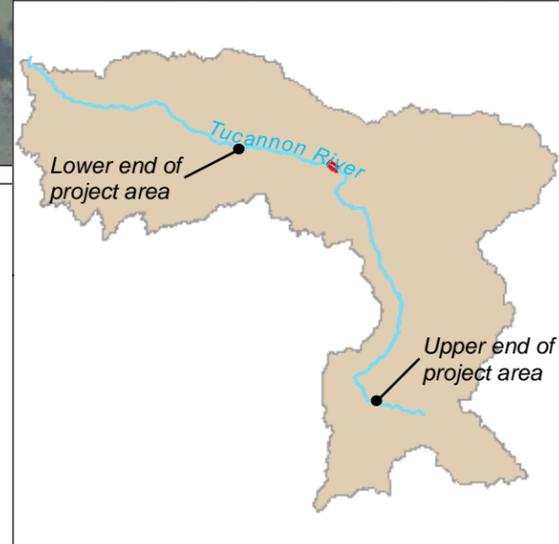
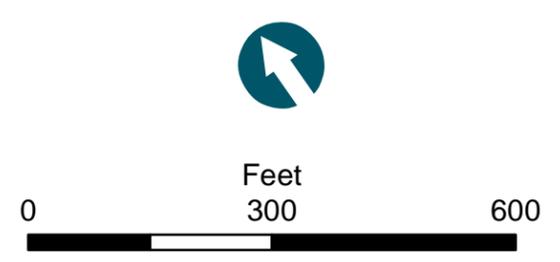
Figure B-24
 Project Area 24, River Mile 28.25 to 27.5
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District

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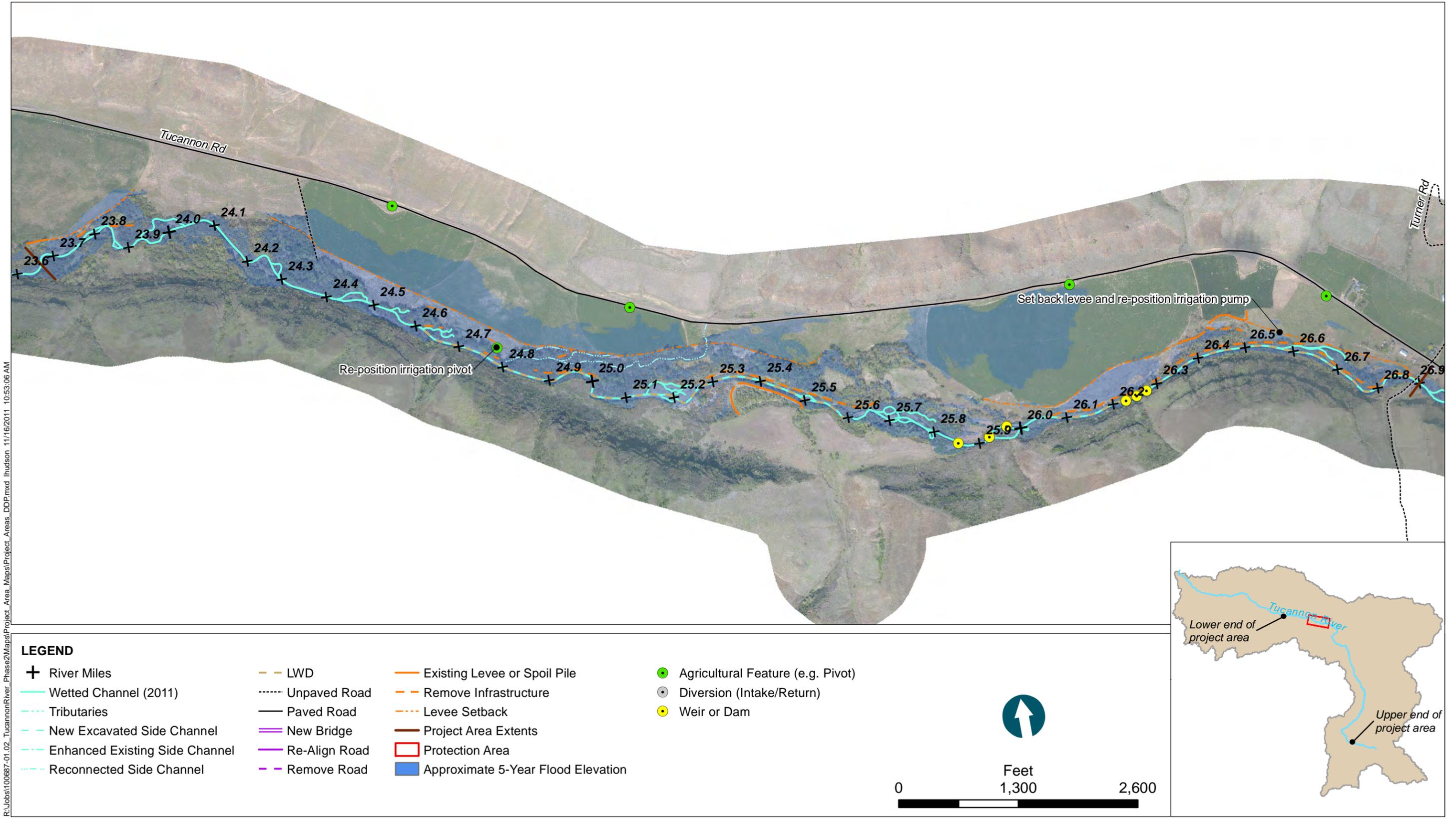
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|-----|--------------------------------|-------|---------------|-------|------------------------------------|---|-----------------------------------|
| + | River Miles | - - - | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | | Unpaved Road | - - - | Remove Infrastructure | ○ | Diversion (Intake/Return) |
| --- | Tributaries | — | Paved Road | - - - | Levee Setback | ● | Weir or Dam |
| --- | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | □ | Protection Area |
| --- | Enhanced Existing Side Channel | — | Re-Align Road | — | Approximate 5-Year Flood Elevation | | |
| --- | Reconnected Side Channel | — | Remove Road | | | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

Figure B-25
 Project Area 25, River Mile 27.5 to 26.9
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District

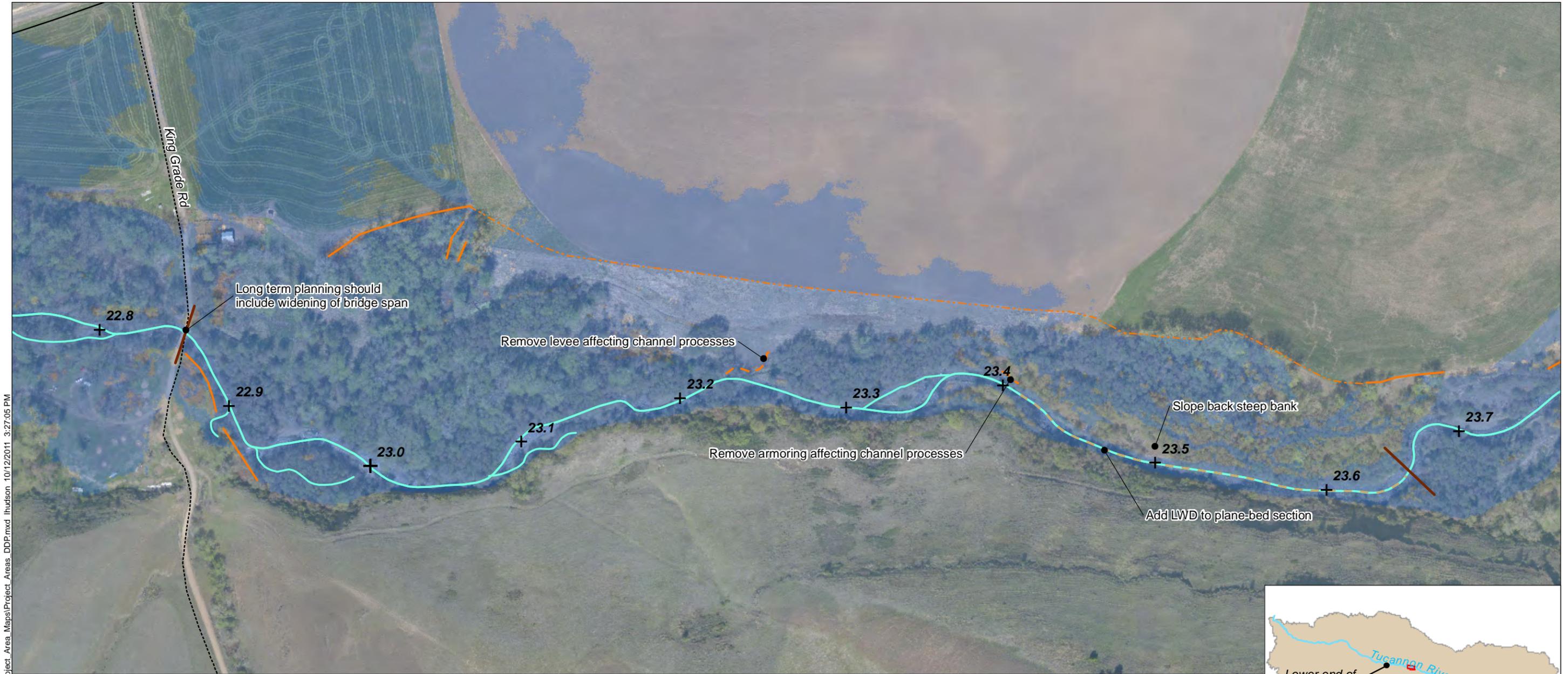


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NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

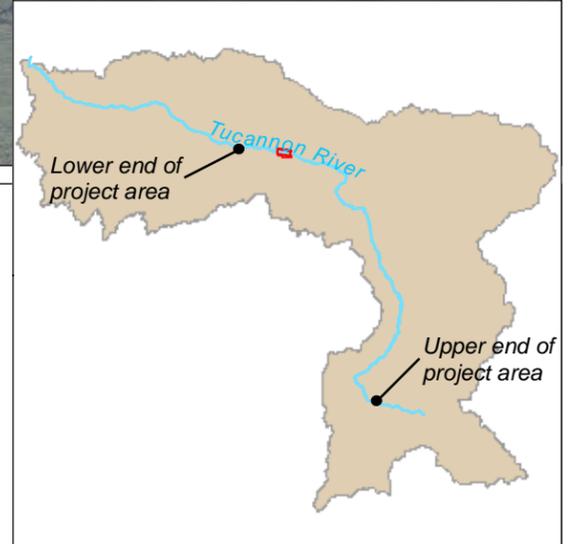
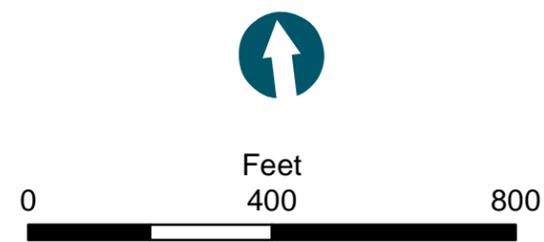
Figure B-26
 Project Area 26, River Mile 26.9 to 23.65
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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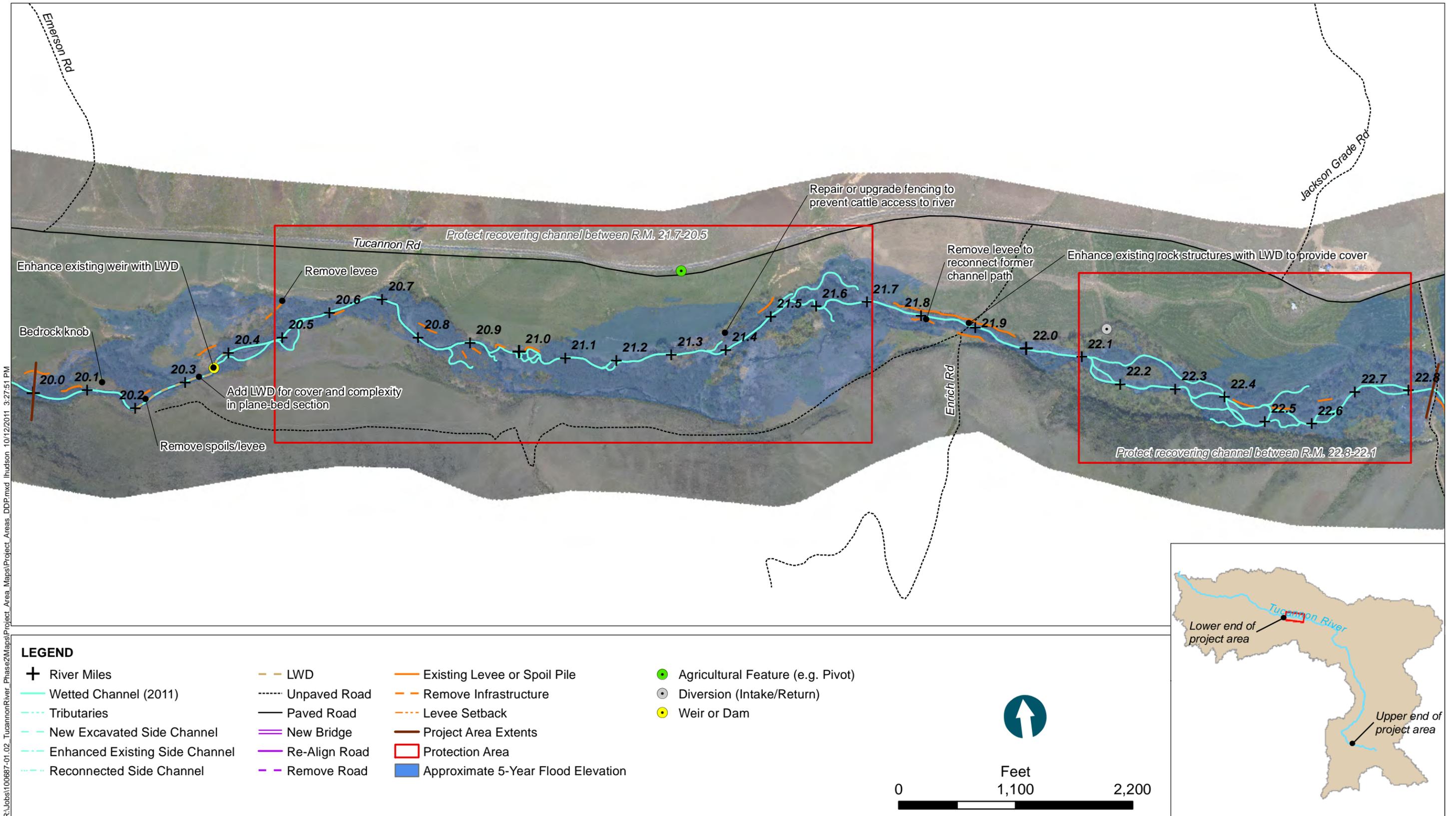
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|---|--------------------------------|---------|---------------|---------|------------------------------------|---|-----------------------------------|
| + | River Miles | - - - - | LWD | — | Existing Levee or Spoil Pile | ● | Agricultural Feature (e.g. Pivot) |
| — | Wetted Channel (2011) | ⋯ | Unpaved Road | - - - - | Remove Infrastructure | ⊙ | Diversion (Intake/Return) |
| ⋯ | Tributaries | — | Paved Road | - - - - | Levee Setback | ● | Weir or Dam |
| ⋯ | New Excavated Side Channel | — | New Bridge | — | Project Area Extents | | |
| ⋯ | Enhanced Existing Side Channel | — | Re-Align Road | □ | Protection Area | | |
| ⋯ | Reconnected Side Channel | — | Remove Road | □ | Approximate 5-Year Flood Elevation | | |



NOTES:
 1. Aerial photo collected in 2010 provided by CCD.
 2. Roads from WA DNR.
 3. Tributary alignments from DOE.
 4. Locations of mapped features are approximate.
 This figure is to be used for conceptual purposes only.

Figure B-27
 Project Area 27, River Mile 23.65 to 22.85
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District



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Figure B-28

Project Area 28, River Mile 22.85 to 20.0
 Tucannon River Habitat Restoration Design, Preliminary Project Areas Memorandum
 Columbia Conservation District